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Focused Feasibility Study for the K Basins Interim Remedial Action

United States
Department of Energy

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EXECUTIVE SUMMARY

This Focused Feasibility Study (FFS) evaluates alternatives for remediation of the K East (KE) and K West (KW) Basins, located in the 100-K Area of the Hanford Site. The basins contain spent nuclear fuel (SNF) and contaminated sludge, water, and debris. The SNF is deteriorating under the current storage conditions. In addition, there have been at least two documented leaks of contaminated water from the basins into the underlying soil and groundwater. The FFS supports implementation of a *Comprehensive Environmental Response, Compensation, and Liability Act of 1980* (CERCLA) interim remedial action on the K Basins cleanout project and development of a CERCLA proposed plan and record of decision for the cleanout.

The K Basins cleanout and disposition of the SNF were originally evaluated by the U. S. Department of Energy (DOE), Richland Operations Office, in the *Environmental Impact Statement for the Management of Spent Nuclear Fuel from the K Basins at the Hanford Site* (EIS) prepared pursuant to the *National Environmental Policy Act of 1972* (NEPA). The alternatives analyzed in the EIS focused on managing the SNF, with secondary discussions of the sludge, water, and debris. The alternative selected in the EIS record of decision consisted of removing the SNF from the basins; vacuum drying, conditioning, and sealing the SNF in canisters; and placing it in dry vault storage in a new facility to be built at the Hanford Site**.** The SNF process was modified subsequently to delete the conditioning process; this modification was reviewed in a NEPA Supplement Analysis. The selected alternative also included removal of the sludge and transfer to either a double-shell tank (DST) or transuranic (TRU) waste management facilities in the 200 Area; disposition of the basin water; removal of the debris and disposal in a low-level burial ground at the Hanford Site; and deactivation of the basins pending decommissioning. Sludge characterization data and storage criteria available at the time the EIS was prepared did not indicate that substantial sludge treatment would be required. Therefore, sludge treatment processes were not analyzed in the EIS.

The U.S. Environmental Protection Agency (EPA) and the Washington State Department of Ecology subsequently determined that cleanout of the K Basins could most effectively be done under CERCLA authority as an interim remedial action. The CERCLA action is consistent with the EIS record of decision and establishes the sludge treatment process. The scope of the K Basins CERCLA action was defined as follows:

- Removing the SNF, sludge, debris, and water from the basins
- Transferring the SNF to the drying facility
- Treating the sludge to meet waste acceptance criteria of interim storage and disposal facilities
- Transferring the sludge to an interim storage facility
- Pretreating the water and transferring it to the Effluent Treatment Facility (ETF)
- Transferring the debris to appropriate waste management facilities
- Deactivating the basins.

The scope of the CERCLA action does not include drying or interim storage of the SNF.

The purpose of this FFS is to (1) identify the requirements under CERCLA for removing the SNF, sludge, water, and debris from the basins and deactivating the basins and (2) evaluate alternatives for treating the K Basins sludge. Alternatives for removing the SNF, sludge, water, and debris from the basins and deactivating the basins are not analyzed because the associated environmental impacts were previously analyzed in the EIS.

Five alternatives were identified for the K Basins CERCLA interim remedial action. Alternative 1, No Action, would consist of leaving the SNF, sludge, water, and debris in the basins. It is included only to provide a baseline for evaluation; it is not the intent to change decisions made via the NEPA process regarding removal of the SNF, sludge, water, and debris. Alternatives 2 through 5 all include the following activities, previously analyzed in the K Basins EIS:

- The SNF will be removed from the basins, packaged in multi-canister overpacks, and transferred to the Cold Vacuum Drying facility located in the 100-K Area.

- The sludge will be retrieved and removed from the basins and, after treatment, transferred to waste management facilities in the 200 Area for interim storage. The specific facility or facilities will depend on the type of sludge treatment.

- The water will be pretreated, using systems installed in the basins, to meet waste acceptance criteria of the ETF and transferred to the ETF in the 200 Area.

- Debris that is not designated as TRU waste will be treated and packaged as appropriate and transferred to the 200 Area for disposal at the Environmental Restoration Disposal Facility (ERDF). Debris that designates as TRU waste will be packaged and transferred to the Central Waste Complex in the 200 Area for management with other Hanford TRU waste.

- The basins will be deactivated by removing equipment that is not permanently fixed to the structure, decontaminating or stabilizing contaminated surfaces, de-energizing systems that are no longer required, and controlling access points.

Alternatives 2 through 5 also include sludge treatment, and it is the type of treatment that distinguishes the alternatives. The alternatives are:

- Alternative 2: Chemical Treatment. Treatment would rely primarily on chemical technologies to meet current DST waste acceptance criteria. Two chemical treatment systems are developed in the FFS, Baseline Chemical Treatment and Modified Chemical Treatment. Treatment would include:

- Separation of organic ion exchange resin (OIER), either as a first step in the treatment system or during removal from the basins
- Acid dissolution of the sludge
- Separation of insoluble solids
- Addition of neutron absorber
- Caustic precipitation and chemical adjustment
- Leaching of OIER and insoluble solids (Baseline Chemical Treatment only)
- Solidification of the OIER and insoluble solids
- Off-gas treatment.

The treated sludge would be a mixed high-level waste (HLW) or TRU waste that would meet DST criteria for nuclear criticality safety, reactivity/pyrophoricity, particle size, and flammable gas control. Polychlorinated biphenyls (PCB) treatment would be achieved by a combination of volatilization and separation with the OIER and insoluble solids; residual PCBs in the treated sludge would present no unreasonable risk to human health and the environment so the sludge would no longer be regulated under the Toxic Substances Control Act (TSCA). The sludge treatment facility would be located in the 100-K Area or at another Hanford Site location determined to be environmentally protective. The treated sludge would be transferred to a DST in the 200 Area for eventual processing with other Hanford tank waste at the planned vitrification facility and disposal at the national geologic repository for SNF and HLW. The solidified OIER and insoluble solids would be disposed at the Hanford Environmental Restoration Disposal Facility if they are non-TRU waste and at the Waste Isolation Pilot Plant (WIPP) if they are TRU waste.

- Alternative 3: Physical Treatment. Treatment would rely primarily on physical technologies to meet current DST waste acceptance criteria. The physical treatment alternative developed in the FFS is high-energy milling/grinding combined with physical separation processes. Treatment would include:

  - Grinding the solids (oxidation would occur concurrently)
  - Separation, removal, and recycle of oversize particles
  - Addition of neutron absorber
  - Chemical adjustment
  - Solidification of ungrindable solids
  - Off-gas treatment.

  The treated sludge would be a mixed HLW or TRU waste that would be intended to meet DST criteria for nuclear criticality safety, reactivity/pyrophoricity, particle size, and flammable gas control. PCB treatment would be achieved by absorption of the PCBs onto the polyurethane liner of the grinder or other suitable treatment; residual PCBs in the treated sludge would present no unreasonable risk to human health or the environment so the sludge would no longer be regulated under TSCA. The sludge treatment facility would be located in the 100-K Area or at another Hanford Site location determined to be environmentally protective. The treated sludge would be transferred to a DST in the 200 Area for eventual processing with other Hanford tank waste at the planned

vitrification facility and disposal at the national geologic repository for SNF and HLW.

- Alternative 4: Thermal Treatment. Treatment would rely primarily on thermal technologies to allow disposal at the national geologic repository or the WIPP without further treatment. Two thermal treatment options are developed in the FFS, Vitrification and Calcination. Both options include chemical pretreatment to size-reduce large particles, which is necessary to facilitate thermal treatment. Treatment would include:

  - Separation of OIER during removal from the basins
  - Separation of the sludge by particle size during removal from the basins
  - Acid dissolution of large particles
  - Separation of insoluble solids
  - Sugar denitration of the acidic solution (Vitrification only)
  - Vitrification or calcination of small particles and the acidic solution
  - Solidification of the OIER and insoluble solids
  - Off-gas treatment.

  The vitrified sludge would be assumed to designate as a HLW and would meet repository criteria for nuclear criticality safety and reactivity/pyrophoricity. The calcined sludge would be assumed to designate as a TRU waste and would meet WIPP criteria for nuclear criticality safety, reactivity/pyrophoricity, and flammable gas generation. In both vitrification and calcination, PCBs would be volatilized or destroyed during treatment; residual PCBs in the vitrified or calcined sludge would present no unreasonable risk to human health or the environment so the sludge would no longer be regulated under TSCA. The sludge treatment facility would be located in the 100-K Area or at another Hanford Site location determined to be environmentally protective. The vitrified or calcined sludge would be transferred to the 200 Area for interim storage and ultimately transported to the national geologic repository for SNF and HLW or the WIPP for TRU waste, respectively, for disposal.

- Alternative 5: Solidification. Treatment would rely primarily on solidification technologies to allow disposal at the WIPP without further treatment. The alternative developed in the FFS includes thermal pretreatment to oxidize metallic particles in the sludge, which is required to meet WIPP waste acceptance criteria. Treatment would include:

  - Separation of the OIER during removal from the basins
  - Separation of the sludge by particle size during removal from the basins
  - Calcination of large particles
  - Hot water oxidation of small particles and OIER
  - Solidification of the large and small particles and OIER
  - Off-gas treatment.

The solidified sludge would be assumed to designate as a TRU waste and would meet WIPP criteria for nuclear criticality safety, reactivity/pyrophoricity, and flammable gas generation. PCBs would be volatilized during thermal pretreatment; residual PCBs in the sludge would present no unreasonable risk to human health or the environment so the sludge would no longer be regulated under TSCA. The sludge treatment facility would be located in the 100-K Area or at another Hanford Site location determined to be environmentally protective. The solidified sludge would be transferred to the 200 Area for interim storage and ultimately transported to the WIPP for disposal.

The alternatives were evaluated against the nine criteria required under CERCLA: overall protectiveness; compliance with applicable or relevant and appropriate requirements (ARARs); long-term effectiveness; reduction of toxicity, mobility, and volume; short-term effectiveness; implementability; cost; State of Washington acceptance; and community acceptance. The evaluation included rating the alternatives on a scale of one star to three stars, with three meaning an alternative performs very well against the criterion. In some cases, none of the alternatives perform very well against a criterion. A compilation of the ratings is provided in Table ES-1.

In summary, all of the alternatives except the No Action Alternative would perform very well in providing overall protection of human health and the environment, complying with ARARs, and being effective in the long term. All of the alternatives except Alternative 1 would succeed in removing hazardous substances from the K Basins and treating residual materials in a protective manner. All of the alternatives would meet ARARs, assuming EPA grants a risk-based disposal approval for PCBs in sludge undergoing treatment and a land disposal restriction treatability variance for PCBs in sludge undergoing thermal treatment.

The alternatives vary significantly in how they would perform against the criterion of reduction of toxicity, mobility, and volume through treatment with respect to sludge treatment. The Thermal Treatment (Vitrification) Alternative would perform very well. Vitrification would reduce both toxicity (flammable gas generation and reactivity/pyrophoricity) and mobility significantly and reduce volume by 50 percent. The Physical Treatment, Thermal Treatment (Calcination), and Solidification Alternatives would all perform moderately well. They would all reduce toxicity (flammable gas generation and reactivity/pyrophoricity) significantly, and Physical Treatment would reduce the potential for criticality. Solidification would perform much better than physical treatment or calcination in reducing mobility, but would perform worse in reducing volume (the volume would increase significantly). Calcination would perform much better than physical treatment or solidification in reducing volume (volume would be reduced by about 75 percent) but would not reduce mobility and would generate a dispersible waste form unless it were subsequently solidified. Physical treatment would not reduce mobility as part of the CERCLA action (mobility would eventually be reduced via processing with DST waste) and the volume of sludge requiring interim storage would increase significantly, but the final volume of glass made from the sludge (after DST processing) would be only a slight increase over the original volume. Neither option under the Chemical Treatment Alternative would perform well against this criterion. Chemical treatment would reduce toxicity (potential for criticality, flammable gas generation, and reactivity/pyrophoricity). However, it would not reduce mobility as part of the CERCLA action (mobility would eventually be reduced significantly via processing with DST

waste) and both the interim and final volumes of waste produced would be significantly greater than the original volume. The No Action Alternative would provide no treatment.

All of the alternatives except the No Action Alternative would perform moderately well in providing short-term effectiveness. The SNF removal and transfer activities would pose a potential risk to the public, the environment, and workers, but control measures are well established. The sludge is highly radioactive so the treatment alternatives would require substantial controls to protect the public, the environment, and workers from routine impacts and impacts associated with upset conditions. The treatment alternatives vary in the degree of difficulty and uncertainty associated with ensuring adequate control, especially control of upset conditions. However, the radionuclide inventory would be the same for all of the alternatives, so the consequences of an upset condition would be similar.

The alternatives vary significantly in how they perform against the criterion of implementability. The No Action Alternative would not perform well because it would fail to meet Tri-Party Agreement schedules and commitments made to regulators, oversight agencies, stakeholders, and the public. None of the individual treatment alternatives would perform very well against this criterion for 100 percent of the sludge volume because of technical and/or administrative uncertainties. The options under the Chemical Treatment Alternative would perform better than the other alternatives. Chemical treatment is a mature technology that is well established in the nuclear industry. Laboratory tests using actual K Basins sludge have demonstrated that chemical treatment could meet the DST acceptance criteria. Once the treated sludge is blended with DST waste, there would be no specific issues associated with downstream waste management. However, a key uncertainty with the Chemical Treatment Alternative is whether the DST system can accommodate the large number of waste transfers to a DST within the Tri-Party Agreement schedule for sludge removal, assuming 100 percent of the sludge must undergo extensive chemical treatment. None of the other treatment alternatives would perform well against this criterion. Physical treatment would rely on the application of technologies that have not been used for similar waste types and there is uncertainty as to whether grinding/milling alone could meet the DST waste acceptance criteria. There is also uncertainty about process control as well as scheduling transfers to the DST. Significant development work would be required. Vitrification, calcination, and solidification are all mature technologies that are well established in the nuclear industry, although they have not been tested using actual or simulated K Basins sludge and development work would be required. There is some uncertainty about the technical viability of vitrification because of the range in sludge composition. In addition, the viability of disposal options is uncertain because of uncertainty about the radioactive designation (TRU waste versus HLW). If the sludge is determined to be TRU waste, it could not be disposed at the national geologic repository. . Conversely, if the sludge is determined to be HLW, it could not be disposed at the WIPP. Vitrified sludge could be disposed at either location, but it would be important to make this determination prior to vitrification to develop a process and waste loading that meet the disposal criteria. It is uncertain whether calcined or grouted sludge could be disposed at the repository. Reworking solidified sludge to meet repository acceptance criteria would be technically difficult. It would be technically feasible to rework calcined sludge, but there would be a cost impact. There is an additional uncertainty as to whether calcined sludge, which would be a dispersible particulate waste, could be transported to or accepted by the WIPP

without further processing. For all of the treatment alternatives, there is significant uncertainty as to whether a treatment system designed and constructed to provide extensive treatment for the entire volume of sludge could be operational by the time sludge removal from the basins begins.

The alternatives do not vary significantly in overall cost of the CERCLA action, but they do vary significantly in the costs associated with sludge. Costs are summarized in Table ES-1. Near-term costs (development, construction, and operation of the sludge treatment system) range from $79 M to $102 M, with the Chemical Treatment Alternative and Solidification Alternative being on the low end and the Thermal Treatment (Vitrification) Alternative being on the high end. Long-term costs (waste storage and disposal) range from $0.2 M to $44.5 M, with the Physical Treatment Alternative, Thermal Treatment (Calcination) Alternative, and Solidification Alternative being on the low end and the Chemical Treatment Alternative being on the high end. These costs do not include contingency, escalation, program management, or regulatory support. Because of the difficulty in assessing and comparing costs for disposal at the WIPP versus at the national geologic repository, there is substantial uncertainty in the long-term costs. The magnitude of the costs reflects the assumption that all of the sludge undergoes extensive treatment in each alternative. Costs might be reduced significantly if only portions of the sludge require extensive treatment.

In summary, the No Action Alternative would fail to meet the requirements for the CERCLA action. The other alternatives would all provide overall protection of human health and the environment, comply with ARARs, and be effective in the long term. All of the alternatives except No Action would achieve a substantial risk reduction by removing SNF, sludge, water, and debris from the K Basins, transferring these materials to environmentally protective facilities, and deactivating the basins. In all of the treatment alternatives, the sludge would be treated to meet the acceptance criteria and all other applicable requirements at the interim storage and final disposal facilities. However, none of the individual treatment alternatives would perform well against all of the CERCLA criteria for the entire volume sludge and range in sludge composition.

There is a high degree of confidence that Chemical Treatment would be able to meet the DST acceptance criteria for the entire range of K Basins sludge. However, the acid dissolution/caustic precipitation process is probably more extensive treatment than necessary for some of the sludge, it would produce a large waste volume, and the cost would be very high. Some of the sludge might be able to meet the DST criteria with very little treatment, such as simple separation and chemical adjustment. Physical Treatment (grinding and physical separation processes) could be a simple way to reduce the size of some particles. However, there is a high degree of technical uncertainty as to whether Physical Treatment would be effective for the full range of particle sizes in the sludge. It is likely that vitrification or calcination could effectively treat smaller particles, but there is uncertainty about radioactive designation, especially with certain sludge fractions, that could affect disposal options. Some of the sludge might designate as HLW and require disposal at the national geologic repository. The repository is most likely to accept a glass form, so Calcination and Solidification might be poor options for this fraction. On the other hand, Calcination and/or Solidification might be very cost-effective for disposal of sludge fractions that are designated as TRU waste and that can be disposed at the WIPP. Finally, it would be very difficult to design and construct a treatment system large enough to treat 100 percent of the

sludge volume using any single treatment alternative in time to treat the sludge immediately after as it is removed from the K Basins. The uncertainties in all of the alternatives could impact cost and schedule.

A hybrid of sludge treatment technologies appears to offer the greatest opportunity for a simple and cost-effective process that meets the Tri-Party Agreement schedule. A hybrid system could involve physically separating the sludge into different fractions based on characteristics such as particle size and radioactivity. Each fraction eventually would be treated using the technology or technologies that are most appropriate and cost-effective for that fraction. If a sludge fraction is already close to meeting the DST waste acceptance criteria or solid waste disposal criteria, it could undergo minimal treatment (such as chemical adjustment, simple grinding, or solidification) as it is removed from the basins or shortly thereafter. Any sludge fraction that would require more extensive treatment (such as chemical dissolution or thermal treatment) to meet the criteria of a double-shell tank, the WIPP, or the repository could be placed into interim storage in the 200 Area upon removal from the basins with minimal treatment, allowing for more extensive treatment at a later date. Although the treatment elements are defined in this FFS, the apportionment of these elements to specific sludge fractions has not been defined.

ES-1. Summary of Evaluation of Alternatives.

Criterion[1]	Alt. 1: No Action	Alt. 2: Chemical Treatment		Alt. 3: Physical Treatment	Alt. 4: Thermal Treatment		Alt. 5: Solidification
		Baseline	Modified		Vitrification	Calcination	
Overall protection	*	***	***	***	***	***	***
Compliance with ARARs[2]	NA	***	***	***	***	***	***
Long-term effectiveness	*	***	***	***	***	***	***
Reduction in toxicity, mobility, and volume	*	*	*	**	***	**	**
Short-term effectiveness	*	**	**	**	**	**	**
Implementability	*	**	**	*	*	*	*
Cost: CERCLA action[3]	NA	$689 M	$689 M	$689 M	$689 M	$689 M	$689 M
Sludge[4]	NA	$126 M	$116 M	$ 98 M	$122 M	$ 81 M	$ 94 M
Total	NA	$815 M	$805 M	$787 M	$811M	$770 M	$783 M

[1] State and community acceptance were not rated on the star system. They are discussed in the text.
[2] Assumes approval of the TSCA risk-based disposal approval and RCRA treatability variance.
[3] Excludes costs associated with sludge treatment and disposal.
[4] Includes costs to design, construct, and operate a sludge treatment system; and to dispose of the treated sludge. Does not include contingency, escalation, transport to final disposal facility, project management, regulatory support, or decontamination/decommissioning.

Note: * Does not perform well against this criterion or there is significant uncertainty about performance.
** Performs moderately well against this criterion.
*** Performs very well against this criterion.

NA = Not applicable

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ACRONYMS

AEA	*Atomic Energy Act of 1954*
ALARA	as low as reasonably achievable
ARAR	applicable or relevant and appropriate requirement
BACT	best available control technologies
BARCT	best available radionuclide control technology
BTU	British thermal unit
CAP-88	Clean Air Act Assessment Package - 1988
CERCLA	*Comprehensive Environmental Response, Compensation, and Liability Act of 1980*
CFR	*Code of Federal Regulations*
CH	contact handled
CSB	Canister Storage Building
CVD	Cold Vacuum Drying
CWC	Central Waste Complex
DOE	U.S. Department of Energy
DOT	U.S. Department of Transportation
DST	double-shell tank
Ecology	Washington State Department of Ecology
EIS	environmental impact statement
EPA	U.S. Environmental Protection Agency
ERDF	Environmental Restoration Disposal Facility
ETF	Effluent Treatment Facility
FFS	focused feasibility study
FGE	fissile gram equivalent
FR	Federal Register
GAC	granular activated carbon
HEPA	high-efficiency particulate air
HLW	high-level waste
IWTS	Integrated Water Treatment System
KE	K East
KW	K West
L	liter
LAW	low-activity waste
LDR	land disposal restriction
LLW	low-level waste
MCO	multi-canister overpack
MEI	maximally exposed individual
NEPA	*National Environmental Policy Act of 1969*
NOC	Notice of Construction
NRC	U.S. Nuclear Regulatory Commission
OIER	organic ion exchange resin
PCB	polychlorinated biphenyl
pCi	picocurie

ppb	parts per billion
ppm	parts per million
RAO	remedial action objective
RCRA	*Resource Conservation and Recovery Act of 1976*
RH	remote handled
ROD	record of decision
SALDS	State-Approved Land Disposal Site
SDWA	*Safe Drinking Water Act*
SNF	spent nuclear fuel
SpG	specific gravity
TBC	to be considered
TCLP	toxicity characteristic leaching procedure
TPA	Tri-Party Agreement (*Hanford Federal Facility Agreement and Consent Order*)
TRU	transuranic
TSCA	*Toxic Substances Control Act*
TWRS	Tank Waste Remediation System
TWRS-P	TWRS Privatization Project
UTS	Universal Treatment Standard
WAC	Washington Administrative Code
WIPP	Waste Isolation Pilot Plant

1.0 INTRODUCTION

This focused feasibility study (FFS) was prepared pursuant to the *Comprehensive Environmental Response, Compensation, and Liability Act of 1980* (CERCLA), as amended by the *Superfund Amendments and Reauthorization Act of 1986*. It evaluates alternatives for interim remedial action at two spent nuclear fuel (SNF) storage basins designated as the K East (KE) and K West (KW) Basins and located in the 100 Area of the Hanford Site. The Hanford Site is a former plutonium manufacturing facility located in Washington State and operated by the U.S. Department of Energy (DOE). As a result of contamination caused by past operations, certain areas of the Site, including the 100 Area, have been placed on the National Priorities List to be addressed under CERCLA.

1.1 K BASINS CLEANOUT STRATEGY

The basins presently contain SNF and contaminated sludge, water, and debris. Past leaks from the basins have contaminated the underlying soil and groundwater. In addition, the SNF is degrading, which poses potential safety concerns.

In the early 1990's, the DOE determined that action was necessary to mitigate further releases from the basins and SNF degradation. Subsequently, the Defense Nuclear Facility Safety Board recommended that the DOE accelerate the program to place deteriorating SNF into a stable configuration for interim storage (Conway 1994) and DOE committed to a number of specific actions to address the recommendation. The DOE used the *National Environmental Policy Act of 1969* (NEPA) process to evaluate alternatives for action. In support of this, DOE prepared the *Draft Environmental Impact Statement, Management of Spent Nuclear Fuel from the K Basins at the Hanford Site, Richland, Washington* (EIS) (DOE 1995) pursuant to NEPA requirements. The K Basins EIS concluded that leaving the SNF in the basins as is would not be protective of human health or the environment and evaluated alternatives to upgrade the basins or remove the SNF and contaminated materials from the basins. After public review of the draft EIS, DOE issued a final EIS (DOE 1996a) and record of decision (ROD) (61 *Federal Register* [FR] 10736) to document the selected alternative, which consisted of the following activities:

- Removal of the SNF from the basins, stabilization at a facility located in the 100-K Area, and interim storage in the 200 Area of the Hanford Site

- Removal of the water, pretreatment at systems installed in the basins, and transfer to the Effluent Treatment Facility (ETF) in the 200 Area for further treatment and disposal

- Removal of the sludge and transfer to either a double-shell tank (DST) or solid waste management facilities in the 200 Area. (Substantial treatment of the sludge prior to the transfer was not expected to be required based on information regarding sludge

characterization and storage requirements at that time; therefore, sludge treatment was not evaluated in the EIS.)

- Removal of the debris and transfer to solid waste management facilities in the 200 Areas

- Preparation of the basins for deactivation and turnover to the decontamination and decommissioning program.

These activities are described in more detail in Section 5, and important conclusions from the K Basins EIS are presented in Appendix A.

Subsequent to preparation of the EIS and ROD, the U.S. Environmental Protection Agency (EPA) and the Washington State Department of Ecology (Ecology), in consultation with the DOE, determined that cleanout of the K Basins could be addressed most effectively under CERCLA regulatory authority as an interim remedial action. The regulatory agencies believe that CERCLA authority will provide the greatest degree of enforceability for ensuring that hazardous substances are removed from the basins. EPA was identified as the lead regulatory agency for the action in June 1998.

The decision to perform the basin cleanout under CERCLA led to the preparation of this FFS. The purpose of the K Basins CERCLA interim remedial action is to address the potential threat of a release of hazardous substances[1] posed by the KE and KW Basins. Certain activities that were covered in the K Basins EIS have been brought under CERCLA authority, including the removal of the SNF, sludge, water, and debris from the basins and pretreatment of the water. Other activities covered in the K Basins EIS and ROD, namely the stabilization and interim storage of the SNF, have not been brought under CERCLA authority. Stabilization and interim storage of the SNF continue to be conducted under the authority of the *Atomic Energy Act of 1954* (AEA) as analyzed via the NEPA process. **The analysis of environmental impacts associated with removing SNF, sludge, water, and debris from the K Basins and pretreating the water was presented in the K Basins EIS and is not repeated in this FFS.** However, the FFS serves as the vehicle for describing how these activities will be conducted under CERCLA authority.

Treatment of the K Basins sludge is an important element of the CERCLA action. However, sludge treatment was not analyzed in the K Basins EIS. Therefore, the identification and evaluation of sludge treatment alternatives are a key focus in this FFS.

1.2 PURPOSE

The purpose of this FFS is two-fold:

[1] "Hazardous substances" are defined under CERCLA as a broad range of constituents including radionuclides. Under this definition, the SNF, sludge, water, and debris all contain CERCLA hazardous substances.

- Identify the requirements under CERCLA for conducting certain basin cleanout activities that were previously addressed in the K Basins EIS and ROD under NEPA

- Evaluate alternatives for treating the K Basins sludge.

This FFS is intended to satisfy the requirements of CERCLA and its implementing regulations (Title 40, *Code of Federal Regulations* [CFR], Part 300). The FFS also includes consideration of NEPA values, for those activities that were not addressed in the EIS.

EPA, Ecology, and DOE will use this FFS and information from the Sludge Treatment Study as the basis for selecting a remedy to mitigate potential threats to human health and the environment posed by the contents of the K Basins. The preferred alternative will be presented for public review and comment in a proposed plan. A remedy will be selected by EPA in a ROD for the K Basin interim remedial action.

1.3 SCOPE

The scope of the K Basins CERCLA interim remedial action and this FFS consists of the following:

- Removing the SNF, sludge, debris, and water from the basin

- Transferring the SNF to the SNF drying facility

- Treating the sludge (including evaluation of treatment alternatives) to meet the waste acceptance criteria of the receiving facility(ies)

- Transferring the sludge to the receiving facility(ies), including disposal at the Environmental Restoration Disposal Facility (ERDF), as appropriate

- Pretreating the water and transferring it to the ETF

- Transferring the debris to appropriate facilities, including disposal at ERDF, as appropriate

- Deactivating the basins.

The scope of the CERCLA action does <u>not</u> include the following:

- Stabilization, transfer to interim storage, interim storage, or final disposition of the SNF

- Interim storage or operation of final treatment or disposal facilities for the sludge, water, or debris[2]

- Final decontamination and decommissioning of the basin structures or remediation of underlying soil and groundwater[3].

The scope of the K Basins CERCLA action evaluated in this FFS versus the scope of the NEPA action evaluated in the K Basins EIS is illustrated in Figure 1-1.

1.4 INTEGRATION WITH OTHER REMEDIATION ACTIVITIES

There are several remediation activities underway or planned in the 100-K Area in addition to cleanout and deactivation of the K Basins. Those activities include remediation of the soil and groundwater, interim safe storage of the KE and KW Reactors, and deactivation and decommissioning of inactive facilities in the 100-K Area. Each of those activities has been or will be addressed in other CERCLA documents as illustrated in Figure 1-2. The contents of the K Basins must be removed and the basins deactivated before other remedial actions at or near the reactor buildings can occur. After basin cleanout and deactivation are complete, the ancillary portions of the reactor building will be decontaminated and demolished. The remaining core of the reactor, including the basins, will be stabilized for interim storage, until the reactors are eventually dispositioned (DOE 1992).

Many of the waste sites in the 100-K Area have been investigated and evaluated in other CERCLA documents (DOE-RL 1993a, DOE-RL 1995a). Those evaluations resulted in the decision that soil and structures at liquid waste disposal sites would be remediated by excavation to meet prescribed cleanup levels (EPA et al. 1995, 1997). Likewise, the groundwater under the 100-K Area has been investigated and evaluated (DOE-RL 1993b, DOE-RL 1995b) and, in 1996, a CERCLA interim remedial action ROD was issued to begin pumping and treating the groundwater to reduce migration of chromium to the Columbia River (EPA et al. 1996). Actions at K Basins addressed by this FFS will be coordinated with these other cleanup activities, as necessary.

1.5 ORGANIZATION

This FFS is organized into the following sections:

- Section 2.0, Background Information, includes a site description and history, the nature and extent of contamination in the basins, and risks justifying the CERCLA action.

[2] Interim storage and disposal facilities that might be used have been authorized under other regulatory actions as described in Section 5.0.
[3] These other cleanup activities will be addressed as separate CERCLA remedial actions.

- Section 3.0, Remedial Action Objectives (RAOs), establishes the objectives and requirements for this action.

- Section 4.0, Screening of Process Options, summarizes various evaluations of sludge treatment, interim storage, and disposal options.

- Section 5.0, Description of Alternatives, describes alternatives for sludge treatment and management and summarizes the common elements of SNF, water, and debris management and basin deactivation.

- Section 6.0, Detailed Evaluation of Alternatives, evaluates the alternatives individually against the CERCLA criteria

- Section 7.0, Comparative Evaluation of Alternatives, compares the alternatives to one another in the context of the CERCLA criteria.

Figure 1-1. Scope of K Basins NEPA Environmental Impact Statement Versus CERCLA Interim Remedial Action.

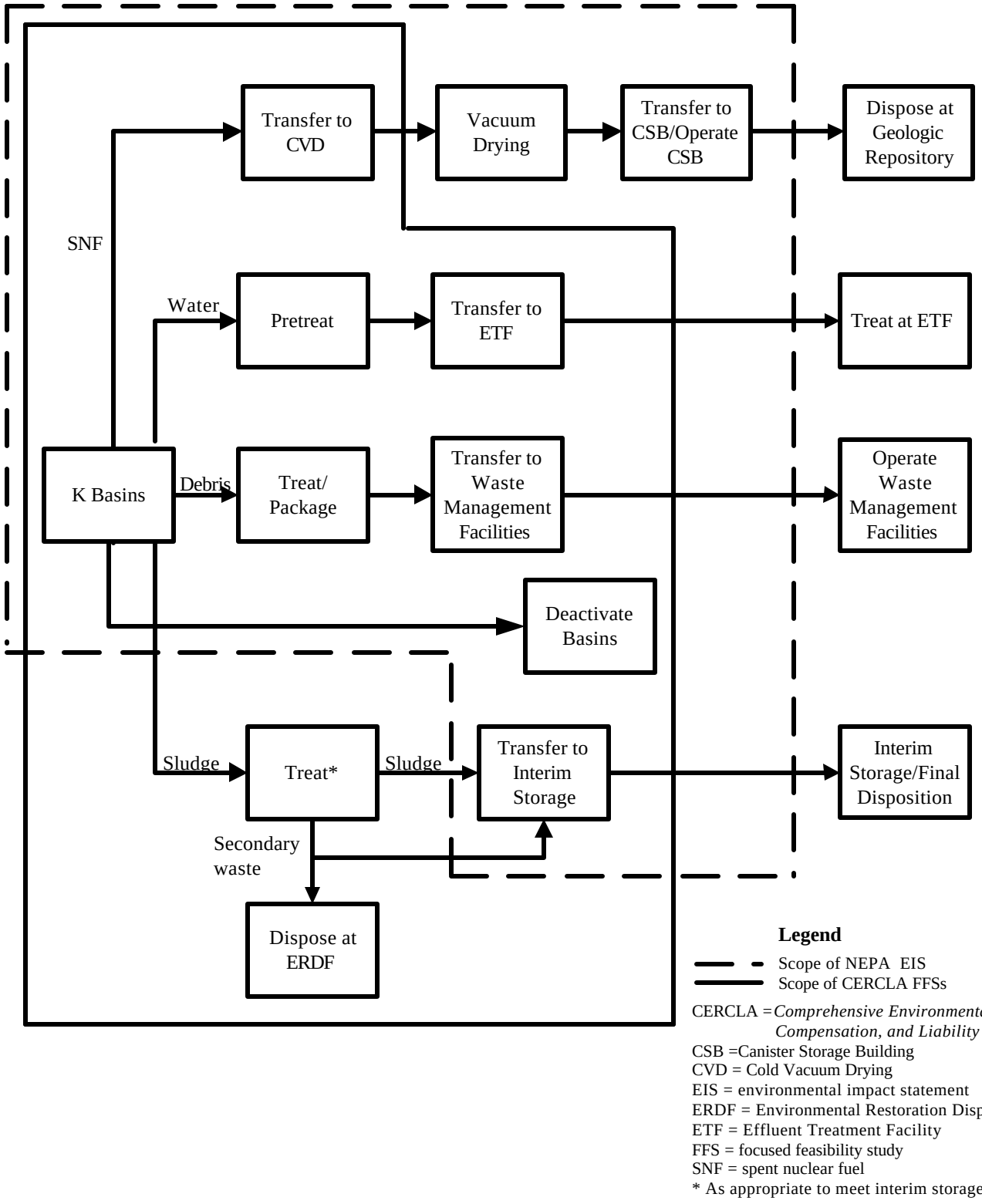
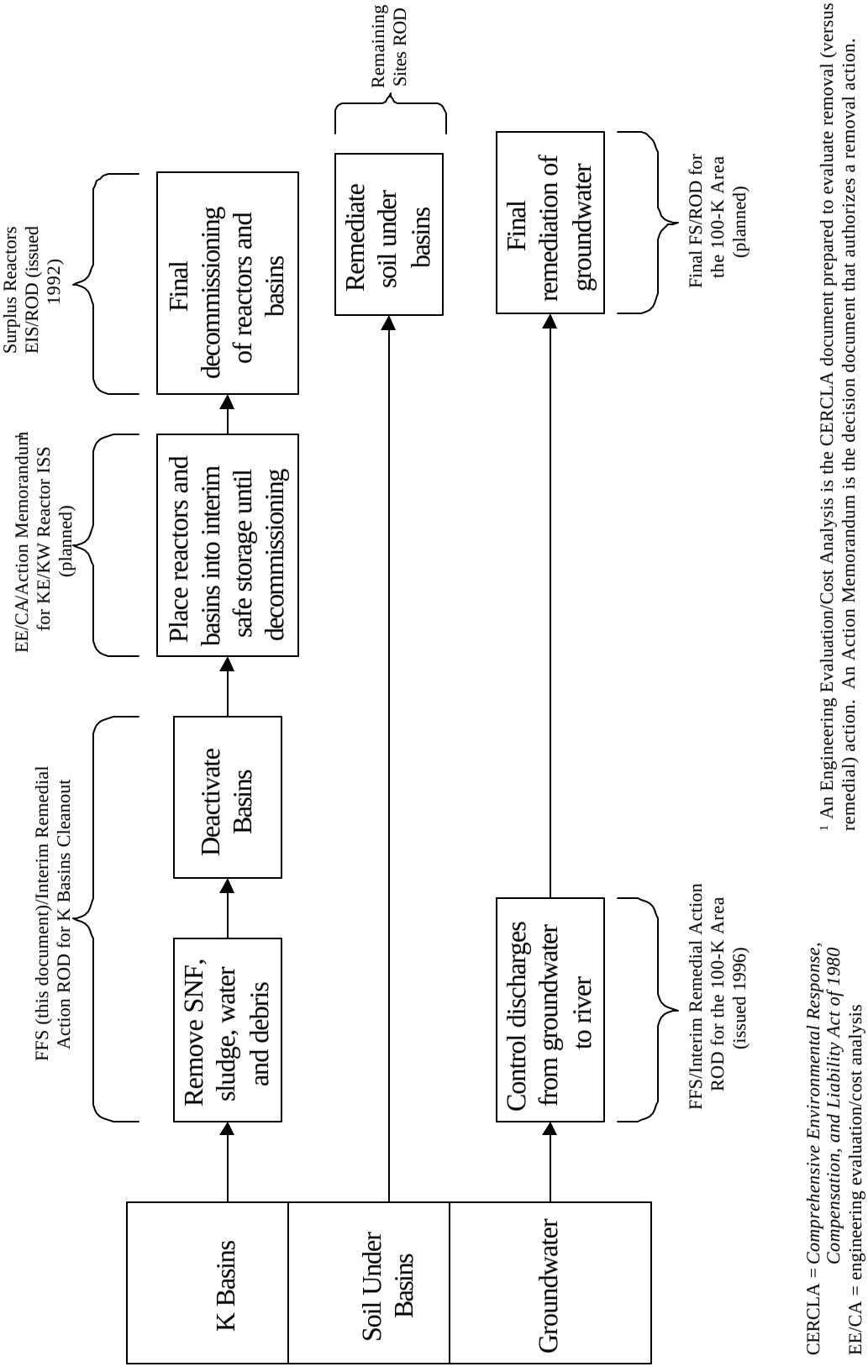


Figure 1-2. Integration of Cleanup in the 100-K Area.



[1] An Engineering Evaluation/Cost Analysis is the CERCLA document prepared to evaluate removal (versus remedial) action. An Action Memorandum is the decision document that authorizes a removal action.

CERCLA = *Comprehensive Environmental Response, Compensation, and Liability Act of 1980*
EE/CA = engineering evaluation/cost analysis
EIS = environmental impact statement
FFS = focused feasibility study
FS = feasibility study
ISS = interim safe storage
ROD = record of decision

2.0 BACKGROUND INFORMATION

2.1 SITE DESCRIPTION

The Hanford Site occupies approximately 1,450 km^2 (560 mi^2) in the Columbia Basin of south central Washington State (Figure 2-1). The Site was selected as the nation's first large-scale nuclear materials production site in January of 1943. It is divided into several operational areas, including the 100 Area, which is located in the north-central part of the Site. The 100 Area contains nine inactive nuclear reactors and associated support facilities and waste sites, which are situated along the southern shore of the Columbia River.

The 100-K Area is one of six reactor areas in the 100 Area. It consists of the KE Reactor, the KW Reactor, and associated support facilities and waste sites (Figure 2-2). The KE and KW Reactors were constructed in the early 1950s and are located about 420 m (1,400 ft) from the Columbia River (DOE 1995). Each reactor building contains an SNF storage basin that originally served as a collection, storage, and transfer facility for the fuel elements discharged from the reactor. The basins are uncovered, unlined, concrete water pools with a capacity of 4.9 million L (1.3 million gal). The SNF is stored in the basins under approximately 5 meters (16 feet) of water. The basins are located inside buildings that are ventilated to the outside. An asphaltic membrane is located beneath each pool. In 1981, after the KW Basin had been in service for about 30 years, the concrete surfaces inside that basin were reconditioned by coating them with an epoxy to keep radioactive elements from being absorbed into the concrete. The KE Basin was not similarly reconditioned. Each basin is divided into three zones: the SNF discharge area, the storage area, and the transfer area. A schematic of the K Basins is shown in Figure 2-3.

The affected environment at the 100-K Area is described in the K Basins EIS (DOE 1995, DOE 1996a). Additional detail can be found in *Hanford Site National Environmental Policy Act (NEPA) Characterization* (Nietzel et al. 1998). In summary, the region in which the Hanford Site is located is characterized as having a semiarid climate with hot summers and mild winters. Public access to the Hanford Site is currently restricted, and land use in the 100 Area consists primarily of DOE cleanup activities such as excavating contaminated waste sites, removing and treating groundwater, and decontamination and decommissioning of facilities, and spent fuel management. The Columbia River adjacent to the 100 Area is accessible to the public and is used for recreational purposes such as boating and sport fishing. The U.S. Department of the Interior has proposed establishing a National Fish and Wildlife Refuge and designating a National Wild and Scenic River along the Hanford Reach of the Columbia River (DOI 1996). Past land use in the 100 Area (prior to federal nuclear activities) includes various Native American uses, irrigated and dry-land farming, livestock grazing, and commercial activities at the old town sites. In the more recent past, members of the Yakama Indian Nation have been authorized access to the 100-K Area for the purpose of raising fish in water basins located near the river, although this activity is currently on hold. Future land use of the 100 Area has not been determined. However, land uses for the next 50 years of Federal occupation are evaluated in a draft EIS that is currently in public review (DOE 1999). Land uses near the Hanford Site include dry and irrigated farming, rural and urban residential use, and commercial activities in the cities and towns. There are no ecological or

cultural resources of significance within the core area around the K Reactors that would be affected by the interim remedial action. Certain buildings in the 100-K Area have been determined to be eligible for listing on the National Register of Historic Places. However, mitigation efforts for these buildings have been completed.

2.2 SITE HISTORY

The KE and KW Reactors operated from the mid-1950s until 1971 and 1970, respectively. SNF discharged from the reactors was stored in the K Basins until it was transferred to the 200 Areas at the Hanford Site for reprocessing. Water in the basins provided both radiation shielding for workers and cooling to remove decay heat until the SNF was transferred. Most of the SNF discharged from the KE and KW Reactors was removed from the basins when the reactors were shut down. The basins subsequently have been used to store N Reactor SNF, starting in 1975 for KE and 1981 for KW. In 1992, the decision was made to deactivate the plant where the SNF was being reprocessed. This left approximately 2,100 metric tons (2,300 tons) of SNF in the K Basins with no means for reprocessing. An estimated one percent of the original mass of this SNF has corroded and become radioactive sludge. The water and debris in the basins are also radioactively contaminated.

The KE Basin leaked up to 56.8 million L (15 million gal) of contaminated water to the soil in the 1970s and another 341,000 L (90,000 gal) in early 1993 (Bergsman et al. 1995). It was suspected that the water was coming from leakage at the construction joints between the foundation of the basin and the foundation of the reactor. To mitigate the consequences of a seismic event, the construction joints in both basins were isolated from the rest of the basin by metal isolation barriers. The previously applied epoxy coating in the KW Basin provides additional protection.

Nuclear fuel is regulated under the AEA. Historically, the K Basins and their contents have been managed in accordance with the AEA with the goal of safely storing the SNF. Activities in the basins have also been subject to regulation under applicable environmental laws and regulations (e.g., regulations governing air emissions). Regulation under the AEA and applicable environmental laws and regulations will continue in the future.

2.3 NATURE AND EXTENT OF CONTAMINATION AND OTHER HAZARDS

The hazardous substances addressed by this interim remedial action are the SNF, sludge, debris, and water present in the KE and KW Basins and surface contamination removed as part of deactivation. They are described in the following subsections. This section does not address the nature and extent of contamination that might be present in underlying soils and groundwater as a result of past releases from the basins. Contamination of the soil and groundwater will be addressed in separate CERCLA documents as described in Section 1.4.

2.3.1 Spent Nuclear Fuel

Approximately 2,100 metric tons (2,300 tons) of SNF are stored in the KE and KW Basins (Praga 1998). (Some of this SNF is currently in the 300 Area for characterization purposes.) Most of the fuel is from the past operation of the N Reactor. In addition, about 160 kg (350 pounds) of SNF removed during the N Basin deactivation will eventually be taken to the K Basins. The SNF consists primarily of metallic uranium, but also includes plutonium and radioactive fission and activation products. The fuel is encased in either an aluminum or Zircaloy cladding.

The KE Basin contains about 1,150 metric tons (1,260 tons) of SNF (Praga 1998), stored underwater in 3,673 open-top canisters. This SNF has been stored for varying lengths of time ranging from 9 to 25 years. Much of the SNF stored in the KE Basin is damaged, and it has been estimated that about one percent of the original mass of the fuel has corroded because of cracks and breaks in the cladding and contributed to the radioactive sludge in that basin (DOE 1995).

The remainder of SNF, approximately 953 metric tons (1,050 tons) (Praga 1998), is stored underwater in the KW Basin in 3,817 closed canisters. Because the SNF was placed in closed containers before storage, corrosion products were retained within the canisters and the volume of sludge accumulated on the floor of the KW Basin is much smaller than in the KE Basin.

2.3.2 Contaminated Sludge

Both the KE and KW Basins contain highly-radioactive sludge that resides on the basin floors, in the basin pits, and in the SNF storage canisters. Sludge will also be generated when additional corrosion product is separated from the SNF as the SNF is washed prior to removing it from the basins. This sludge is referred to as wash sludge. The composition of the sludge is complex and varies depending on the location and the basin.

Sludge on the floor and in the pits of the KE Basin is potentially a mix of the following:

- SNF corrosion products (including metallic uranium, uranium hydrides and oxides, plutonium, fission and activation products, and aluminum and zirconium compounds from the cladding)
- Iron and aluminum oxide from the storage racks and canisters
- Inorganic zeolite ion exchange media and organic ion exchange resin (OIER) beads (Purolite) inadvertently introduced from the water treatment system
- Concrete grit from the basin walls
- Sand and dirt from outside the basins
- Biological debris.

These components are not uniformly distributed throughout the basin. The large quantity of fuel corrosion products in the floor and pit sludge is a result of the open tops, and in some cases open-screened bottoms, of the fuel storage canisters in the KE Basin. Sludge in the KE Basin canisters themselves consists primarily of fuel corrosion products.

There is very little sludge on the floor of the KW Basin, and what there is appears to consist primarily of dust and sediment. The floor sludge is not expected to contain significant amounts of fuel corrosion products because the canisters in the KW Basin have closed tops and bottoms, but there are still low levels of radioactivity in the floor sludge. Only one of the areas in the KW Basin (the North Loadout Pit) contains a significant amount of sludge and this is likely to consist of a mix of sand and fuel corrosion products. Because the canisters in the KW Basin are completely closed, any sludge in them is expected to derive almost exclusively from SNF and consist of fuel corrosion products.

Estimated volumes of sludge are shown in Tables 2-1 and 2-2. The total volume of sludge in the KE and KW Basins combined is estimated to be about 51 m^3 (1,800 ft^3 or 13,000 gallons). While the sludge is in the basins, it is commingled with SNF and is not considered a waste by DOE. When the sludge is separated from the SNF and removed from the basins it will be designated and managed as a waste (Wagoner 1996). For purposes of differentiating sludge from SNF and debris, any material less than or equal to 0.64 cm (0.25 in) in diameter is defined as sludge (Pearce et al. 1998).

Estimated compositions for the K Basins sludge are provided in Tables 2-1 and 2-2 and are taken from tables in Pearce et al. (1998). These compositions are based on three sludge characterization campaigns that have been conducted at the K Basins, one for the KE Basin floor and Weasel Pit, one for the KE Basin canisters, and one for the KW Basin canisters. Where a specific sludge population was not sampled, the composition estimate was based on a similar sludge population that was sampled. The sludge in the KE Tech View Pit and Dummy Pit were assumed to be similar to the sludge in the KE Weasel Pit. The fuel wash sludge was assumed to be similar to the canister sludge. No sludge samples have been collected from the floor or pits in the KW Basin. Sludge at these locations was assumed to be similar in composition to the corresponding locations in the KE Basin.

Based on the characterization data, the waste designation of the sludge would be as follows:

- The sludge will designate as either a transuranic (TRU) waste[4] or a high-level waste (HLW)[5]. A formal designation has not yet been made. For purposes of baseline planning, it has been assumed that the sludge will designate as a TRU waste. However, some fractions of the sludge (the canister sludge and wash sludge) that derive predominantly from corrosion of the SNF might be determined to be HLW. Either designation would

[4]TRU waste is defined as waste that contains more than 100 nCi/g of alpha-emitting TRU isotopes with half-lives greater than 20 years. Transuranic refers to those isotopes with an atomic number greater than 92.

[5] High-level waste is defined as (1) irradiated reactor fuel, (2) liquid wastes resulting from the operation of the first cycle solvent extraction system, or equivalent, in a facility for reprocessing irradiated reactor fuel, and (3) solids into which such liquid wastes have been converted (10 CFR 60.2).

require eventual offsite disposal of the sludge, but the designation would restrict options as described in Section 4.

- The K Basins sludge will designate as a mixed waste. The mixed waste designation is based on total concentrations of cadmium, chromium, and lead, which are included on the toxicity characteristic list (*Washington Administrative Code* [WAC] 173-303-090[8][c]). The sludge has not been analyzed using the Toxicity Characteristic Leaching Procedure (TCLP), so leachable concentrations of these metals are not known. However, making the designation based on total concentrations is conservative.[6]

- The K Basins sludge will be regulated as a polychlorinated biphenyl (PCB) remediation waste[7] under the *Toxic Substances Control Act* (TSCA) based on the detection of PCBs in the KE Basin floor and pit sludge and the KE and KW canister sludge.

In summary, the K Basins sludge will be designated as a TSCA-regulated mixed TRU waste or TSCA-regulated mixed HLW. It is assumed that the sludge from the floor and pits of the KW Basin will be similar in composition to the floor and pit sludge from the KE Basin and, therefore, will have the same waste designation. The KW floor and pit sludge will be managed in a manner similar to the KE floor and pit sludge unless actual samples of the KW sludge demonstrate that an alternate management is appropriate.

The K Basins sludge contains a significant quantity of fuel corrosion products. This is particularly true for the canister and wash sludges. Because of this, concerns that are important in developing sludge treatment alternatives include the following:

- The sludge is highly radioactive, and the surface dose for an unshielded container of sludge is many times higher than the 200-mrem/hr limit for contact-handled waste (FDH 1998). Based on preliminary calculations, the contact dose associated with floor and pit sludge could be as high as 128,000 mrem/hr and the contact dose rate associated with canister and wash sludge could be as high as 1.75 million mrem/hr. Because of this, it is anticipated that containers of treated sludge will need to be managed as a remote-handled[8] waste unless special overpacking is provided.

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[6] The standard process for determining whether a waste is a toxicity characteristic waste involves testing the waste using the TCLP prescribed by the dangerous waste regulations in WAC 173-303, which governs mixed waste designation. The K Basins sludge was not analyzed using the TCLP procedure. However, the sludge was analyzed to determine the total concentrations of constituents in the sludge. The total concentrations will always be greater than the leachable concentrations. Therefore, using the total concentrations to make a mixed waste determination is conservative.

[7] PCB remediation waste means waste containing PCBs as a result of a spill, release, or other unauthorized disposal, at the following concentrations: Materials disposed of prior to April 18, 1978, that are currently at concentrations of $\geq$50 ppm PCBs, regardless of the concentration of the original spill; materials which are currently at any volume or concentration where the original source was $\geq$500 ppm PCB beginning on April 18, 1978, or $\geq$50 ppm PCBs beginning on July 2, 1979; and materials which are currently at any concentration if the PCBs are from a source not authorized for use (40 CFR 761.3).

[8] TRU waste is classified as either contact-handled or remote-handled based on the contact dose rate at the surface of the waste container. If the contact dose rate is less than or equal to 200 millirem per hour, the waste is defined as contact-handled TRU. If the contact dose rate is greater than 200 millirem per hour, the waste and its container are defined as remote-handled TRU. Because of the higher contact dose rate, remote-handled TRU requires special

- The high concentrations of fissile materials (uranium and plutonium) require careful evaluation of criticality control for all activities involving the sludge.

- Metal fines and metal hydrides in the sludge (e.g., uranium, uranium hydride, and zirconium) are potentially pyrophoric, reactive, and capable of generating flammable gas.

During sludge characterization activities, the sludge was sometimes observed to be generating bubbles, presumably of hydrogen gas. This phenomenon was evaluated to determine whether excessive accumulation of flammable gas could occur during sludge retrieval and removal activities. It was determined that the gas did not pose a potential for excessive flammable gas accumulation.

2.3.3 Contaminated Debris

For purposes of this FFS, debris is defined as any solid waste with a size of 0.64 cm (0.25 in.) or greater. The definition excludes SNF and sludge. It includes but is not limited to the following:

- Approximately 7,500 fuel canisters[9]

- Old basin equipment and piping, hand tools, the storage racks used to hold the SNF canisters, construction materials from the basins, and miscellaneous scrap

- Equipment used to remove SNF, sludge, water, and debris from the basins

- Components of the basin water pretreatment system (e.g., spent ion exchange modules containing resin) when they are no longer required for service

- Previously-generated ion exchange columns packaged in burial boxes that currently reside in the 100-K Area

- Components of the sludge treatment system when the system is no longer required for service

- Waste generated during deactivation of the basins such as contaminated equipment and structural materials.

The debris could designate as uncontaminated solid waste, low-level waste (LLW), mixed waste, TRU waste, or mixed TRU waste, depending on the chemical composition of the debris itself and residual sludge attached to the debris. The debris is also regulated as a PCB remediation waste where it has contacted sludge that is a PCB remediation waste. The K Basins annual debris report

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handling and management.

[9]Approximately 2,000 empty canisters that were in the basins were removed in 1998.

states that debris that has contacted sludge (which is regulated under TSCA) in the KE Basin pool is considered a PCB article (DOE-RL 1998a).

2.3.4 Contaminated Water

Each basin contains approximately 4.9 million L (1.3 million gal) of water that is used to shield and cool the SNF. The water is currently maintained in a closed-loop system and is continually recycled from the basins, circulated through existing treatment systems, then returned to the basins. This treatment is required to maintain adequate water quality (e.g., reduce cloudiness) and temperatures in the basins and also functions to reduce concentrations of soluble radionuclides.

The primary contaminants in the water are radionuclides, including tritium at a concentration of about 3 µCi/L in the KE Basin and other soluble or partially soluble nuclides (e.g., Cs-134 and Cs-137). Based on concentrations of chemical constituents, the water is not regulated as a mixed waste. It is regulated as a PCB remediation waste because PCBs have been detected at low concentrations.

2.4 RISK EVALUATION

The contaminants of concern in the K Basins that drive the risk evaluation are primarily radionuclides. Concentrations of radionuclides in the basin water exceed drinking water standards established under the *Safe Drinking Water Act* (SDWA). For example, the maximum concentration level for tritium established under the SDWA is 20,000 pCi/L, compared to basin water concentrations of about 3,000,000 pCi/L. Concentrations of radionuclides in the K Basins sludge (Tables 2-1 and 2-2) are such that unshielded exposure to the sludge would result in a significant radiation dose. Any substantial release of water or sludge from the basins would cause further degradation of the groundwater.

Potential risks to human health and the environment associated with current conditions at the K Basins include the following:

- **Potential for releases.** Past deterioration of construction joints in the KE Basin resulted in large releases of contaminated water to the underlying soil and groundwater, and groundwater contaminant concentrations near the K Basins exceed human health protection criteria. For example, Well 199-K-30, located near the KE Reactor, showed a maximum tritium concentration of 2.36 million pCi/L in 1998 as compared to the drinking water standard of 20,000 pCi/L (Hanford Environmental Information System). Additional information on groundwater monitoring data in the 100-K Area can be found in Johnson et al (1998). The potential for future releases has been mitigated by modification of the construction joints as described in Section 2.1, and there is currently no public use of the groundwater in the 100-K Area or public access to the K Basins. However, deficiencies at both basins continue to present a potential for future leaks.

- **Fuel degradation**. The SNF was not designed for long-term wet storage. However,

some of the SNF has been stored underwater in the basins for more than 20 years. In the KE Basin, damaged fuel cladding surrounding the metallic uranium fuel elements has allowed water to corrode the fuel. The corrosion further damages the fuel, releasing radioactive material to the water and contributing to the buildup of a thick layer of sludge on the basin floor.

- **Basin Design and seismic adequacy**. As the basins continue to age there is a potential for further loss of structural integrity and further releases from the basins to the environment. The K Basins have currently exceeded their 20-year design life by more than 20 years. Because of poor historical maintenance of systems, major problems have been experienced with electrical systems and water distribution and treatment systems. Upgrades are required to ensure occupational safety. The K Basins were designed to consensus codes and standards of the 1950s. Accordingly, the electrical, fire protection, and water systems and the basin structures do not conform to modern design standards and the basins do not provide confinement of radioactive materials (airborne or liquid). In addition, the basins were not designed to modern seismic criteria. Seismic isolation barriers have been installed to isolate the discharge chute area from the main basin at both the KE and KW Basins. In the event of a seismic event, the barriers will limit basin water leakage to the soil through the construction joints where it is assumed previous leakage has occurred. However, analyses indicate that other areas of the basin structure could fail during a seismic event and allow large volumes of water to leak to the soil. Failure to maintain a sufficient amount of water to cool the SNF and sludge and provide shielding for workers would allow the SNF and sludge to dry and heat, resulting in an airborne release of radionuclides.

- **Location.** The K Basins are located approximately 430 m (1,400 ft) from the Columbia River. The proximity of the basins to the river increases the likelihood that the river would become contaminated as a result of a leak from the basins and migration to the soil and groundwater.

- **Occupational exposure.** The lack of confinement for the corroding fuel in the KE Basin has resulted in higher than desired radiation exposure to workers during routine and non-routine activities. Dose reduction activities are underway at the basin. These activities are designed to improve overall occupational safety at the K Basins but are not expected to achieve current standards for occupational exposure for prolonged storage at the K Basins.

DOE believes the potential for a near-term release is small, but the K Basins are continuing to age and are already considered substandard by current codes. A major natural event (e.g., seismic event) could release most or all of the basin water and potentially some of the basin sludge to the subsurface environment, where it would be available for leaching to groundwater and transport to the Columbia River. Specific accident scenarios for continued storage of basin hazardous substances were evaluated for the no action alternative in the K Basins EIS (DOE 1995). The potential risk to the environment combined with the continued occupational risk to workers justifies the interim remedial action.

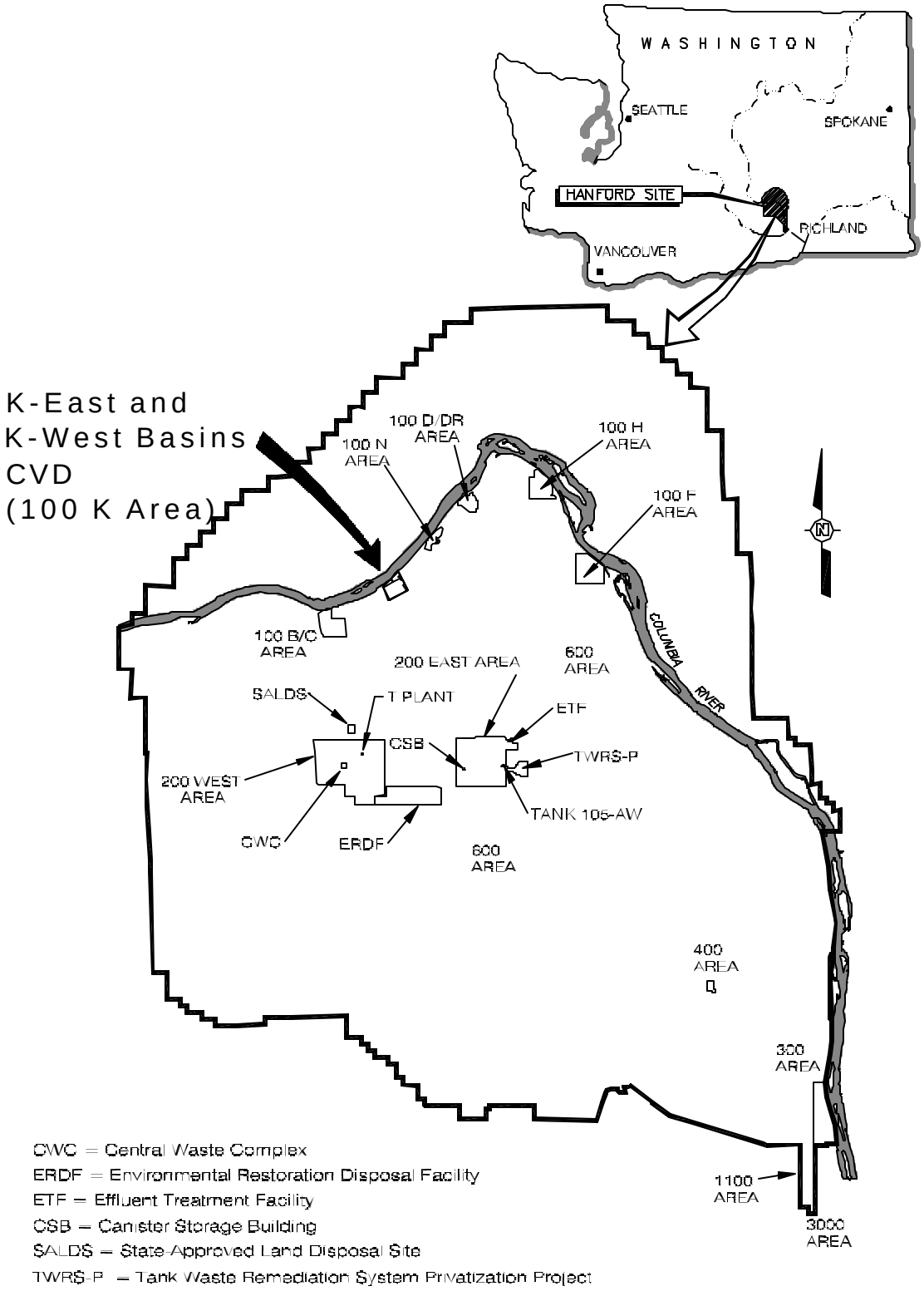
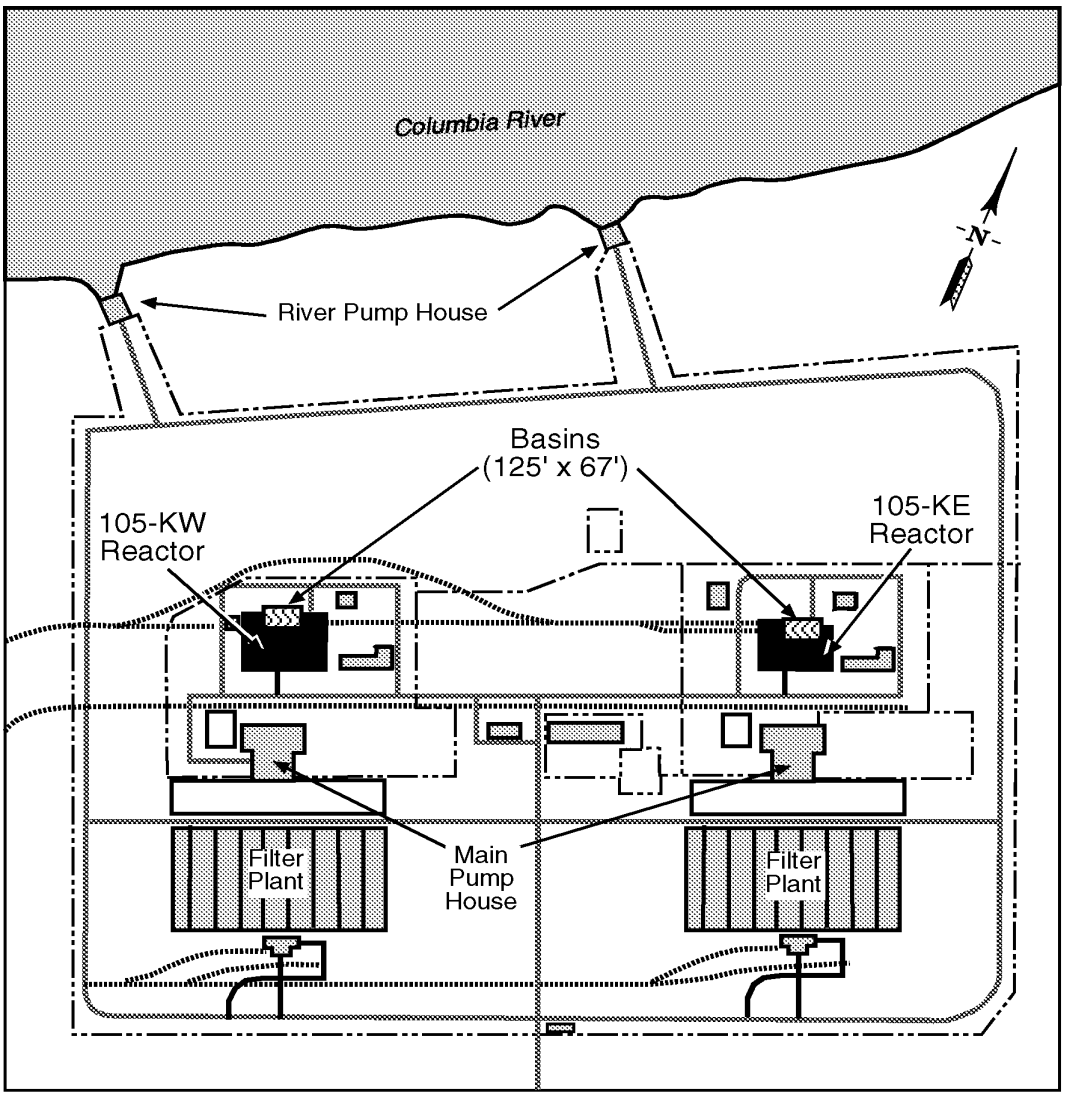

WASHINGTON
SEATTLE
SPOKANE
HANFORD SITE
RICHLAND
VANCOUVER
K-East and
K-West Basins
CVD
(100 K Area)
100 D/DR
AREA
100 N
AREA
100 H
AREA
100 F
AREA
100 B/C
AREA
200 EAST AREA
600
AREA
SALDS
T PLANT
ETF
CSB
TWRS-P
200 WEST
AREA
TANK 105-AW
CWC
ERDF
600
AREA
400
AREA
300
AREA
1100
AREA
3000
AREA
COLUMBIA
RIVER
N
CWC = Central Waste Complex
ERDF = Environmental Restoration Disposal Facility
ETF = Effluent Treatment Facility
CSB = Canister Storage Building
SALDS = State-Approved Land Disposal Site
TWRS-P = Tank Waste Remediation System Privatization Project

Figure 2-2. 100-K Area Site Plan.



SG95100088.16

Note:

K-Basin (125' x 67')

Fenceline

Roads

Railroad Tracks

0 500 Scale in Feet

0 100 Scale in Meters

Figure 2-3. Schematic of KE and KW Basins.

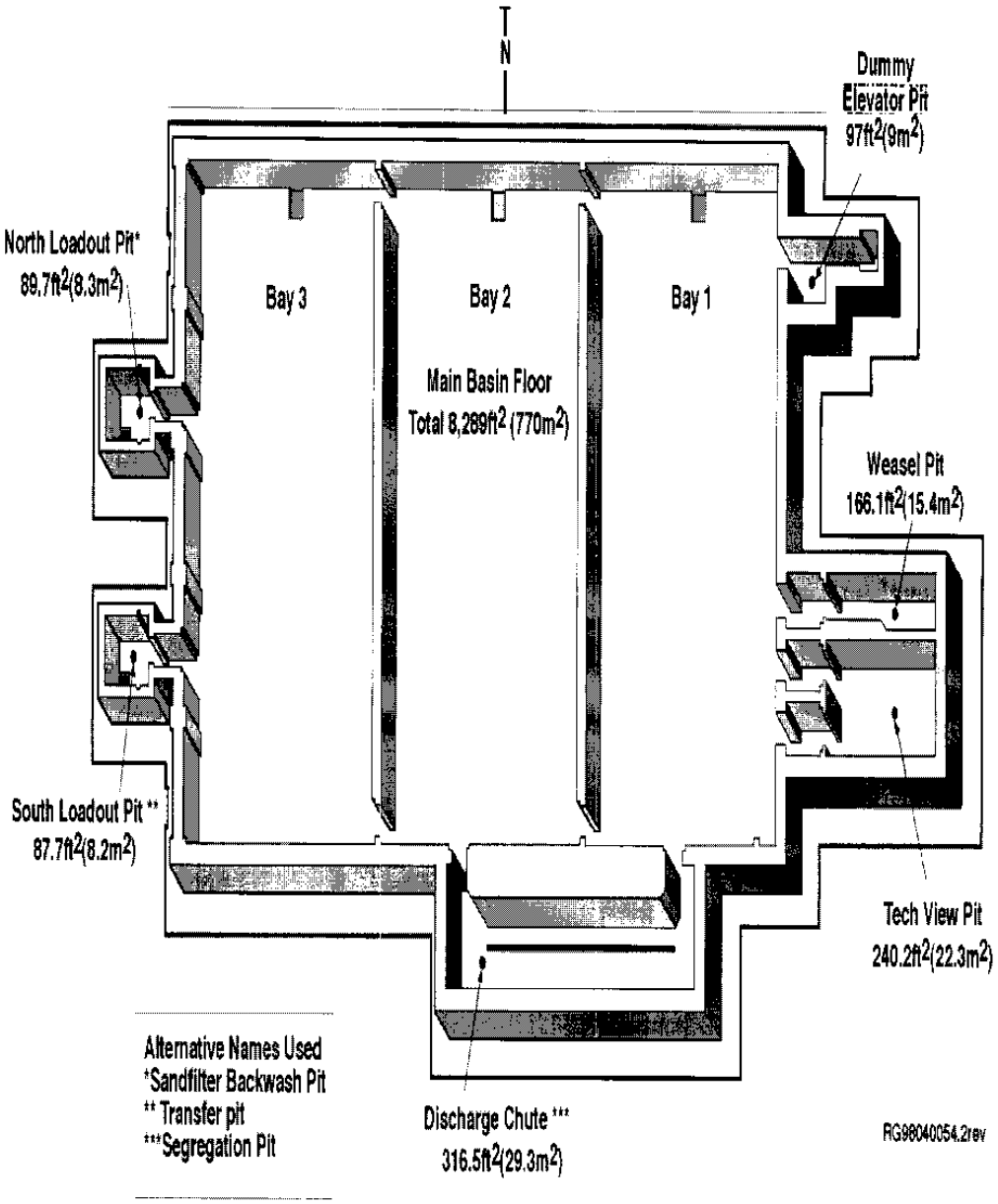


Table 2-1. Estimated Inventory for KE Basin Sludge Locations. (3 sheets) (from Pearce et al. 1998)

		Source -- K East						
	Units	**Weasel Pit**	**Main Basin Floor**	**Tech View**	**North Loadout Pit**	**Dummy Elevator Pit**	**Canisters Full**	**Canisters Empty**
As-settled Sludge **Solid Content** (g dry solids/cm3 as-settled sludge)	g/cm^3	0.931	0.375	0.931	0.370	0.931	0.884	0.884
As-settled Sludge **Density**	g/cm^3	1.56	1.32	1.56	1.27	1.56	1.62	1.62
Volume of Sludge	m^3	10.10	21.50	0.40	6.30	1.40	3.00	0.40
As-settled Sludge Composition Chemical								
U	g/cm^3	0.000554	0.000336	0.000554	0.000133	0.000554	0.023489	0.023489
UO_2	g/cm^3	0.031127	0.018880	0.031127	0.007471	0.031127	0.239820	0.239820
U_3O_7	g/cm^3	0.031741	0.019253	0.031741	0.007619	0.031741	0.244557	0.244557
UO_4 $C4H_2O$	g/cm^3	0	0	0	0	0	0	0
UH_3	g/cm^3	0	0	0	0	0	0.023785	0.023785
$Al(OH)_3$	g/cm^3	0	0	0	0	0	0.170042	0.170042
Al_2O_3	g/cm^3	0.062895	0.041372	0.062895	0.014103	0.062895	0	0
FeO(OH)	g/cm^3	0.403050	0.128683	0.403050	0.037761	0.403050	0.109399	0.109399
SiO_2	g/cm^3	0.235325	0.073942	0.235325	0.297060	0.235325	0.039261	0.039261
CaO	g/cm^3	0.015968	0.003087	0.015968	0.003699	0.015968	0.001624	0.001624
CO_2	g/cm^3	0.007600	0.004923	0.007600	0	0.007600	0.007565	0.007565
C	g/cm^3	-	0.001107	-	0	-	0.002339	0.002339
Sum of Other Compounds	g/cm^3	0.080532	0.026479	0.080532	0.001955	0.080532	0.010330	0.010330
Miscellaneous solids								
PCB	g/cm^3	0.000225	0.000083	0.000225	0	0.000225	0.0000018	0.0000018
OIER	g/cm^3	0	0.056651	0	0	0	0.010235	0.010235
Zeolite	g/cm^3	0.062079	0	0.062079	0	0.062079	0	0
Zircalloy 2	g/cm^3	0	0	0	0	0	0	0
Grafoil [1]	g/cm^3	0	0	0	0	0	0	0
Dry solid - radionuclide content								
^{238}Pu and $^{239/240}Pu$	g/cm^3	0.000076	0.000102	0.000076	0.000060	0.000076	0.001536	0.001536
^{238}Pu and $^{239/240}Pu$	µCi/g	5.37	19.88	5.37	10.05	5.37	108.70	108.70
^{241}Am	µCi/g	8.17	28.11	8.17	7.27	8.17	138.34	138.34
^{137}Cs	µCi/g	293.54	310.24	293.54	37.84	293.54	806.35	806.35
$^{89/90}Sr$	µCi/g	223.55	302.20	223.55	0	223.55	1053.40	1053.40
Uranium composition								
U	kg	559.83	722.84	22.17	83.87	77.60	1408.97	187.86
^{233}U	mass%	-	-	-	0.00000	-	0.00050	0.00050
^{234}U	mass%	0.00697	0.00587	0.00697	0.00685	0.00697	0.00836	0.00836
^{235}U	mass%	0.69730	0.57976	0.69730	0.70079	0.69730	0.66250	0.66250
^{236}U	mass%	0.07477	0.05735	0.07477	0.07586	0.07477	0.06864	0.06864

Table 2-1. Estimated Inventory for KE Basin Sludge Locations. (3 sheets) (from Pearce et al. 1998)

		Source -- K East						
	Units	**Weasel Pit**	**Main Basin Floor**	**Tech View**	**North Loadout Pit**	**Dummy Elevator Pit**	**Canisters Full**	**Canisters Empty**
^{238}U	mass%	99.22096	99.35702	99.22096	99.21790	99.22096	99.26036	99.26036
	Units	**Fuel Wash – Internal Sludge**	**Fuel Wash -- Coating**	**Fuel Wash -- Fuel Pieces**		**Totals**		
As-settled Sludge **Solid Content** (g dry solids/cm3 as-settled sludge)	g/cm^3	2.312	0.969	10.611				
As-settled Sludge **Density**	g/cm^3	3.00	1.50	11.02				
Volume of Sludge	m^3	0.518	0.061	0.149		43.83	m^3	
As-settled Sludge Chemical Composition								
U	g/cm^3	-		9.828354		1,558.9	Kg	
UO_2	g/cm^3	1.734693	-	-		2,537.3	Kg	
U_3O_7	g/cm^3	-	-	-		1,671.1	Kg	
UO_4 $C4H_2O$	g/cm^3	-	0.673135	-		41.1	kg	
UH_3	g/cm^3	0.172178	-	-		170.1	kg	
$Al(OH)_3$	g/cm^3	0.02539	0.213762	-		604.3	kg	
Al_2O_3	g/cm^3	-	-	-		1,726.8	kg	
FeO(OH)	g/cm^3	0.004348	0.028622	-		8,176.8	kg	
SiO_2	g/cm^3	0.348580	-	-		6,575.7	kg	
CaO	g/cm^3	-	0.014884	-		286.1	kg	
CO_2	g/cm^3	-	-	-		222.0	kg	
C	g/cm^3	-	-	-		31.8	kg	
Sum of Other Compounds	g/cm^3	0.017895	0.036809	0.056162		1,595.0	kg	
Miscellaneous solids								
PCB [2]	g/cm^3					4.5	kg	
OIER	g/cm^3					1,252.8	kg	
Zeolite	g/cm^3					738.7	kg	
Zircalloy 2	g/cm^3			0.692665		103.2	kg	
Grafoil	g/cm^3					-		
	Units	**Fuel Wash – Internal Sludge**	**Fuel Wash -- Coating**	**Fuel Wash -- Fuel Pieces**		**Totals**		
Dry solid - radionuclide content								
^{238}Pu and $^{239/240}Pu$	g/cm^3	0.008681	0.001794	0.033569		18.3	kg	
^{238}Pu and $^{239/240}Pu$	µCi/g	232.67	114.50	195.91				
^{241}Am	µCi/g	210.50	93.40	168.01				
^{137}Cs	µCi/g	3443.33	1,410.00	5342.20				
$^{89/90}Sr$	µCi/g	3851.61	1,767.75	4045.39				
Uranium composition								
U	kg	880.43	26.14	1464.42		5434.1	kg	
^{233}U	mass%	0.00000	0.00000	0.00000				
^{234}U	mass%	0.00726	0.00694	0.0065				

Table 2-1. Estimated Inventory for KE Basin Sludge Locations. (3 sheets) (from Pearce et al. 1998)

		Source -- K East						
	Units	**Fuel Wash – Internal Sludge**	**Fuel Wash -- Coating**	**Fuel Wash -- Fuel Pieces**		**Totals**		
^{235}U	mass%	0.764	0.682	0.719				
^{236}U	mass%	0.0859	0.086	0.090				
^{238}U	mass%	99.14	99.23	99.19				

[1] Grafoil is a carbon-based material used to seal canister lids in the KW Basin.

[2] To convert PCB concentrations from g/cm^3 to ppm divide the PCB concentration (in g/cm^3) by the density (in g/cm^3) and multiply by one million.

Values shown in this table are approximate; the high precision implied by the number of significant figures was required to permit consistent preparation of design and data sheets.

PCB = polychlorinated biphenyl

OIER = organic ion exchange resin

Table 2-2. Estimated Inventory for KW Basin Sludge Locations. (2 Sheets) (From Pearce et al. 1998)

		Source -- K-West						
	Units	Weasel Pit	Main Basin Floor	Discharge Chute	Tech View	North Loadout Pit	Dummy Elevator Pit	Canisters Full
As-settled Sludge **Solid Content** (g dry solids/cm3 as-settled sludge)	g/cm^3	0.869	0.318	0.869	0.869	0.370	0.869	2.053
As-settled Sludge **Density**	g/cm^3	1.56	1.32	1.56	1.56	1.27	1.56	2.68
Volume of Sludge	m^3	0.03	0.82	0.06	0.07	3.65	0.04	1.01
As-settled Sludge Chemical Composition								
U	g/cm^3	0.000554	0.000336	0.000554	0.000554	0.000133	0.000554	0.066167
UO_2	g/cm^3	0.031127	0.018880	0.031127	0.031127	0.007471	0.031127	0.675574
U_3O_7	g/cm^3	0.031741	0.019253	0.031741	0.031741	0.007619	0.031741	0.688918
$UO_4 \bullet 4H_2O$	g/cm^3	0	0	0	0	0	0	0
UH_3	g/cm^3	0	0	0	0	0	0	0.067001
$Al(OH)_3$	g/cm^3	0	0	0	0	0	0	0.117661
Al_2O_3	g/cm^3	0.062895	0.041372	0.062895	0.062895	0.014103	0.062895	0
FeO(OH)	g/cm^3	0.403050	0.128683	0.403050	0.403050	0.037761	0.403050	0.209042
SiO_2	g/cm^3	0.235325	0.073942	0.235325	0.235325	0.297060	0.235325	0
CaO	g/cm^3	0.015968	0.003087	0.015968	0.015968	0.003699	0.015968	-
CO_2	g/cm^3	0.007600	0.004923	0.007600	0.007600	0	0.007600	0.002910
C	g/cm^3	-	0.001107	-	-	0	-	0.002934
Sum of Other Compounds	g/cm^3	0.080532	0.026479	0.080532	0.080532	0.001955	0.080532	0.161471
Miscellaneous solids								
PCB	g/cm^3	0	0	0	0	0	0	0.000015
OIER	g/cm^3	0	0	0	0	0	0	0
Zeolite	g/cm^3	0	0	0	0	0	0	0
Zircalloy 2	g/cm^3	0	0	0	0	0	0	0
Grafoil	g/cm^3	0	0	0	0	0	0	0.055248
Dry solid - radionuclide content								
^{238}Pu and $^{239/240}Pu$	g/cm^3	0.000076	0.000102	0.000076	0.000076	0.000060	0.000076	0.005648
^{238}Pu and $^{239/240}Pu$	µCi/g	5.37	19.88	5.37	5.37	10.05	5.37	175.03
^{241}Am	µCi/g	8.17	28.11	8.17	8.17	7.27	8.17	136.66
^{137}Cs	µCi/g	293.54	310.24	293.54	293.54	37.84	293.54	1898.75
$^{89/90}Sr$	µCi/g	223.55	302.20	223.55	223.55	0	223.55	3096.25
Uranium composition								
U	kg	1.66	27.57	3.33	3.88	48.59	2.22	1,329.96
^{233}U	mass%	-	-	-	-	0.00000	-	0.00000
^{234}U	mass%	0.00697	0.00587	0.00697	0.00697	0.00685	0.00697	0.00451
^{235}U	mass%	0.69730	0.57976	0.69730	0.69730	0.70079	0.69730	0.80023
^{236}U	mass%	0.07477	0.05735	0.07477	0.07477	0.07586	0.07477	0.09443
^{238}U	mass%	99.22096	99.35702	99.22096	99.21999	99.21790	99.21999	99.15356

Table 2-2. Estimated Inventory for KW Basin Sludge Locations. (2 Sheets) (From Pearce et al. 1998)

	Units	Fuel Wash -- Internal Sludge	Fuel Wash – Coating	Fuel Wash -- Fuel Pieces		Totals	
As-settled Sludge **Solid Content** (g dry solids/cm3 as-settled sludge)	g/cm^3	2.310	0.970	10.612			
As-settled Sludge **Density**	g/cm^3	3.00	1.50	11.02			
Volume of Sludge	m^3	0.518	0.405	0.149		6.75	m^3
As-settled Sludge Chemical Composition							
U	g/cm^3	-	-	9.828354		1,531.8	kg
UO_2	g/cm^3	1.718239	-	-		1,618.0	kg
U_3O_7	g/cm^3	-	-	-		742.3	kg
$UO_4 \bullet 4H_2O$	g/cm^3	-	0.022194	-		9.0	kg
UH_3	g/cm^3	0.170544	-	-		155.7	kg
$Al(OH)_3$	g/cm^3	0.129080	0.544151	-		405.5	kg
Al_2O_3	g/cm^3	-	-	-		98.0	kg
FeO(OH)	g/cm^3	0.004031	0.306839	-		660.4	kg
SiO_2	g/cm^3	0.194161	0.028835	-		1,300.3	kg
CaO	g/cm^3	-	0.004574	-		21.1	kg
CO_2	g/cm^3	-	-	-		8.5	kg
C	g/cm^3	-	-	-		3.9	kg
Sum of Other Compounds	g/cm^3	0.087033	0.063777	0.056162		290.4	kg
Miscellaneous solids							
PCB	g/cm^3					0.015	kg
OIER	g/cm^3					-	
Zeolite	g/cm^3					-	
Zircalloy 2	g/cm^3			0.692665		103.2	kg
Grafoil	g/cm^3					55.5	kg
Dry solid - radionuclide content							
^{238}Pu and $^{239/240}Pu$	g/cm^3	0.006865	0.000073	0.034805		14.8	kg
^{238}Pu and $^{239/240}Pu$	µCi/g	184.00	4.62	203.12			
^{241}Am	µCi/g	148.00	4.38	165.58			
^{137}Cs	µCi/g	2210.00	57.70	6505.54			
$^{89/90}Sr$	µCi/g	2116.08	92.90	5065.27			
Uranium composition							
U	kg	872.08	5.72	1464.42		3,759.4	kg
^{233}U	mass%	0.00000	0.00000	0.00000			
^{234}U	mass%	0.00594	0.00901	0.00690			
^{235}U	mass%	0.67100	0.90860	0.78000			
^{236}U	mass%	0.08870	0.09256	0.09900			
^{238}U	mass%	99.24000	98.98856	99.11000			

Values shown in this table are approximate; the high precision implied by the number of significant figures was required to permit consistent preparation of design and data sheets.

PCB = polychlorinated biphenyl

OIER = organic ion exchange resin

3.0 REMEDIAL ACTION OBJECTIVES

RAOs are based on the nature and extent of contamination, the associated risk, and compliance with federal and State of Washington applicable or relevant and appropriate requirements (ARARs). The nature and extent of the contamination and the potential risk associated with hazardous substances at the K Basins were presented in Section 2. A discussion and comprehensive list of ARARs is provided in Appendix B. Key ARARs for the K Basin cleanout include standards related to how wastes removed from the basins must be managed (i.e., stored, treated, and disposed) or that define constraints for the sludge treatment process design (e.g., air emissions limits).

The overall purpose of this action is to control a potential source of environmental contamination by removing the SNF, debris, sludge, and water from the K Basins and transferring them to facilities that will manage them in a manner that protects human health and the environment. The scope of this action does not include final disposition of the basin structures themselves or remediation of the underlying soil or groundwater. Disposition of the basins, contaminated soil, and groundwater has been or will be addressed under other CERCLA actions as described in Section 1.4.

The RAOs are as follows:

- Reduce the potential for future releases of hazardous substances from the K Basins to the environment
    - Remove hazardous substances from near the Columbia River
    - Provide pathway for safe treatment, storage, and final disposal of the SNF, sludge, water, and debris removed from the K Basins
    - Prevent further deterioration of the SNF
- Reduce occupational radiation exposure to workers at the basins.

4.0 IDENTIFICATION AND SCREENING OF TECHNOLOGIES AND PROCESS OPTIONS

CERCLA guidance identifies a range of general response actions that includes no action, institutional controls, containment, in-situ treatment, ex situ treatment, and removal. As described in Section 1.1, this interim remedial action and FFS adopt the alternative for removal of the SNF, sludge, water, and debris from the basins; management of the SNF, water, and debris; and deactivation selected in the K Basins EIS and ROD. Therefore, response actions for the removal activities, SNF, water, and debris management, and deactivation are not identified and new alternatives for these activities are not developed as part of this FFS.

However, the K Basins EIS and ROD did not evaluate alternatives for sludge treatment. Thus, this FFS focuses on the evaluation of alternatives for treating the K Basins sludge. With respect to the sludge, the only response actions that would meet the RAOs are removal and ex situ treatment. Removal is required because institutional controls would not mitigate the potential for an environmental release from the basins and the poor condition of the basins and difficulty associated with upgrades effectively precludes containment or in situ treatment. Removal without ex situ treatment would not meet the RAO of providing for safe treatment, storage, and/or disposal of the sludge.

Several studies have been conducted previously to evaluate options for treating and dispositioning the sludge. This section summarizes the results of those studies and uses them to define remedial alternatives for further analysis. Section 4.1 addresses storage of the sludge and Section 4.2 addresses final disposition. Potential storage and disposal locations are described first because they tend to define treatment needs. Section 4.3 addresses options for treatment.

4.1 SLUDGE STORAGE

The proposed *Hanford Federal Facility Agreement and Consent Order* (Tri-Party Agreement) milestone date to begin sludge removal is July 31, 2004. It is not anticipated that there will be any facilities available at the Hanford Site or off-site capable of receiving the K Basins sludge for final disposal by that date. Therefore, it is necessary to provide for interim storage of the sludge after it is removed from the K Basin. The preferred alternative in the final K Basins EIS (DOE 1996a) identified existing DST in the Hanford 200 Area as the interim storage location for sludge removed from the K Basins. The K Basins ROD (61 FR 10736) clarified that if it were not possible to place the sludge into the tanks, the sludge would be stored and disposed as a solid waste or continue to be managed as SNF. DOE subsequently determined that the sludge would be managed as a waste rather than as SNF when it is removed from the basins (Wagoner 1996).

A value engineering study was conducted in 1996 for the purpose of evaluating interim storage options for the K Basins sludge (ARES 1996). More than 50 interim storage options were identified, including various options for DST storage and solid waste storage. The study then narrowed the list to the six most feasible options. These options are listed in Table 4-1, along

with key advantages and disadvantages. Storage of the sludge in an existing DST was the recommended option. Based in part on the ARES study, the current SNF Project baseline is to store the K Basins sludge in an existing DST, identified in the project baseline as Tank 241-AW-105 (Tank 105-AW). The contents of this tank ultimately will be separated into high-level and low-activity waste streams for vitrification. Other interim storage options considered since the ARES study was completed are also listed in Table 4-1.

Safety issues are the primary concern for interim storage of K Basins sludge in Tank 105-AW. These issues include nuclear criticality prevention; metal fines (potential pyrophoricity and reactivity issues); and flammable gas generation, accumulation, and sudden release (Daling et al. 1997). Additional concerns include corrosivity, retrievability, and the presence of *Resource Conservation and Recovery Act of 1976*- (RCRA) and TSCA-regulated wastes. Acceptance criteria for storing the sludge in Tank 105-AW are listed in Table 4-2. Because some of the waste in Tank 105-AW will ultimately be vitrified, the acceptance criteria for the vitrification facility are also important. Preliminary acceptance criteria for the HLW vitrification facility are provided in Table 4-3.

Methods of preventing a nuclear criticality include using neutron absorbers or storing the sludge in tanks that are geometrically favorable for criticality prevention. Daling and Vail (1997) evaluated the use of neutron absorbers and identified two options for achieving criticality control:

- A co-precipitated solid having the absorber bound in the crystal structure with the fissile material

- A physical mixture of absorber and sludge in which the particle size is small enough that the particles of fissile material and neutron absorber remain intermingled.

The chemical co-precipitation option could be achieved by dissolving the uranium-bearing K Basins sludge in acid, adding a neutron absorber (ferric nitrate was recommended), and reprecipitating the solution through caustic addition. The physical mixture option would involve reducing the maximum particle size of the sludge to meet a particle size limit to be set somewhere in the range of 10 to 50 microns and blending it with ferric oxide particles meeting the same maximum particle size limit.

The pyrophoricity. reactivity, and potential for corrosion associated with metal fines in the sludge (specifically, uranium and zirconium) can be addressed by oxidizing or removing the metal. The acid dissolution process used to co-precipitate neutron absorber would oxidize uranium, but would not be aggressive enough to oxidize zirconium. Other processes for chemical oxidation are available, including enhanced oxidation with water under certain conditions. Thermal treatment (i.e., heating the sludge to high temperatures in air) can also be used to oxidize metals.

Flammable gas is generated both by corrosion of metal fines and by radiolysis of water in the sludge. Oxidizing the metals can reduce the production of flammable gas. Limiting the volume and density of the sludge as stored in a DST can mitigate excessive accumulation of flammable gas in the sludge that can result in a sudden release. It has been calculated that 100,000 gallons of

K Basins sludge could be added to Tank 105-AW without causing excessive gas retention (Carothers 1997). Drying the sludge can reduce radiolytic gas generation, although drying would not be appropriate for tank storage.

Subsequent to the ARES study, further consideration has been given to other storage options, in particular storage in a new tank or as a solid waste. A new tank for the sole purpose of storing K Basins sludge would not necessarily be cost effective. However, if evaluation of the need for additional tanks within the Tank Waste Remediation System (TWRS) program indicates that additional tank capacity is required, it could be advantageous to include consideration of the K Basins sludge in the design of new tanks. For example, a new tank could be designed and constructed to be geometrically favorable for criticality prevention; otherwise, criticality prevention likely would be provided in much the same manner as in an existing DST. The primary difference between using an existing DST and a new tank would be that an existing tank would have some fissile material in it that would have to be accounted for in calculating limits for criticality prevention. A new tank could also be provided with mixing systems and ventilation systems that could mitigate flammable gas concerns and provide greater flexibility on particle size, for example, if in-tank mixing were to be provided.
The K Basins sludge could also be packaged in containers and stored as a solid waste at the Hanford Central Waste Complex (CWC) in the 200 Area. The CWC is authorized to store mixed waste and has specific areas for storage of TSCA-regulated TRU waste. Key acceptance criteria at the CWC are provided in Table 4-2. Criticality control for solid waste is relatively simple (although potentially expensive) and can be achieved by a combination of geometrically favorable containers and limiting the quantity of sludge in individual containers. However, high radioactivity levels such as those associated with the K Basins sludge would present other concerns with storage as a solid. Containers with relatively large quantities of sludge would have high surface dose rates and would require either remote handling. Remote-handled storage capacity at the CWC is limited. Smaller quantities of sludge could be placed into containers with substantial overpacking to achieve contact-handled dose rates, but this would generate a larger number of containers, again with the potential for capacity issues. Capacity limitations at the CWC and the potential need to expand CWC would have to be considered as part of any solid waste storage option.

Another sludge storage alternative that has been proposed is storage in a new or existing tank at the T Plant or storage in containers at the T Plant. The T Plant is a former reprocessing facility that currently serves as a decontamination facility for large equipment. Acceptance criteria for T Plant storage have not been developed. Tank storage criteria would likely include requirements for control of criticality, reactivity, and flammability. Container storage criteria would likely be similar to container storage criteria at CWC.

Sludge stored at the CWC or the T Plant could eventually be dispositioned either individually or with other Hanford wastes.

4.2 SLUDGE DISPOSAL

The K Basins ROD (61 FR 10736) did not specify how sludge in interim storage would ultimately be disposed, although there was an underlying assumption that if the sludge were to be stored in a DST, it would be treated and disposed with the tank waste. In any case, disposal options for the sludge are limited mainly because of the waste designation and radioactivity. Waste acceptance criteria for various disposal facilities are listed in Table 4-3. Disposal options are listed and evaluated in Table 4-4. The disposal options are essentially driven by the waste acceptance criteria associated with each disposal facility.

For final disposal of the K Basins sludge, the distinguishing features of disposal options are a disposal facility's ability to accept TRU waste or HLW. It has not been determined which designation will apply to the treated K Basins sludge. Neither TRU waste nor HLW can be disposed at the Hanford Site. Waste that is TRU can be disposed of at the Waste Isolation Pilot Plant (WIPP) in New Mexico as authorized under the *Waste Isolation Pilot Plant Land Withdrawal Act* (Public Law 102-579). Under some circumstances, such as high activity levels, TRU waste might also be disposed at the planned national geologic repository. The WIPP is a RCRA-permitted facility. The *Land Withdrawal Act Amendment* (Public Law 104-201) states that RCRA land disposal restrictions do not apply to waste disposed at the WIPP. The WIPP currently is not a TSCA-permitted landfill. However, from a regulatory standpoint, the TSCA PCB Disposal Amendments allow bulk PCB remediation waste (like the sludge) to be disposed at a RCRA-permitted (or State of Washington equivalent) landfill (40 CFR 761.61). The WIPP waste acceptance criteria currently limit PCB concentrations to less than 50 ppm (DOE 1996b), although this criterion is expected to be eliminated as a result of passage of the TSCA PCB Disposal Amendments. The WIPP cannot accept HLW for disposal.

The national geologic repository is intended primarily for the disposal of SNF and HLW. At this time, it is anticipated that the national geologic repository will not be a RCRA-permitted facility. Mixed waste must be treated to remove hazardous waste characteristics (and delisted, if appropriate) prior to repository disposal (TRW 1996). It is further anticipated that the national geologic repository will not seek approval as a TSCA-approved landfill.

Although disposal of the sludge at Hanford Site facilities is prohibited if it is TRU waste or HLW, acceptance criteria for selected Hanford facilities are provided because they may be considered for disposal of non-TRU wastes generated during sludge treatment. For example, the ERDF is a CERCLA-authorized facility that can accept mixed LLW and certain types of PCB-contaminated waste.

4.3 SLUDGE TREATMENT

Treatment technologies and process options focus on preparing the sludge to meet acceptance criteria for the various storage/disposal options discussed in Sections 4.1 and 4.2. The treatment options address the following issues: nuclear criticality, corrosivity, flammable gas generation, pyrophoricity, particle size for retrievability, and PCBs.

Many treatment technologies and process options for the K Basins sludge have been considered in previous Hanford studies (Beary et al. 1995, Papp 1997, Ashworth and Flament 1998, Precechtel and Turnbaugh 1998) and are summarized in Table 4-5. The table also identifies treatment options that have been identified from other sources. Process options are grouped into the categories of physical, thermal, chemical, and solidification treatment technologies.

As discussed in Section 4.1, nuclear criticality prevention, metal fines, and flammable gas generation, accumulation, and sudden release are the overriding concerns for tank storage of the sludge. Processing options to address these issues include the following:

- Criticality: chemically dissolving the fissile material in the sludge and coprecipitating with a neutron absorber, or blending the sludge with a neutron absorber and reducing the particle size of the mixture to such a size (10 to 50 microns) that separation of the particles becomes physically impossible.

- Metal fines: chemical or thermal oxidation, high-energy milling (water oxidation enhanced by particle size reduction), and solidification.

- Flammable gas: oxidation of metal fines, moisture reduction, minimization of solids volume and density.

A treatment system designed to address criticality, metal fines, and flammable gas might also address the issues of corrosivity, OIER, and PCBs. If it does not, additional treatment processes can be added to the system, as appropriate. Corrosivity can be addressed by chemical adjustment of the sludge. The OIER can be addressed via physical separation, (e.g., sieving), thermal treatment to pyrolize or oxidize the OIER, or stabilization (e.g., grouting). Process options that would remove PCBs from the sludge include low- and high-temperature desorption/volatilization, solvent extraction, mechanochemical reaction (e.g., addition of an oxider to a high-energy mill), or high temperature thermal oxidation or pyrolysis.

At least three offsite facilities capable of treating some TSCA-regulated radioactive waste are currently available or are planned to be available in the DOE complex at the time sludge is removed from the basins:

- A LLW TSCA-permitted treatment unit is planned as part of the privately-operated Allied Technology Group mixed waste treatment facility to be constructed in Richland, Washington, near the Hanford Site. The facility is expected to be operational within several years. The facility is not designed for treating high-activity TRU waste. Thus, it could not treat sludge directly. However, it may be of value for treating secondary wastes associated with sludge treatment or other basin cleanout activities.

- A TSCA-permitted facility for treating PCB-contaminated contact-handled TRU waste is proposed as part of the Advanced Mixed Waste Treatment Facility at the Idaho National Engineering Laboratory in Idaho Falls, Idaho. The facility is proposed to open in 2003.

- A LLW TSCA-permitted incinerator currently operates at the Oak Ridge National Laboratory. Again, this facility cannot accept TRU waste, but it may be a viable treatment facility for secondary wastes generated as a result of sludge treatment or other basin cleanout activities. A limitation is that the State of Tennessee currently prohibits out-of-state waste from being received at the incinerator.

Table 4-1. Screening of Options for Storage of K Basins Sludge. (2 Sheets)

Storage Option	Comments	Applicability
Existing DST (cladding removal tank or neutralized acid waste tank)	• Advantages: - Low incremental cost for interim storage/disposition if treated to TWRS acceptance criteria because it uses an existing facility - Good blending characteristics between K Basins sludge and tank waste for vitrification - No new construction required - DST retrieval/disposition pathway already identified • Issues/disadvantages: - Potential safety concerns related to criticality control, metal fines, flammable gas - Requires potentially extensive treatment to meet Tank Waste Remediation System (TWRS) acceptance criteria - Adds to overall volume of DST system.	Baseline storage option for slurry product from chemical treatment of sludge
New Tanks (critically safe or non-critically safe)	• Advantages - Does not add to volume in DST system - May reduce sludge treatment requirements (more likely for critically safe tanks than non-critically safe tanks) - May allow greater flexibility in performing sludge treatment (e.g., in-tank treatment) - Could be coordinated with vitrification project • Issues/disadvantages - Tradeoff between concentrated storage (more criticality and off-gas control issues) and dilute storage (would require additional tank space) - If not blended with other tank waste for vitrification, substantial increased cost associated with production of additional glass logs - Moderate (noncritically safe) to high (critically safe) cost for new tanks	Potentially applicable for alternate storage of slurry product from treatment of sludge
Shielded Container	Container storage would require a facility at which to store the containers such as CWC, Canister Storage Building (CSB), or T Plant described below.	
Railcars	• Advantages - Does not require construction of a new facility - Does not add to volume in DST system • Issues/disadvantages - Issues related to unknown retrieval process, freeze protection, and gas generation - Potential exposure to workers during loading/offloading - Rail upgrade required - Process/location for offload to feed vitrification facility undefined - Railcar storage area unidentified - Possible weight limitations associated with load plus shielding	Eliminated from further consideration

Table 4-1. Screening of Options for Storage of K Basins Sludge. (2 Sheets)

Storage Option	Comments	Applicability
KW Basin	• Advantages - Does not add to volume in DST system - Delay in retrieving sludge may allow direct feed to vitrification facility • Issues/disadvantages: - Would not meet Tri-Party Agreement schedule and conflicts with regulatory agreement to mitigate the potential to release hazardous substances - Requires significant upgrades at basin (heating and ventilation) - Requires verification that SNF mixed with sludge has been removed - Significant cost associated with continued basin operation	Extended storage at K Basins eliminated from further consideration because delay conflicts with regulatory agreements
Central Waste Complex (CWC)	• Advantages - Does not add to volume in DST system - Uses an existing facility • Issues/disadvantages - Option to store as remote-handled waste (less volume) or over pack and store as contact-handled waste (greater volume) - Potential capacity limits at CWC - Would require treatment prior to storage for pyrophoric metals - No current plans for PCB treatment system at CWC	Potentially applicable for storage of dry solids from some sludge treatment processes
Canister Storage Building (CSB)	• Advantages - Does not add to volume in DST system - May be able to utilize existing multi-canister overpack (MCO) design as starting point for sludge container design - Uses an existing facility • Issues/disadvantages - Potential capacity limits at CSB - Potential safety concerns with use of existing MCO design for small particle storage - Storage criteria/impacts/sludge treatment requirements undefined	Potentially applicable for storage of dry solids from some sludge treatment processes
T Plant	• Advantages - Does not add to volume in DST system - Uses an existing facility • Issues/disadvantages - Storage criteria/impacts/sludge treatment requirements undefined - Extent of facility modification required unknown	Would require further evaluation

Table 4-2. Acceptance Criteria for Selected Interim Storage Facilities.

Sludge Characteristic	Tank Waste Remediation System (TWRS) Tank 241-AW-105 (Carothers et al. 1997)	Central Waste Complex (CWC) (FDH 1998)
Corrosion	Nitrite and hydroxide concentrations as specified in Lockheed Martin Hanford Corporation (1996)	Waste compatible with container
Criticality	Maintain K^{10}_{∞}<0.95 (for pH > 8, particle size < 50 microns and neutron absorbers)	Fissile material limited to 177 Pu-239 fissile gram equivalents (FGE)/55-gallon drum and Class C limits; Greater than Class C with DOE approval
Energetics	No separable organic layer; exotherms/endotherms < 1.0	No requirement specified
Flammable gas	Eliminate non-radiolytic gas generation; specific gravity (SpG) x solids depth < 148 (solids < 379 m^3)	Radiolytic gas generation must be controlled
Heat generation	<70,000 British thermal units (BTU)/hr (commingled with DST contents)	< 3.5 watts/m^3 or ensure integrity of container
Particle size	Less than 177 microns (for retrieval/mobilization)	No requirement specified
Pyrophoric material	Eliminate reactive materials in sludge	Radioactive pyrophorics < 1%; non-radioactive pyrophorics prohibited
RCRA-regulated metals	Specific waste codes acceptable	Specific waste codes acceptable
TSCA-regulated material	Prohibited, unless there is a formal determination that TSCA regulations do not apply *and* [PCB] < 50 ppm	Acceptable for non-TRU waste; requires DOE approval for TRU waste because of WIPP limits

[10] K^{10}_{∞} is nuclear reactivity of an infinitely large system fully moderated.

Table 4-3. Acceptance Criteria for Final Treatment and Disposal Facilities.

SLUDGE CHARACTERISTIC	Acceptance Criteria				
	High-Level Waste Envelope[a] (DOE-RL 1998b)	**National Geologic Repository (TRW 1996)**	**Waste Isolation Pilot Plant (Remote Handled TRU) (DOE 1996b)**	**Low Level Burial Grounds (FDH 1998)**	**Environmental Restoration Disposal Facility (BHI 1998)**
Particle Size	< 177 microns[b]	Particulate materials must be incorporated into encapsulating matrix	Not applicable	Not applicable	Not applicable
Pyrophoric Constituents	Prohibited[c]	No pyrophoric or reactive materials in amount that would compromise repository	Radioactive pyrophorics: <1%. Non-radioactive pyrophorics prohibited	Prohibited	Prohibited
Flammable Gas	Cannot cause[c] episodic gas generation	No combustible waste forms or explosive materials	Flammable VOCs ≤500 ppm in headspace	Must be controlled to limit pressures to 1.5 atm over 20 years	≤10 % organic/ carbonaceous material
Fissile Material	Pu < 0.054 g/100 grams waste oxides	Pu < 2500 grams/m^3	< 325 g total of Pu-239 FGE/cask	< 100 nCi/g and < Class C limits	<100 nCi/g and <Class C limits
Activity/Dose Rate	Specific maximum, Ci/100 grams oxides: Cs-137: 1.0E+01 U-233: 9.0E-07 U-235: 2.5E-07 Pu-238: 3.5E-04 Pu-239: 3.1E-03	Radiolytic heat generation < 1500 watts per canister	<23 Ci/L total activity ≤1000 rem/hr per canister ≤200 mrem/hr per cask	Contact handled: <200 mrem/hr, contact; <100 mrem/hr at 30 cm Remote handled: ALARA but must not exceed 100 mrem/hr	
TRU Waste	TRU constituents accepted in HLW.	Accepted if NRC determines geologic disposal appropriate	Accepted (non-TRU waste specifically prohibited)	Prohibited	Prohibited
RCRA-Regulated Waste	Accepted	Prohibited	Accepted for specific waste codes	Accepted at mixed waste trenches with appropriate treatment	Accepted with appropriate treatment
TSCA/PCB-Regulated Waste	TSCA-regulated waste prohibited	No criterion defined	<50 ppm PCBs	<50 ppm PCBs	Solids containing PCBs accepted

[a] Vitrified HLW will be stored at CSB prior to final disposal at the national geologic repository.
[b] Not specified in High Level Waste Envelope. Limit from Carothers (1997).
[c] Not specified in High Level Waste Envelope. Limitation based on preliminary treatment facility design and operation.

Table 4-4. Screening of Options for Final Disposal of K Basin Sludge.

Disposal Option	Screening Comments	Applicability
Waste Isolation Pilot Plant (WIPP)	Authorized for disposal of TRU waste. May be able to accept mixed waste in the future, but not yet approved. Currently prohibits waste with PCB concentrations $\geq$ 50 ppm.	Suitable for sludge designated as TRU waste. May require treatment or risk-based disposal approach for PCBs in sludge.
National geologic repository for SNF and HLW	Hazardous or mixed waste disposal may be prohibited. No criterion established relative to PCBs. Currently identifies only borosilicate glass as a standard waste form.	Suitable for range of sludge designations. May require treatment or risk-based disposal approach for PCBs in sludge.
Hanford Site mixed waste trenches (Trenches 31 and 34)	Currently accepting waste for storage but not for final disposal.	Suitable for non-TRU, non-TSCA regulated mixed wastes.
Hanford Site low-level burial grounds	Authorized to accept only LLW for disposal. Mixed waste and TSCA-regulated waste prohibited.	Suitable for non-TRU, non-TSCA regulated LLW.
Hanford Site grout vaults	Anticipated use of grout vaults is for disposal of low-activity vitrified tank waste. Disposal of TRU waste prohibited.	Potentially suitable for non-TRU, non-TSCA regulated waste, but unlikely to be available.
Hanford Site Environmental Restoration Disposal Facility (ERDF)	Authorized to accept mixed LLW. Disposal of TRU waste prohibited. Some PCB wastes can be accepted.	Suitable for disposal of non-TRU, TSCA-regulated mixed wastes.

Table 4-5. Acceptance Criteria for Final Treatment and Disposal Facilities. (6 Sheets)

Technology Type	Process Option	Screening Comments	Purpose/Benefit
Solidification/Stabilization	Macro encapsulation	Application of surface coating materials such as polymeric organics (e.g., resins and plastics) or use of a jacket of inert materials to substantially reduce surface exposure to potential leaching material.	Purpose: reduce mobility of certain contaminants in sludge or debris waste streams designated as mixed waste. Benefit: meeting land disposal restriction (LDR) treatment standards for metals.
	Grouting	Encapsulating contaminants as fine particles within a solid grout (solidification) or chemically reacting contaminants with a stabilizing agent to reduce mobility (stabilization). Target contaminants are heavy metals, including certain radionuclides; pozzolanic and cement-based binding agents are typically appropriate for these contaminants (EPA 1993a). Effectiveness with organic contaminants varies. Limited effectiveness for PCBs; test results do not typically show significant differences between the leachability of PCBs in the untreated and treated medium (EPA 1993a).	Purpose: reduce leachability of certain contaminants in sludge or debris waste streams designated as mixed waste. Benefit: meeting LDR treatment standards for metals.
Physical Treatment	Grinding	The use of mechanical processes to reduce particle size. Standard methods include ball mills or hammer mills and typically cannot achieve very fine particle sizes.	Purpose: reduce particle size in sludge. Benefit: meeting particle size limits for sludge storage/treatment.
	High-energy milling	A well-established process used in the ceramics, powder metallurgy and pharmaceutical industries to prepare fine particle slurries and powders and to accomplish powder/liquid reactions. Hard, wear-resistant milling media, such as alumina, zirconia, and silicon carbide, would be required for uranium particles due to hardness (Precechtel and Turnbaugh 1998). The increased surface area of the particles coupled with process heat generation would cause metals and metallic hydrides to react rapidly with slurry water to form stable hydrated oxides (Precechtel and Turnbaugh 1998).	Purpose: reduce particle size and oxidize metals and metal hydrides in sludge. Benefit: meeting sludge storage/ treatment criteria for particle size and reactivity.

Table 4-5. Acceptance Criteria for Final Treatment and Disposal Facilities. (6 Sheets)

Technology Type	Process Option	Screening Comments	Purpose/Benefit
	Sieving	The use of screens of varying mesh size to segregate particles.	Purpose: separate larger particles (e.g., OIER) from bulk sludge. Benefit: facilitate further sludge treatment.
	Phase separation	Takes advantage of differences in physical properties (e.g., density, form) to segregate two or more phases. Examples include solids-liquids separation using filtration or settling and decanting.	Purpose: remove specific components from sludge (e.g., OIER, PCBs) or secondary waste streams (e.g., PCBs in off-gases). Benefit: facilitate further sludge treatment, meet PCB treatment standards .
Thermal Treatment	Vitrification	A proven technology, primarily for the stabilization of contaminants. Wastes or contaminated media are mixed with glass formers and heated to 1,200° C (2,000 °F) to melt and convert the mixture into glass (Federal Remediation Technologies Roundtable [FRTR] 1998). Borosilicate and soda-lime are the principal glass formers and provide the basic matrix of the vitrified product. The high temperatures volatilize or destroy organic constituents with few byproducts. Heavy metals and non-volatile radionuclides are incorporated into the glass structure which is a relatively strong, durable material that is resistant to leaching. Vitrification has been demonstrated to destroy PCBs under specific operating conditions (Davila et al. 1993). However, under some conditions, such as vitrification designs that use lower temperatures, PCBs could be volatilized rather than destroyed, necessitating PCB treatment of the off-gas.	Purpose: immobilize heavy metals and radionuclides and volatilize/destroy PCBs. Benefit: stabilize sludge to meet long-term storage criteria and potentially remove solidified sludge from TSCA regulation.
	Thermal desorption	A proven technology for removing organic contaminants including PCBs from wastes or contaminated soils and sludges (Papp 1997). Wastes are heated to 150 to 560 °C (300 to 1,000 °F) to volatilize water and contaminants (Davila 1993). A carrier gas or vacuum system transports volatilized water and organics to a gas treatment system. Bed temperatures and residence times designed into these systems will volatilize selected contaminants but will typically not oxidize them (Davila 1993). Particulate material is removed by conventional particulate removal equipment, such as wet scrubbers or fabric filters. Contaminants are removed through condensation followed by carbon adsorption, or they are destroyed in a secondary combustion chamber or a catalytic oxidizer (FRTR 1998). Thermal desorption is being used to remove PCBs from LLW at the Sandia National Laboratory (Richardson 1996).	Purpose: volatilize PCBs and potentially oxidize some metals and metal hydrides. Benefit: remove solidified sludge from TSCA regulation and potentially reduce sludge reactivity to meet long-term storage criteria.

Table 4-5. Acceptance Criteria for Final Treatment and Disposal Facilities. (6 Sheets)

Technology Type	Process Option	Screening Comments	Purpose/Benefit
	Incineration (dry oxidation)	A well-established and proven technology for the destruction of organic contaminants including PCBs (Davila et al. 1993). Incineration uses high temperatures, 870 to 1,400 °C (1,400 to 2,500 °F), to volatilize and combust organic contaminants in the presence of oxygen. Destruction of PCBs requires temperatures of 1,200 to 1,400°C. The destruction and removal efficiency for properly operated incinerators meets the 99.9999% requirement for PCBs. Off-gases and combustion residuals generally require treatment. In the case of K Basins sludge, specific off-gas concerns would be Cs, C, I, Kr, Tc and Ru (Papp 1997). Incineration would also oxidize metals and metal hydrides present in the waste matrix. However, unless particle sizes are very small, the oxide coating formed on the metal must be continuously removed (e.g., through agitation) to maintain reaction rates (Papp 1997).	Purpose: oxidize metals and metal hydrides and destroy PCBs. Benefit: reduce sludge reactivity to meet long-term storage criteria and remove incinerated sludge from TSCA regulation.
	Calcination/ Pyrolysis	Demonstrated technologies that are closely related in that they use high temperatures to effect a chemical reaction. Calcination is the heating of a solid to a temperature below its melting point to effect a thermal decomposition or phase transition other than melting. Calcination is often performed in the presence of oxygen or other oxidizing gas. Pyrolysis is the conversion of a compound into one or more other substances by heat alone and in the absence of oxygen; for a waste containing PCBs, pyrolysis has the disadvantage of forming dioxins. Operating temperatures for both are typically above 430 °C (800 °F). Calcination and pyrolysis of organic materials produces combustible gases, including carbon monoxide, hydrogen and methane, and other hydrocarbons. The off-gases are treated by combustion or condensation. Particulate removal equipment is also required. Chemical contaminants for which treatment data exist include PCBs.	Purpose: oxidize metals and metal hydrides and volatilize PCBs. Benefit: reduce sludge reactivity to meet long-term storage criteria and remove dry sludge from TSCA regulation.
Chemical Treatment	Acid dissolution/ caustic precipitation	A proven technology for first dissolving then resolidifying the uranium found in SNF, offering opportunities to separate the SNF components (Papp 1997). In laboratory tests with K Basins sludge, two product streams are generated: the dissolved/precipitated solids (containing the bulk of the radionuclides) and solids that are insoluble in nitric acid (zirconium alloy, sand/gravel, ion exchange beads). The dissolution/precipitation process reduces particle size and oxidizes metallic uranium and uranium hydrides (Papp 1997). With the addition of an appropriate neutron absorber (e.g., iron) prior to precipitation, the process can also provide criticality control.	Purpose: oxidize metals and metal hydrides in sludge and provide criticality control. Benefit: reduce sludge reactivity and provide criticality control to meet interim storage and future treatment criteria.

Table 4-5. Acceptance Criteria for Final Treatment and Disposal Facilities. (6 Sheets)

Technology Type	Process Option	Screening Comments	Purpose/Benefit
	Chemical oxidation	Use of chemical agents to oxidize metals, metal hydrides, and/or PCBs. Potential oxidizers for uranium and uranium hydride include hydrogen peroxide (in nitric acid), iodine (in 2-propanol), and sodium hypochlorite (Papp 1997). The reaction rate for iodine is relatively slow, and no information is available on the ability to oxidize other reactor fuel components (Zircaloy) or on the production of off-gas products. Sodium hypochlorite produces chlorine in addition to other off-gasses. Potential oxidizers for PCBs include hydrogen peroxide, used with ultraviolet radiation or ferrous iron, Fe(II) (Fenton's reagent) (Papp 1997). If complete mineralization is achieved, the final products of oxidation are carbon dioxide, water, and salts (EPA 1993b). Carbonates, nitrates, and metal oxides can inhibit contaminant destruction efficiency (EPA 1993b).	Purpose: oxidize metals, metal hydrides, and/or PCBs in sludge. Benefit: reduce sludge reactivity to meet interim storage and future treatment criteria, potentially remove sludge from TSCA regulation.
	TRU-targeted ion exchange	A two-step process whereby the waste stream is dissolved in nitric acid and the resulting solution is processed through ion exchange resin to separate TRU from non-TRU components (Papp 1997).	Purpose: reduce TRU concentrations in secondary waste streams from sludge treatment. Benefit: allow waste stream to be disposed as a LLW rather than a TRU waste, allows consideration for disposal at the ERDF.
	Water oxidation	Oxidation of metals and metal hydrides by water. The reaction rate for uranium and uranium hydride is slow at temperatures under 100ºC; a faster rate would require a pressurized reactor to effect higher temperature (Papp 1997).	Purpose: oxidize metals and metal hydrides in sludge. Benefit: reduce sludge reactivity to meet interim storage and future treatment criteria.
	Base-catalyzed decomposition	A demonstrated process for destroying PCBs. The PCB-contaminated medium is mixed with sodium bicarbonate and heated to above 330°C (630°F) to partially decompose and volatilize PCBs (Papp 1997). The volatilized PCBs are captured and condensed. The vapor condensate is treated by reacting with sodium hydroxide at 350°C (662°F) in hydrocarbon solvent in the presence of a catalyst (Davila et al. 1993).	Purpose: oxidize PCBs in sludge. Benefit: potentially remove sludge from TSCA regulation.

Table 4-5. Acceptance Criteria for Final Treatment and Disposal Facilities. (6 Sheets)

Technology Type	Process Option	Screening Comments	Purpose/Benefit
	Dechlorination	A demonstrated process for destroying PCBs (Davila et al. 1993). Contaminated media and an alkaline polyethylene glycol reagent are mixed and heated in a treatment vessel. The reaction causes the polyethylene glycol to replace chlorine molecules and render the PCBs nonhazardous or less toxic (Davila et al. 1993). Byproducts include glycol ether and/or a hydroxylated compound and an alkali metal salt. The process often takes numerous cycles of the process to achieve the desired results, effects partial dehalogenation, and dioxins and furans often form (Papp 1997).	Purpose: oxidize PCBs in sludge. Benefit: potentially remove sludge from TSCA regulation.
	Mechano-chemical destruction of PCBs	A variation on the base-catalyzed decomposition. This is a low temperature process (on a macro-scale) in which chemical reactions are induced by mechanically milling in the presence of suitable reactants. The milling action induces very high micro-scale temperatures (Hall et al. 1996). The destruction of PCBs (Arochlor 1254) using calcium oxide in a laboratory sized ball mill has been demonstrated (Rowlands et al. 1994; Donecker, 1997).	Purpose: oxidize PCBs in sludge while reducing particle size. Benefit: potentially remove sludge from TSCA regulation and meet interim storage and future treatment criteria for particle size.
Biological Treatment	Aerobic	A process whereby organic contaminants are destroyed or transformed to less toxic chemicals by bacteriological processes in the presence of air. Contaminated media are aerated either in situ or ex situ, often with the addition of nutrients, water, and/or heat, to facilitate bacterial action. Although proven effective for petroleum products and many volatile organic contaminants, aerobic degradation is not typically effective with PCBs.	Not applicable to contaminants or characteristics of K Basins sludge.
	Anaerobic	A process whereby organic contaminants are destroyed or transformed to less toxic chemicals by bacteriological processes in the absence of air. Nutrients, water, and/or heat may be added to facilitate bacterial action. Anaerobic treatment is not typically effective with PCBs (Davila et al. 1993).	Not applicable to contaminants or characteristics of K Basins sludge.

5.0 DESCRIPTION OF ALTERNATIVES

This section describes the remedial alternatives determined to be suitable for the K Basins interim remedial action. The alternatives were developed using the remedial technologies and screening of process options presented in Section 4.0 and represent a range of chemical, physical, thermal, and solidification technologies.

Certain features of the SNF Program and the sludge constrain sludge management and disposal, regardless of the technology used. These constraining features were critical in developing viable alternatives and include the following:

- The sludge must be removed from the basins beginning no later than July 2004 and ending no later than August 2005 to meet milestones established in the Tri-Party Agreement. It is assumed that removal of the sludge from the basins occurs within this 13-month window.

- The sludge contains a significant quantity of uranium and plutonium, so treatment must assure nuclear criticality safety.

- The sludge will be designated as either a TRU waste or a HLW. A final determination has not been made. Sludge or fractions thereof designated as TRU waste or HLW cannot be disposed at the Hanford Site, but rather must be disposed at the WIPP or at the national geologic repository.

- The sludge contains reactive and potentially pyrophoric and corrosive metals and metal hydrides, primarily uranium and a zirconium alloy. Treatment must address reactivity, pyrophoricity, and potential for corrosivity.

- It is assumed that the sludge contains TCLP metals at concentrations that cause the sludge to be designated as a mixed waste, thus the sludge must be managed in accordance with the state Dangerous Waste Regulations.

- The sludge is designated as a PCB remediation waste and is regulated under TSCA. Neither TWRS nor the national geologic repository can accept TSCA-regulated waste. A risk-based approach that requires PCB treatment is used to exit TSCA regulation.

- The sludge generates hydrogen gas. The generation, accumulation, and sudden release of hydrogen gas must be controlled.

The remedial alternatives for sludge management consist of the following:

- Alternative 1: No Action
- Alternative 2: Chemical Treatment
- Alternative 3: Physical Treatment
- Alternative 4: Thermal Treatment

- Alternative 5: Solidification.

For Alternative 2, two chemical treatment options were developed, the current project baseline process and a modification of that process. For Alternative 4, two thermal technology options were developed, vitrification and calcination. Alternatives 2 and 3 share the common goal of treating the sludge sufficiently to meet requirements for interim storage, final treatment, and disposal with existing DST wastes. Alternatives 4 and 5 would treat the sludge sufficiently so that no further treatment would be required to dispose of the waste in a final offsite disposal facility. Figure 5-1 illustrates the overall sludge management approach for each of the treatment alternatives.

The sludge treatment alternatives are described in Sections 5.1 through 5.5. The descriptions of the alternatives are based on the present understanding of the chemistry and physics of the K Basins sludge and currently available information on treatment technologies and waste management facility acceptance criteria. More definitive conceptual and detailed designs of the sludge treatment system selected in the ROD for this CERCLA action will be conducted during remedial design.

It is uncertain whether a facility to provide extensive treatment for the entire volume of sludge could be operational by the time sludge removal operations are initiated at the K Basins. In that case, some or all of the sludge may be removed from the basins and placed into interim storage with minimal treatment, with more extensive treatment to meet final disposition requirements provided at a later date. Examples of minimal treatment include separating the sludge into fractions by particle size and simple chemical adjustment. Interim storage could consist of either tank or container storage. The interim storage location would be in the 200 Area, most likely in an existing facility such as the CWC, T Plant, or the Waste Encapsulation and Storage Facility. Sufficient treatment would be performed and appropriate packaging would be provided to meet the storage requirements for the selected storage facility. Interim storage would begin in 2004 when the sludge is removed from the basins.

The CERCLA action also includes management of SNF, water, and debris, and deactivation of the basins. Alternatives 2 through 5 are identical with respect to these activities. Section 5.6 describes these common elements.

5.1 ALTERNATIVE 1: NO ACTION

CERCLA regulations (40 CFR 300) require that a No Action Alternative be evaluated as a baseline for comparison with other remedial alternatives. The No Action Alternative represents a situation where there would be continued storage of the SNF, sludge, debris, and water in the K Basins for up to 40 years with no modifications except for routine maintenance, monitoring, and ongoing safety upgrades. There would be no major upgrades to significantly enhance storage capabilities. The No Action alternative is included only to provide a baseline for evaluation; it is not the intent to change the decision made via the NEPA process to remove the SNF, sludge, water, and debris.

5.2 ALTERNATIVE 2: CHEMICAL TREATMENT

Since 1996, the SNF Project baseline has assumed that the K Basins sludge would be stored in an existing DST and dispositioned with tank wastes. To support the baseline, the TWRS program developed DST waste acceptance criteria specifically for the K Basins sludge (Table 4-2). Early evaluations of the TWRS criteria and available technologies identified chemical treatment via acid dissolution as a viable method for meeting the criteria and led to the development of the Baseline Chemical Treatment Alternative (Westra et al. 1998). The Modified Chemical Treatment Alternative is developed as a simplification of the baseline process.

The TWRS waste acceptance criteria limit the particle size in the sludge (to control criticality during interim storage and support retrievability), prohibit pyrophoric materials and TSCA-regulated waste, and specify chemistry requirements (for criticality control and corrosion control). Under both the Baseline and Modified Chemical Treatment Alternatives, these criteria would be met as follows:

- Acid dissolution, separation of insoluble solids, and caustic precipitation would be used to reduce particle size.

- The reduction in particle size and the addition of neutron absorbers would be used to ensure that the resulting slurry would be critically safe.

- Acid dissolution and separation of insoluble solids would oxidize or remove metals and metal hydrides, thus eliminating reactivity and pyrophoricity.

- Corrosion requirements would be met through the addition of sodium hydroxide and sodium nitrite.

- The sludge would exit TSCA regulation through the use of a risk-based disposal approval (Appendix C)[11]. This approval would require some treatment for PCBs, which would be achieved by a combination of separation with the insoluble solids and volatilization. This treatment would also meet the PCB concentration limit of 50 ppm established by TWRS.

[11] The risk-based disposal approval was not available when the Baseline Chemical Treatment Alternative was originally developed. Under the regulations in effect at that time, exiting TSCA regulation would have required treating the sludge to reduce concentrations of PCBs to specified levels. It was anticipated that the PCBs would have an affinity for the insoluble solids, so PCB treatment would consist in part of removing the insoluble solids. Treatment would also be achieved by volatilizing PCBs during acid dissolution and capturing them in the off-gas system. Subsequent to developing Baseline Chemical Treatment Alternative, EPA finalized the PCB Disposal Amendments of 1998, which allow for the risk-based disposal approach. The request and justification for a risk-based disposal approval is provided in Appendix C. As part of the risk-based approach, the sludge treatment system would be required to provide treatment for PCBs. Specific PCB concentrations would not have to be achieved in the treated sludge, but off-gas would have to be treated to ensure that emissions contain less than 10 $\mu g/m^3$ PCBs. For both the Baseline Chemical Treatment Alternative and the Modified Chemical Treatment Alternative, PCB treatment would be provided by (1) volatilization and capture of PCBs and (2) adsorption to and a subsequent separation with the insoluble solids.

The resulting slurry would meet the waste acceptance criteria established by TWRS and would be transferred to an existing DST for interim storage. Final treatment (beyond the scope of the CERCLA action) would be via the privatized vitrification facilities, with subsequent disposal at the national geologic repository.

Interim storage in a tank (such as a vitrification plant feed tank) other than an existing DST may be evaluated during remedial design. Most of the issues related to storage in an existing DST are generally relevant to any interim tank storage. The specific performance requirements for the treatment system would be modified as appropriate if the waste acceptance criteria for an alternate tank differ from the existing DST criteria, or if the DST criteria are modified in the future.

5.2.1 Sludge Retrieval and Removal

Baseline Chemical Treatment. In general, canister, floor, and pit sludge would be collected (retrieved) and moved to staging locations (such as existing pits) within the basins for consolidation and interim storage until SNF removal is complete. Sludge would also be collected from the wash stations associated with the Fuel Removal System, from the water treatment systems, and from the debris removal systems. From the staging locations, the sludge would be removed from the basins via the Sludge Loadout System into specially-designed containers on transport trailers and transported to the sludge treatment system.

It is currently anticipated that five distinct sludge streams would be removed from the basins as follows:

1) KE1: KE Basin floor and pit sludge with particle sizes less than 0.64 cm (0.25 in), plus fuel-washing sludge with particle sizes less than 250 micron (0.01 in)

2) KE2: KE Basin canister and fuel-washing sludge with particle sizes greater than 250 micron (0.01 in)

3) KW1: KW Basin floor and pit sludge with particle sizes less than 0.64 cm (0.25 in),

4) KW2: KW Basin canister fuel-washing sludge with particle sizes between 500 microns (0.02 in) and 0.64 cm (0.25 in),

5) KW3: KW Basin canister fuel-washing sludge with particle sizes less than 500 microns (0.02 in).

The total volume of sludge removed as a slurry from the basins would be about 260 m^3 (8,800 ft^3).

An important technical and safety issue during sludge retrieval and removal would be hydrogen gas generation and control. The metallic particles and metal hydrides present in the sludge oxidize in water resulting in hydrogen gas generation. Transfers and agitation of the sludge

particles during treatment may disturb the non-protective oxide layer on the particles and accelerate this reaction. Therefore, the retrieval and removal equipment would be designed to vent and/or dilute the evolved hydrogen and to provide some method of cooling.

In addition, metallic particles and metal hydrides are pyrophoric and can self-ignite in dry air, moist air, or even underwater in the case of uranium hydride. Thus, it would be important to ensure that the sludge is covered with an excess of water during retrieval and removal.

Modified Chemical Treatment. Sludge retrieval and removal under Modified Chemical Treatment differs from that under Baseline Chemical Treatment in that the sludge would be segregated into three separate feed streams at the basins: Type A, Type B, and OIER.

Type A would consist of material with a particle size less than 250 :m. This material would be retrieved from the basins through a screen. Based on characterization data and process knowledge, it would include nearly all of the KW1 and KW3 streams and about 80% of the KE1 stream, or about two-thirds of the total sludge volume. Any oversize material would be retained at the basins to be included in the Type B feed. Type B feed would include all of the KE2 and KW2 streams along with the material with a particle size greater than 250 :m separated while retrieving Type A feed. The Type B feed would include about one-third of the total sludge volume.

The OIER would be screened and elutriated in the basin to remove it from the sludge. Separation of the OIER would be important to avoid contacting the OIER with nitric acid in the dissolver. Nitrated resin, if allowed to dry out, could undergo an energetic reaction that could pose a safety issue. Separation of the OIER prior to the dissolver would also reduce the amount of plutonium and americium adsorbed onto the OIER. The OIER is also separated in the Baseline Chemical Treatment Alternative, but as part of the chemical treatment process rather than at the basins. Separating the OIER in the basins would reduce the amount of equipment that would need to be located in the sludge treatment facility.

5.2.2 Process Description

Baseline Chemical Treatment. The Baseline Chemical Treatment flowsheet is shown schematically in Figure 5-2. Baseline Chemical Treatment includes the following operations (Numatec 1999):

- Transferring the sludge from the transport container to a lag storage tank
- Sieving the sludge on a screen to remove the large sludge particles, OIER, Grafoil, and some inorganic ion exchange media
- Separating the OIER from the larger sludge particles in an elutriation column and recombining the large and small sludge particles
- Dissolving the sludge in nitric acid at near-boiling conditions

- Physically separating residual solids (mostly zirconium, sand, dirt, and the remaining inorganic ion exchange media) from the solution using a centrifuge and polishing filter
- Adding iron and/or depleted uranium as a neutron absorber
- Precipitating the solution using sodium hydroxide
- Chemically adjusting the solution using sodium nitrite
- Leaching the OIER to remove absorbed Cs-137 and TRU constituents
- Leaching the insoluble solids to remove absorbed Cs-137 and TRU constituents
- Combining and solidifying the OIER and insoluble solids.

Modified Chemical Treatment. The Modified Chemical Treatment flowsheet is shown schematically in Figure 5-3. It differs from the Baseline Chemical Treatment flowsheet in the following areas:

- It does not include an OIR separation step (OIER is separated at the basins).
- Residual solids (mostly zirconium, sand, dirt, and the remaining inorganic ion exchange media) would be separated from the dissolved solution using a hydropulse filter instead of a centrifuge
- OIER and insoluble solids would be solidified directly without the leaching step to remove absorbed Cs-137 and TRU constituents.

Features Common to Baseline Chemical Treatment and Modified Chemical Treatment. Due to the radiation dose rate from the K Basins sludge, the main processing equipment would be located inside a hot cell. The hot cell would be designed with remote maintenance capability. Generally, only equipment that would not be expected to require maintenance would be located inside the hot cell. Pumps, valves, and flow meters would be located in small shielded cubicles above the hot cell so that contact maintenance could be used to repair or replace failed items. The agitator and centrifuge motors would also be located on top of the cell with shafts extending down through the shielding. Failed equipment would be flushed to lower the dose rate prior to contact maintenance. The radiation dose from the OIER/insoluble solids tank and the grouting equipment would be expected to be low enough to allow contact maintenance.

The vapor space in the acid dissolution tank would be purged with nitrogen. Hydrogen gas concentrations (produced from uranium/zirconium water reactions and radiolysis) would be maintained below the lower flammability limit by monitoring and dilution with nitrogen and air. The hydrogen generation rate would not be constant during processing (i.e., higher rates are expected early in the processing cycle) and would be dependant upon the uranium concentration in each batch.

The Chemical Treatment Alternative would not be intended to treat for the dangerous waste characteristics of the sludge. (The existing DSTs are approved to store mixed waste and the TWRS vitrification facility would treat for TCLP metals and underlying constituents to meet appropriate LDR requirements.) However, because the sludge is a mixed waste, the sludge treatment process would have to be designed to meet dangerous waste design standards. These would include double containment and leak detection of liquid process streams, process vessels, and storage tanks.

The current SNF Project baseline includes the assumption that the hot cell for the sludge treatment system would be installed inside the Cold Vacuum Drying (CVD) facility, which is located in the 100-K Area. The CVD facility is currently under construction and will be used to dry the SNF (Section 5.6.1). Bays in the CVD facility that are not needed to dry the SNF would be modified to accommodate the sludge treatment system. The CVD facility has been designed to achieve a nuclear safety equivalency comparable to U.S. Nuclear Regulatory Commission (NRC)-licensed facilities. The hot cell and the CVD facility will be equipped with ventilation systems and thus would provide secondary air emissions control in addition to the ventilation system on the treatment process itself. If the CVD facility is determined not to meet the operational and schedule requirements, an alternate onsite treatment location would be selected as part of remedial design.

The waste streams that would be generated from treatment would include the following:

- Treated sludge. It is anticipated that the treated sludge would be designated as a mixed TRU waste or a mixed HLW. It would be designated as a mixed waste because of TCLP metals. Under the risk-based disposal approval for PCBs (Appendix C), the sludge would no longer be regulated under TSCA. PCB concentrations in the sludge would be expected to be less than 50 ppm (Mong et al 1998).

- OIER/insoluble solids (Baseline Chemical Treatment). The insoluble solids and OIER would designate as TSCA-regulated LLW. Under the Baseline Chemical Treatment process, it is expected that TCLP metals and TRU constituents would be removed during the leaching process and thus would not be present above dangerous waste designation levels or the TRU waste limit of 100 nCi/gram. The treated sludge would still be subject to the LDR treatment standards for underlying constituents, including PCBs. The insoluble solids and OIER would be combined and treated as appropriate to meet disposal criteria prior to disposal either onsite at the ERDF or at an offsite disposal facility.

- OIER/insoluble solids (Modified Chemical Treatment). The insoluble solids and OIER would designate as TSCA-regulated TRU waste or mixed TRU waste. The mixed waste designation would depend on whether TCLP metals are present above designation levels. The insoluble solids and OIER would be treated as appropriate to meet disposal criteria prior to disposal. They would be disposed at the ERDF, the WIPP, or another offsite disposal facility as appropriate for the waste designation.

- Contaminated off-gas. Treatment would generate an off-gas that would contain volatile and particulate radionuclides, PCBs, and other regulated contaminants (e.g., nitrogen oxides). A best available control technologies (BACT) evaluation would be performed, as required, during remedial design to identify appropriate control technologies for airborne emissions of toxics. A best available radionuclide control technologies (BARCT) evaluation would be performed, as required, to identify appropriate control technologies for airborne emissions of radionuclides. Air emissions control technologies would be likely to include the use of granular activated carbon (GAC) to absorb PCBs, a scrubber to remove nitrogen oxides, and high-efficiency particulate air (HEPA) filters to remove radioactive particulate matter.

- Granular activated carbon. Assuming that GAC would be used to absorb PCBs in the offgas, the spent GAC generated from the off-gas treatment system would likely be designated as a TSCA-regulated LLW. With this designation, it would be grouted and disposed at the ERDF.

- Aqueous waste. An aqueous waste stream (e.g., condenser condensate) would be generated as a byproduct of chemical treatment. Under the project baseline, excess aqueous streams generated during sludge treatment would be combined with the treated sludge and be transferred to the DST.

- Miscellaneous wastes. Other potential wastes would include contaminated air filters, debris collected during initial sludge screening (particles > 0.064 cm [0.25 in]), contaminated equipment, personal protective equipment, etc. This debris would be managed as described in Section 5.6.3 of this FFS.

5.2.3 Final Disposition

The product from both the Baseline Chemical Treatment process and Modified Chemical Treatment process would be a slurry that meets TWRS waste acceptance criteria as specified in Table 4-2. After the chemical additions required as part of the treatment, the slurry volume transferred to the DST would be about 1,620 m^3 (430,000 gallons) under Baseline Chemical Treatment and 1,525 m^3 (400,000 gallons) under Modified Chemical Treatment (Numatec 1999). The difference in volumes would result mainly from eliminating the OIER and insoluble solids leaching step and the concomitant neutralized acid waste that would be generated from this step. Based on a transport container size of 8 m^3 (282 ft^3), Baseline Chemical Treatment would require about 203 shipments and Modified Chemical Treatment would require 191 shipments (Numatec 1999).

The treated sludge would be shipped by truck via a trailer-mounted Sludge Transportation System from the 100-K Area to an existing DST (currently identified as Tank 105-AW) in the Hanford 200 Area to be off-loaded. A Sludge Receiving Station would be constructed at the tank farms to enable direct transfer of the neutralized slurry from the transportation system into the selected tank. The interim storage tank would have to comply with the design and operating requirements specified for tank storage in the State of Washington dangerous waste regulations. The existing

DSTs are operated in accordance with interim status tank storage regulations, which meet this requirement. Amendment of the TWRS Authorization Basis would be required prior to receiving definitive acceptance of the sludge from TWRS.

The solids associated with the treated sludge would be processed with other HLW at the HLW vitrification plant; the glass produced would eventually be disposed of at the national geologic repository. The liquids associated with the treated sludge would be treated with other low-activity waste (LAW) and disposed on the Hanford Site. Vitrification services are currently planned to be secured from a private contractor (TWRS Privatization Project [TWRS-P]). The treated K Basins sludge would be transferred to at least two other DST prior to vitrification. One would be the TWRS feed staging tank and the other would be the TWRS-P staging or lag storage tank. These transfers would intimately mix the K Basins sludge with the existing tank sludge, thus masking any unique identity the treated sludge may have had. The volume of waste from the K Basins sludge is very small compared to the existing tank waste volume.

The Chemical Treatment Alternative would have no incremental impact on the production of HLW glass. The volume of HLW glass produced by vitrifying the K Basins sludge solids with the solids currently present in Tank 105-AW would be the same as the volume generated from vitrifying the solids in Tank 105-AW alone (Numatec 1999) because the constituents in the K Basins sludge solids complement the constituents in the Tank 105-AW solids. However, there would be an incremental impact in the volume of LAW glass volume produced because the Chemical Treatment Alternative would increase the amount sodium in Tank 105-AW. The sodium would result in approximately 571 m^3 (20,200 ft^3) of additional LAW glass under Baseline Chemical Treatment and 468 m^3 (16,500 ft^3) of additional LAW under Modified Chemical Treatment.

At the present time, the TWRS-P contract for construction and operation of tank waste treatment facilities is not in place. The current contract with the vendor is to produce certain technical, regulatory, and business deliverables that will demonstrate the technical viability and economics of the privatization approach. At the end of two years, a path forward decision will be made either to proceed with privatization or to adopt an alternate coarse of action. No alternate strategy for treatment of tank wastes has been proposed at this time.

Under Baseline and Modified Chemical Treatment, the OIER and insoluble solids would be grouted in lined shipping casks (ERDF disposal) or 55-gallon drums (WIPP disposal) for immobilization. Under Baseline Chemical Treatment assuming both the OIER and the insoluble solids would be disposed at the ERDF, the total grouted volume would fill about 7 liners for a total grouted volume of about 34 m^3 (1,200 ft^3) (Numatec 1999). Under Modified Chemical Treatment assuming both the OIER and the insoluable solids would be disposed at ERDF, the total grouted volume would be about 371 m^3 (13,100 ft^3) (Numatec 1999).

5.3 ALTERNATIVE 3: PHYSICAL TREATMENT

Particle size reduction is a key requirement for DST storage of the K Basins sludge both for

criticality safety and retrievability. Particle size can be reduced through chemical processing as described in the Chemical Treatment Alternative, but the chemical treatment process would require the addition of large quantities of sodium hydroxide to neutralize the acid used in dissolution which would produce large volumes of waste both in interim and final form. Mechanical size reduction of particles was identified as a technology that could potentially achieve the particle size requirements and at the same time reduce waste volumes. A combination of high-energy milling and physical separation processes was developed to evaluate the Physical Treatment Alternative.

Under the Physical Treatment Alternative, grinding/milling and physical separation of ungrindable solids would be used to meet the TWRS particle size limits and oxidize or remove metals and metal hydrides. The reduction in particle size and the addition of neutron absorbers would be used to ensure that the resulting slurry would be critically safe. Corrosion requirements would be met through chemical addition of sodium hydroxide and sodium nitrite. As in the Chemical Treatment Alternative, the sludge would exit TSCA regulation through the use of a risk-based disposal approval (Appendix C). The PCB treatment required as part of this approval and to meet the TWRS PCB concentration limit would be achieved by lining the grinder with a material that adsorbs PCBs.

The resulting slurry would meet the waste acceptance criteria established by TWRS and would be transferred to an existing DST for interim storage. Final treatment (beyond the scope of the CERCLA action) would be via the privatized high-level melter, with subsequent disposal at the national geologic repository.

5.3.1 Sludge Retrieval and Removal

Sludge retrieval and loadout would be the same as described for Baseline Chemical Treatment, Section 5.2.1.

5.3.2 Process Description

The Physical Treatment flowsheet is shown schematically in Figure 5-4. This alternative would include the following process steps:

- Transferring the sludge from the transport container to a lag storage tank
- Grinding the sludge in a high-energy mill
- Separating, removing, and recycling oversize particles
- Adding iron and/or depleted uranium as a neutron absorber
- Chemically adjusting the solution using sodium hydroxide and sodium nitrite
- Solidifying the particles that could not be size reduced.

Both uranium and zirconium, key components in the K Basins sludge, are very hard in the metallic state and are not generally amenable to mechanical size reduction. While there is some information to suggest that irradiated uranium might be successfully ground, there is insufficient experience grinding this type of material to assure that the grinding would actually work.

(Numatec 1999). In addition, mechanical size reduction might be facilitated by the concurrent oxidation of the surface of uranium particles. If the mechanism of size reduction relies on oxidation of the surface, the cycle times might not allow processing within the 13-month window. Full size reduction of all uranium particles would likely not occur during initial grinding, and almost no size reduction of zirconium particles would be expected. After the first pass through the grinder, the slurry would pass through a particle separation system to remove those particles that do not meet the TWRS particle size criterion. Oversize particles would be returned to the grinder for additional processing. Once processing is complete, large particles would be removed for separate management. The fraction of uranium particles that would be expected to be recycled back to the grinder from each batch has not been determined. The uranium recycle rate would impact the overall process throughput and as well as the criticality control strategy.

A defoaming agent would be added to the grinder feed stream as necessary to minimize foaming. Sufficient water would be added to the slurry via the add line to keep the slurry and grinding media covered with water in the grinder. The process chamber and incoming slurry would be heated to 80^{o}C. The method for criticality control would require development.

The grinding media would be expected to wear during processing and consequently would contribute to the solids in the discharge stream. Actual wear values would depend upon the final media selection, processing times, and the abrasiveness of the K Basins sludge. If aluminum oxide grinding media were to be selected, significant quantities of aluminum oxide could be added to the treated K Basins sludge stream. Grinding media would be replenished as needed through an addition line from the aqueous makeup area.

As with the Chemical Treatment Alternative, the main processing equipment would be located inside a hot cell because of the dose rate associated with the K Basins sludge, and the hot cell would be designed with remote maintenance capability. The vapor space above the grinding/milling media would be purged with nitrogen to maintain hydrogen gas concentrations below the lower flammability limit. The treatment system would be designed to meet dangerous waste design standards, including double containment and leak detection of liquid process streams, process vessels, and storage tanks. The grinding/milling treatment system would be installed inside the CVD facility, which is located in the 100-K Area, or an alternate facility located at the Hanford Site.

The waste streams that would be generated under the Physical Treatment Alternative would include the following:

- Treated sludge. It is anticipated that the treated sludge would be designated as a mixed TRU waste or a mixed HLW. The mixed waste designation would depend on leachable concentrations of TCLP metals. Under the risk-based disposal approval for PCBs (Appendix C), the sludge would no longer be regulated under TSCA. It is assumed that PCB treatment would be sufficient to meet the TWRS criterion of PCBs less than 50 ppm.

- Ungrindable solids. It is anticipated that this stream would designate as TSCA-regulated TRU waste or mixed TRU waste. It would be managed as described for the

OIER/insoluble solids under Modified Chemical Treatment in Alternative 2.

- Contaminated off-gas. Treatment would generate an off-gas that would contain volatile and particulate radionuclides, PCBs, and potentially other regulated contaminants. The off-gas would be treated as described in the Alternative 2, with the exception that treatment for nitrogen oxides would not be required.

- Granular activated carbon. Spent GAC generated from the off-gas treatment system would likely be designated as a TSCA-regulated LLW. The GAC would be managed as described in Alternative 2.

- Aqueous waste. Aqueous streams (e.g., condenser condensate) generated during sludge treatment would be combined with the treated sludge and transferred to the DST.

- Miscellaneous wastes. Other potential wastes would include contaminated air filters, debris collected during initial sludge screening (particles >0.064 cm [0.25 in]), contaminated equipment, personal protective equipment, etc. This debris would be managed as described in Section 5.6.3 of this FFS.

5.3.3 Final Disposition

The product from the Physical Treatment process is assumed to be a slurry that meets TWRS waste acceptance criteria as specified in Table 4-2. After the chemical additions required as part of the treatment, the slurry volume would be about 276 m^3 (72,900 gallons) (Numatec 1999). Water would need to be added to the slurry to meet radioactive waste transport limits for shipping to the DST. The water addition would bring the total volume of slurry transferred to the DST to 1,208 m^3 (320,000 gallons). Based on a transport container size of 7 m^3 (247 ft^3), Physical Treatment would require about 173 shipments. The treated sludge would be shipped, stored, and eventually vitrified as described in the Chemical Treatment Alternative.

As with Chemical Treatment, the treated sludge produced by Physical Treatment would blend favorably with the contents of Tank 105-AW such that the volume of HLW glass produced would be no greater than the volume of HLW glass generated by vitrifying the contents of Tank 105-AW alone. The volume of LAW glass produced would increase due to the sodium associated with the treated sludge and the sodium added subsequently during caustic washing in the DST. However, the amount of sodium added in the Physical Treatment Alternative would be substantially less than in the Chemical Treatment Alternative, so the incremental increase in LAW glass would be much less. The sodium would result in approximately 69 m^3 (2,400 ft^3) of additional LAW glass under Physical Treatment (Numatec 1999).

Under the Physical Treatment Alternative, the ungrindable solids would be solidified into 55-gallon drums. Sufficient solidification agents would be added to meet the ERDF or WIPP waste acceptance criteria. Assuming disposal to the ERDF, the total grouted volume would be about 22 m^3 (780 ft^3).

5.4 ALTERNATIVE 4: THERMAL TREATMENT

The Thermal Treatment Alternative would involve treating the K Basins sludge with thermal technologies such that it could be disposed directly at an off-site disposal facility (either the national geologic repository or the WIPP) without further processing. This would bypass issues associated with managing the treated sludge with DST waste in TWRS.

There are several thermal treatment technologies available. The two that were developed to evaluate this alternative were vitrification and calcination. Vitrification would produce a glass waste form that would be intended to meet the waste acceptance criteria at the national geologic repository. Calcination would produce a particulate waste form that would be intended to meet the waste acceptance criteria at the WIPP. Final disposal would be beyond the scope of the CERCLA action.

5.4.1 Sludge Retrieval and Removal

Sludge retrieval and removal would be similar to that described for Modified Chemical Treatment in Section 5.2.1. Three feed streams would be removed: OIER, particles with sizes less than 250 microns (.01 in) (Type A feed), and particles with sizes greater than 250 microns (.01 in) (Type B feed). Type B feed would be delivered to the thermal treatment facility after Type A material is processed.

5.4.2 Process Description

Vitrification. The Vitrification Alternative would involve using a small-scale vitrification unit to process the K Basins sludge into glass outside of the TWRS system. This would create a unique glass form that would be designed to meet the criteria for direct disposal at the national geologic repository. The repository waste acceptance criteria limit pyrophorics and fissile material concentration; require incorporation of particulate material into an encapsulating matrix; and limit the size of inclusions in the glass. In addition, it is anticipated that the repository will prohibit RCRA- and TSCA-regulated waste. The chemical pretreatment and the high temperatures and chemical environment of the vitrification process would oxidize metals and metal hydrides. The high temperatures would also volatilize PCBs, allowing the sludge to exit TSCA regulation. Fissile material loading would be controlled by appropriate blending with glass formers. Vitrification is the specified technology for treating HLW designated for TCLP metals to exit RCRA regulation.

The glass would need to undergo waste form qualification to be accepted at the repository. Particles greater than 250 microns (.01 in) would still require chemical pretreatment prior to vitrification in the small-scale unit. Because the sludge would not be blended with tank waste, additional HLW glass would be produced. However, because the quantity of chemicals added would be less than in the Chemical and Physical Treatment Alternatives, no LAW glass would be produced. The vitrified product would be transferred to an interim storage location at the Hanford Site, and ultimately disposed at the national geologic repository.

The Vitrification Alternative flowsheet is shown schematically in Figure 5-5. This alternative would include the following process steps:

- Transferring the sludge from the transport container to a lag storage tank
- Dissolving the sludge in nitric acid at near-boiling conditions (Type B feed only)
- Physically separating residual solids (mostly zirconium, dirt, and the remaining inorganic ion exchange media) from the acid solution (Type B feed only)
- Evaporating excess water from the acid solution and adding sugar (sucrose) to denitrate the solution prior to feeding the melter (Type B feed only)
- Vitrifying the Type A and Type B feeds and pouring the molten glass into canisters
- Solidifying the OIER (separated out at the basins) and insoluble solids.

The presence of large particles in the vitrification feed would make it difficult to obtain a representative sample of the waste slurry, which would be required to calculate the glass former addition to control the glass composition. Other problems that could result from large particles include accumulation of material on the melter floor, accelerated refractory corrosion, and inclusion in the glass. Therefore, the Vitrification Alternative would include an acid dissolution process to oxidize and size-reduce the large particles found in the Type B feed. Although the acid dissolution step would be similar to the process in the Chemical Treatment Alternative, it would differ in two key respects. First, the particle size requirement would be based on the capabilities of the small-scale melter rather than criticality and retrievability requirements of a DST, and a larger particle size could be tolerated. Second, the melter would be capable of accepting an acid feed, eliminating the need to add sodium hydroxide; this would be a significant factor in the volume of LAW glass produced.

Denitration of the acid solution would be included to reduce nitrogen oxide emissions from the melter. Additional sugar would be added to the melter feed to offset the oxidizing effect of remaining nitric acid and control oxidation in the melter. The latter would be important because an overly-oxidized glass could result in foaming of the melt.

Calcination. The Calcination Alternative would involve using a small-scale calcination unit to process the K Basins sludge into a dry particulate material. This would create a unique waste form that would be designed to meet the criteria for direct disposal at the WIPP. The WIPP waste acceptance criteria limit pyrophorics, total activity, and PCBs; limit fissile material loading; and prohibit free water. The high temperatures of the calcination process would remove free water, oxidize most metals and metal hydrides, and volatilize PCBs. Acid dissolution would be used to size reduce and oxidize larger particles prior to calcination. Fissile material loading would be addressed by limiting the amount of calcined product in a cask.

The Calcination Alternative flowsheet is shown schematically in Figure 5-6. This alternative

would include the following process steps:

- Transferring the sludge from the transport container to a lag storage tank
- Dissolving the sludge in nitric acid at near-boiling conditions (Type B feed only)
- Physically separating residual solids (mostly zirconium, dirt, and the remaining inorganic ion exchange media) from the acid solution (Type B feed only)
- Calcining the sludge with particle size less than 250 :m and the acid solution and pouring the calcined material into a container filling bin, and from there into containers
- Solidifying the OIER (separated out at the basins) and insoluble solids.

As in the Vitrification Alternative, Type B sludge would undergo acid dissolution prior to calcination. The dissolution process would facilitate oxidation of particles greater than 250 microns (.01 in). Sugar denitration would not be required because oxidation-reduction control would not be required in the calciner and because the offgas flow would be sufficiently low to allow absorber columns to remove nitrogen oxides from the offgas. Volume reduction of the feed would not be required because evaporation of excess liquid would be handled in the calciner. This would simplify the feed tank by eliminating the need to supply heat and provide a condenser.

It is assumed that the calciner maximum temperature would be 500^{o}C. The actual temperature selected would be determined based on a review of the uranium hydrate decomposition temperatures and an estimate of the hydrate-related hydrogen generation rates. Higher temperatures could be required to meet WIPP acceptance criteria if hydrogen generation from residual hydrates is an issue. Similarly, if the rates are determined to not be an issue, lower temperatures may be permissible.

Features Common to Both Vitrification and Calcination. As in the Chemical Treatment Alternative, the main processing equipment would be located inside a hot cell because of the dose rate associated with the K Basins sludge, and the hot cell would be designed with remote maintenance capability. The vapor space above the lag storage tank would be purged with air to maintain hydrogen gas concentrations below the lower flammability limit. The treatment system would be designed to meet dangerous waste design standards, including double containment and leak detection of liquid process streams, process vessels, and storage tanks. The system would be installed inside the CVD facility, which is located in the 100-K Area, or an alternate facility located at the Hanford Site.

The waste streams that would be generated under the Thermal Treatment Alternative would include the following:

- Treated sludge (Vitrification). It is anticipated that the treated sludge would be a glass matrix that would be designated as a HLW. It would not be regulated as a mixed waste

because vitrification is the specified treatment technology for HLW containing TCLP metals. Under the risk-based disposal approval for PCBs (Appendix C), the sludge would no longer be regulated under TSCA.

- Treated sludge (Calcination). It is anticipated that the treated sludge would be a calcined particulate material that would be designated as a TRU waste or mixed TRU waste. Under the risk-based disposal approval for PCBs (Appendix C), the sludge would no longer be regulated under TSCA.

- OIER/insoluble solids. It is anticipated that these streams would designate as TSCA-regulated TRU waste or mixed TRU waste. They would be managed as described for OIER/insoluble solids under Modified Chemical Treatment in Alternative 2.

- Contaminated off-gas. Treatment would generate an off-gas that would contain volatile and particulate radionuclides, PCBs, and potentially other regulated contaminants. The off-gas would be treated as described in the Alternative 2.

- Granular activated carbon. Spent GAC generated from the off-gas treatment system would likely be designated as a TSCA-regulated LLW. The GAC would be managed as described in Alternative 2.

- Aqueous waste. Aqueous streams (e.g., condenser condensate) generated during sludge treatment would be managed with other basin water as described in Section 5.6.2.

- Miscellaneous wastes. Other potential wastes would include contaminated air filters, debris collected during initial sludge screening (particles > 0.064 cm [0.25 in]), contaminated equipment, personal protective equipment, etc. This debris would be managed as described in Section 5.6.3 of this FFS.

5.4.3 Final Disposition

Vitrification. The product from the vitrification process would be a glass that meets the acceptance criteria at the national geologic repository. The glass would be required to undergo an extensive qualification process before being accepted at the repository. The canisters containing the glass would be loaded into shipping casks and shipped to interim storage awaiting final repository disposal. A total of 27 m^3 of glass would be generated, requiring about 46 3-meter canisters (Numatec 1999). The maximum fissile glass loading would be limited to 2500 g Pu/m^3.

Two locations were evaluated for interim storage of the glass canisters, the Canister Storage Building (CSB) and the CWC. Storage in the CSB would not be viable because of insufficient capacity (Numatec 1999). However, space may become available pending further studies by the TWRS regarding vitrified HLW storage and construction and operation of a new facility by the privatization contractor.

Although remote-handled material has been accepted at CWC in the past, CWC does not routinely accept remote-handled material. Special arrangements would be needed for storage of the remote-handled canisters. For purposes of the current study it was assumed that if sent to CWC, the glass canisters would be placed into cask storage systems (four canisters per system) and standalone casks (one canister per cask) that would provide shielding to contact dose levels. The cask storage systems and standalone casks would then be stored at CWC. Additional work would be required to determine the optimum storage package and location.

Calcination. The product from the calcination process would be a dry particulate material that meets the WIPP acceptance criteria. The containers holding the calcined product would be 3.8 L (1 gallon) cans. Manipulators would be used to fill the cans and place them into 80-liter (21-gallon) overpacks. Calcining the K Basins sludge would produce a total of 16 m^3 (565 ft^3) of calcined product, which would require filling about 4039 cans. Twenty-one cans would be placed into a single overpack for a total of about 192 overpacks. The overpacks would be expected to have a dose that allows for contact handling.

Three overpacks would be shipped in a single truckload to the CWC. For shipment to WIPP it is intended that the shielded overpack would itself be overpacked then placed into a TRUPACT-II shipping cask. The package arrangement would need to be approved by WIPP prior to shipment of the material to WIPP.

Under both Vitrification and Calcination, the OIER and insoluble solids would be solidified into 55-gallon drums. Solidification agents would be added to meet the ERDF or WIPP waste acceptance criteria. Assuming disposal to the ERDF, a total of 189 drums of waste would be generated with a total grouted volume of about 40 m^3 (1,400 ft^3).

5.5 ALTERNATIVE 5: SOLIDIFICATION

The Solidification Alternative would involve mixing the K Basins sludge with appropriate solidifying agents so that it could be disposed directly at the WIPP without further processing. Solidification would be an alternative to calcination as a method of treating the K Basins sludge to meet WIPP waste acceptance criteria. The WIPP waste acceptance criteria limit pyrophorics, total activity, and PCBs; limit fissile material loading per cask; and prohibit free water. Thermal pretreatment processes would be used to oxidize metals and metal hydrides and volatilize PCBs. The solidification process would eliminate free water. Total activity and fissile material loading requirements would be met through appropriate ratios of solidifying agents and mass loadings in containers.

Solidification would produce a bulk solid that would be transferred to an interim storage location at the Hanford Site, with final disposal (beyond the scope of the CERCLA action) offsite at the WIPP.

5.5.1 Sludge Retrieval and Removal

Sludge retrieval and removal would be the same as described for Modified Chemical Treatment in

Section 5.2.1. Three feed streams would be removed: OIER, particles with sizes less than 250 microns (.01 in) (Type A feed), and particles with sizes greater than 250 microns (.01 in) (Type B feed).

5.5.2 Process Description

The Solidification Alternative flowsheet is shown schematically in Figure 5-7. This alternative would include the following process steps:

- Transferring the small-particle sludge from the transport container to a feed tank
- Transferring the larger particle feed to a cell for pretreatment
- Draining and calcining the large-particle feed in batch furnaces, then transferring to the grout feed tanks
- Hot-water oxidation of the small-particle feed
- Combining the OIER with the small-particle feed
- Sampling the oxidized particles, adjusting the feed mix to maintain radiolytic heat generation and fissile content within acceptable limits in the final grout., then transferring to a mixing tank
- Adding water and solidifying agents, which could include Portland cement, fly ash, clays, or other additives, mixing, then pumping into canisters to solidify.

Oxidation of the metals and metal hydrides in the sludge prior to grouting would be important to reduce the pyrophoricity of the grout matrix and reduce the generation of flammable gas inside the grout canisters. Smaller particles could be effectively oxidized at a temperature of 100^{o}C, although it is estimated that it would require about 100 hours to oxidize a 250-micron (.01 in) metallic uranium particle. Particles larger than 250 micron (.01 in) would be oxidized via the more aggressive furnace process because the temperature and residence time in the grout process feed tanks would be insufficient to oxidize large particles of metals. The furnace process would be staged so that the sludge temperature is increased in increments. This would prevent spattering and uncontrolled hydride reactions during oxidation.

A cleaning system with spray nozzles would be included in the mixing tank. The system would be capable of using water or a weak acid decontamination solution and would be operated after each batch to prevent accumulation of grout deposits. Flush water and neutralized decontamination solution would be used in place of raw water to in making the grout.

As with the Chemical Treatment Alternative, the main processing equipment would be located inside a hot cell because of the dose associated with the K Basins sludge, and the hot cell would be designed with remote maintenance capability. The treatment system would be designed to meet dangerous waste design standards, including double containment and leak detection of liquid

process streams, process vessels, and storage tanks. The solidification system would be installed inside the CVD facility, which is located in the 100-K Area, or an alternate facility located at the Hanford Site.

The waste streams that would be generated under the Solidification Alternative would include the following:

- Treated sludge. It is anticipated that the treated sludge would be a solidified waste that would be designated as a TRU waste. It is assumed that solidification would meet RCRA treatment requirements for TCLP metals and that thermal pretreatment would be approved for treatment of PCBs as underlying constituents under a treatability variance (Appendix D). Under the risk-based disposal approval for PCBs (Appendix C), the sludge would no longer be regulated under TSCA.

- Contaminated off-gas. Treatment would generate an off-gas that would contain volatile and particulate radionuclides, PCBs, and potentially other regulated contaminants. The off-gas would be treated as described in the Alternative 2, with the exception that treatment for nitrogen oxides would not be required.

- Granular activated carbon. Spent GAC generated from the off-gas treatment system would likely be designated as a TSCA-regulated LLW. The GAC would be managed as described in Alternative 2.

- Aqueous waste. Aqueous streams (e.g., condenser condensate) generated during sludge treatment would be recycled to the treatment process. If an aqueous waste stream remains at the end of treatment, this stream would be managed with other basin water as described in Section 5.6.2.

- Miscellaneous wastes. Other potential wastes would include contaminated air filters, debris collected during initial sludge screening, contaminated equipment, personal protective equipment, etc. This debris would be managed as described in Section 5.6.3 of this FFS.

5.5.3 Final Disposition

The product from the Solidification process would be a grout that meets WIPP waste acceptance criteria as specified in Table 4-2. Assuming the addition of sufficient quantities of grout formers, the total volume of grout produced would be 315 m^3 (11,100 ft^3). Approximately 0.62 m^3 (22 ft^3) of slurry would be grouted in each batch to form 0.865 m^3 (30.5 ft^3) of grout. The grout would be placed into WIPP remote-handled (RH) canisters, which have a maximum volume of 0.89 m^3 (31 ft^3). Assuming that each canister would be about 97% full, a total of 364 RH canisters would be required.

There are two container options for the grout, WIPP RH canisters or shielded overpack containers that would allow disposal as contact handled (CH) waste. For purposes of developing

this alternative, it was assumed that RH canisters would be used. The currently approved WIPP packages would not provide sufficient shielding to allow shipment of the sludge in the CH configuration. Requiring WIPP approval of a new package prior to solidification would introduce significant schedule risk to the CH option. However, the reprocessing of the treated sludge to a different container would be difficult. The specific type of container would be evaluated further during remedial design.

The canisters containing the grouted sludge would require remote handling and would be stored at the Hanford Site prior to disposal at the WIPP. It is assumed that the CWC would serve as the interim storage location. Although RH material has been accepted at CWC in the past, CWC does not routinely accept RH material and special arrangements would be needed for storage of these canisters. It is assumed that the canisters would be placed into vented steel overpacks that would shield the canisters to CH dose levels. This overpack would then be stored at CWC. The canisters of grout would be transported to the WIPP in the NuPac-72B cask.

5.6 COMMON ELEMENTS

5.6.1 Spent Nuclear Fuel Management

SNF will be removed from the K Basins, subjected to cold vacuum drying at the CVD facility, and transferred to the CSB for interim storage. Alternatives for managing the SNF currently

stored in the K Basins were evaluated in the K Basins EIS (DOE 1995, DOE 1996a) and included the following:

- No action
- Enhanced K Basin storage
- New wet storage
- Drying/passivation with dry storage
- Calcination with dry storage
- Onsite processing
- Foreign processing.

The preferred alternative identified in the EIS and selected in the ROD (61 FR 10736) was removal of the SNF from the basins, drying/passivation, and dry storage. The passivation process consisted of hot conditioning. Subsequent to issuing the ROD, the method for drying the SNF was modified to cold vacuum drying. Environmental impacts of the modification were evaluated in a NEPA Supplement Analysis that determined that the environmental impacts of deleting the passivation process were bounded by the original EIS and that no further NEPA review was required (DOE 1998).

The K Basins EIS analyzed the environmental impacts of the SNF removal, drying, and interim storage and that analysis is not repeated here. Rather, this section describes those activities associated with the SNF that are part of the CERCLA action: removal and transfer to the CVD

facility. Drying at the CVD facility and interim storage at the CSB are not part of the CERCLA action, but the CVD facility is briefly described here to demonstrate that SNF will be managed appropriately. The cold vacuum drying process and interim storage continue to be authorized under the original EIS and ROD and the Supplement Analysis. The specific activities conducted under the authority of the CERCLA action are as follows:

- The SNF will be agitated to loosen and remove sludge and corrosion product; the sludge and corrosion product will remain in the basin to be consolidated with other sludge.
- The SNF will be placed into fuel baskets, and the fuel baskets will be placed inside multi-canister overpacks (MCOs).
- The MCOs will be closed and transferred to the CVD for drying. The CVD has been constructed in the 100-K Area near the K Basins.
- Liquid drained from the MCOs at the CVD and during further processing will be returned to the K Basins for recycling, or transferred to an authorized onsite water treatment facility.

The SNF retrieval, washing, and packaging activities at the basins could potentially generate emissions such as airborne particulate. These activities will be conducted under water to control the generation of airborne particulate. Air emissions approvals will be obtained from the appropriate regulatory agencies prior to the start of SNF retrieval.

The CVD is an appropriate facility to receive the SNF. The CVD is being designed and constructed to achieve nuclear safety equivalence comparable to NRC-licensed facilities. The use of standards consistent with NRC requirements provides a high level of safety and environmental protection. All necessary regulatory approvals, such as air emissions approvals, will be obtained for the CVD prior to receipt of the SNF.

5.6.2 Water Management

The K Basins together contain about 9.8 million L (2.6 million gal) of contaminated water. The contaminated water removed from the K Basins will be pretreated at the basins, transferred to the ETF in the 200 East Area for further treatment, then disposed at the State-Approved Land Disposal Site (SALDS) in the 200 West Area. The K Basins EIS analyzed the environmental impacts of the water pretreatment process, treatment at ETF, and disposal at SALDS and that analysis is not repeated here. Rather, this section describes those activities associated with the K Basins water that are part of the CERCLA action: removal, pretreatment, and transfer to the 200 Area. Treatment at ETF and disposal at the SALDS are not part of the CERCLA action but are described here to demonstrate that these facilities are appropriate for receiving the water generated by the CERCLA action.

New and upgraded systems are being added to the existing water treatment system at the K Basins to create an Integrated Water Treatment System (IWTS) for each of the basins. The

IWTS will provide the necessary collection of contaminated basin water, treatment of the water, and return of treated water to all basin processes that require water, such as canister decapping, fuel retrieval, debris cleaning, and sludge retrieval. During SNF retrieval, some water will be removed with the SNF and trapped inside the MCOs. When the water is drained from the MCOs during later processing, it may be recycled to the basins and managed with the bulk of the contaminated water. This recycle will help maintain necessary water levels in the basins and reduce the volumes of wastewater generated. Alternately, the water may be transferred directly to an authorized onsite treatment facility. Clean water will be added to the basins to maintain the water at the level necessary to cool and provide radiation shielding in the basins during removal activities.

The water that is removed will be treated via the IWTS at each basin. The IWTS as planned consists of a pre-filter to remove particulate matter and an ion exchange module to remove remaining radioactive contaminants except tritium. Tritium cannot be effectively separated from water. The basin water will be sampled to determine if it contains PCBs. If PCBs are detected at concentrations greater than 0.5 ppb, additional filtration will be added to the IWTS to ensure that PCB concentrations in the water leaving the system are equal to or less than 0.5 ppb. If an aqueous stream that is separated from a TSCA-regulated waste stream has PCB concentrations less than 0.5 ppb, the aqueous stream is not regulated under TSCA (40 CFR 761.79).

Operation of the IWTS and any other water treatment systems associated with the CERCLA action will generate secondary wastes such as ion exchange modules and cartridge filters. Any carbon filters added to provide PCB treatment would be managed as a TSCA-regulated waste upon removal. All other components of the IWTS, such as ion exchange modules, will be managed as debris as described in Section 5.5.3, e.g., drained of free-flowing liquid and managed as LLW, mixed waste, TRU waste, or mixed TRU waste, as appropriate.

The IWTS will meet or be modified, as appropriate, to meet the ETF waste acceptance criteria. The pretreated water will be pumped into tanker trucks for transport to the 200 East Area. In the 200 East Area, the K Basins water will be off-loaded at the ETF and either processed there or routed to the Liquid Effluent Receiving Facility for storage. The ETF is an existing water treatment system that treats a variety of liquid wastes generated at the Hanford Site. The facility meets all applicable requirements associated with air emissions, wastewater treatment and discharge, and management of mixed waste. The ETF treatment system includes filtration to remove particulate matter, an ultraviolet/oxidation system to destroy organic constituents and a reverse osmosis and ion exchange unit that removes inorganic and radionuclide constituents, except tritium. There is currently no economically viable treatment for tritium. Treated effluent from the ETF is piped to the SALDS in the 200 West Area where it is discharged to the soil column. The discharge is performed in accordance with a State of Washington water discharge permit (Ecology 1995). The ETF also operates in accordance with dangerous waste interim status requirements, the requirements of the ETF air approval (DOH 1995), and the requirements of the final delisting (40 CFR 261, Appendix IX, Table 2-2). The water discharge permit and other documents will be modified as necessary before K Basins water is received. Contaminants and by-products removed during the treatment process at the ETF are concentrated and dried into a powder. The powder generated from treating water generated under the K Basins interim remedial action may be disposed at the ERDF if it meets the ERDF waste acceptance criteria and if the powder is associated exclusively with the treatment of K Basins water or other water generated from CERCLA activities. Otherwise, the powder will be disposed at another authorized facility.

5.6.3 Debris Management

All of the SNF management alternatives in the K Basins EIS (except no action) considered management of debris generated as part of the basin cleanout to be part of the alternative. As described in Section 2, debris is defined as any solid waste resulting from the CERCLA remedial action, excluding sludge and wastewater. Debris includes items located both above and below the water in the basins, wastes generated from operation of the water and sludge treatment systems, and wastes generated during basin deactivation. Debris will be removed from the basins throughout the course of the K Basins cleanout and during deactivation of the basins. The scope of this FFS only includes removing the debris from the basins or treatment facilities, assigning the appropriate waste designation, and transferring the debris to an approved waste management facility appropriate for the designation.

The K Basins EIS assumed that the debris would be designated as LLW and would be disposed of at Hanford Site LLW disposal facilities. Under CERCLA, the disposal facility for debris designated as LLW will be the ERDF. Based on further evaluation, debris might also designate as solid waste, low-level mixed waste, TRU waste, or TRU mixed waste, depending on contaminant concentrations associated with the specific items. All debris will be drained of free-flowing liquid as it is removed from the basins and will not subsequently be regulated under TSCA[12]. Debris for

[12] Because some on the debris might have contacted TSCA-regulated sludge, it constitutes a PCB Article. In accordance with regulations at 40 CFR 761.60(b)(5)(ii), PCB Articles that are drained of free-flowing liquid are no longer regulated under TSCA.

which no reuse, recycle, or decontamination option is identified will be assigned an appropriate waste designation (e.g., solid, radioactive, dangerous, mixed). Debris management will depend on the waste designation:

- **Low-level waste.** It is anticipated that most of the debris will designate as radioactive LLW and be disposed at the ERDF. The ERDF is authorized to accept debris that is designated as LLW and also non-liquid TSCA-regulated PCBs (BHI 1998). The ERDF is a near-surface landfill located in the 200 West Area, designed for permanent disposal of wastes generated from Hanford Site remediation activities. The ERDF was authorized via a CERCLA ROD (EPA et al. 1995) and can accept any remediation waste that is addressed in a CERCLA decision document and that meets the ERDF waste acceptance criteria. The ERDF meets minimum technological requirements for dangerous waste landfills including standards for a double liner, a leachate collection and removal system, leak detection, and final cover. Current and anticipated future public access controls at the 200 Area limit inadvertent intrusion.

  Before disposal at the ERDF, LLW from the K Basins might be treated (e.g., by crushing, sizing, sorting, etc.) to minimize volumes for disposal. For example, when the fuel canisters are emptied, they may be transported to an offsite facility to be crushed, then returned for disposal. The crushed canisters will be returned to the Hanford Site for disposal at ERDF.

- **Mixed waste.** Some of the debris might designate as mixed (radioactive and dangerous) waste. Mixed waste will be disposed at either the ERDF (described above) or the radioactive mixed waste trenches (Trenches 31/34) located in the 200 West Area of the Hanford Site. Both the ERDF and Trenches 31/34 meet the 10 CFR 61 standards for disposal of LLW and State of Washington dangerous waste landfill design standards. The ERDF can accept mixed waste that is TSCA-regulated. Trenches 31/34 are not approved as chemical landfills under TSCA, however, TSCA allows bulk PCB waste to be disposed at RCRA-permitted (or State of Washington equivalent) facilities. Trenches 31/34 are near surface trenches engineered for permanent disposal of mixed wastes generated from Hanford Site activities and operated under dangerous waste interim status. They meet minimum technological requirements for dangerous waste landfills including standards for a double liner, a leachate collection and removal system, leak detection, and final cover. The trenches are currently able to store containerized waste but have not begun receiving waste for disposal. Mixed waste from the K Basins that might eventually be disposed there will be temporarily stored in the trenches or at the CWC in the 200 West Area. The CWC consists of a set of buildings designed to store a variety of

wastes including TRU, radioactive, and mixed wastes. The buildings are designed and operated in accordance with dangerous waste storage provisions.

Before disposal at either Trenches 31/34 or ERDF, mixed waste debris from the K Basins will be treated as necessary to meet the LDR requirements (e.g., by macro encapsulation of lead items) or to minimize volumes for disposal.

- **TRU Waste, Mixed TRU Waste.** A small fraction of the debris might designate as either contact-handled or remote-handled TRU waste, or TRU mixed waste (waste that designates as both dangerous waste and TRU waste). This might happen if sludge or fuel particles are trapped inside debris. Debris with entrained sludge or fuel particles will be placed into a basket at the K Basins, agitated to dislodge the sludge and particles, and washed with water. Any debris that is still TRU-designated after this washing will be stored temporarily at the CWC until it can be packaged and certified at Hanford's Waste Receiving and Packaging facility for eventual disposal at WIPP. Under all of the alternatives, neither SNF nor TRU waste would be disposed at the Hanford Site. The WIPP meets 40 CFR 191 requirements for TRU waste disposal and is a RCRA-permitted disposal facility. It is not authorized as a chemical landfill under TSCA. However, TSCA allows bulk PCB waste to be disposed at RCRA-permitted facilities. The WIPP waste acceptance criteria restrict PCB concentrations to less than 50 ppm.

- **Solid Waste.** Debris that is not contaminated will be managed as solid waste. To the extent practicable, such debris will be recycled. Debris that designates as solid waste and that cannot be recycled will be disposed at an authorized municipal landfill or construction debris landfill as appropriate.

5.6.4 Basin Deactivation

Once the SNF, sludge, water, and debris such as canisters are removed from the K Basins, the basins will be deactivated. Deactivation will remove additional hazardous materials and place the basins into a condition such that they can be maintained safely with minimal surveillance and maintenance until such time as interim safe storage activities are implemented. Deactivation could include the following activities:

- Equipment that is not an integral part of the basin structures will be drained, removed, decontaminated as appropriate, packaged, and disposed of as debris (see Section 5.5.3). Such equipment could include components of the SNF retrieval system and washing station, the IWTS, and the sludge retrieval system.

- Sludge treatment system equipment and the structure in which it is installed will be removed, decontaminated as appropriate, packaged, and disposed as debris.

- The basin structure will be decontaminated to the extent required to meet criteria for transition to the Environmental Restoration program.

- Support systems such as electrical, heating, ventilation, and air conditioning, water supply, and monitoring that are not required for future environmental compliance or personnel safety will be de-energized.

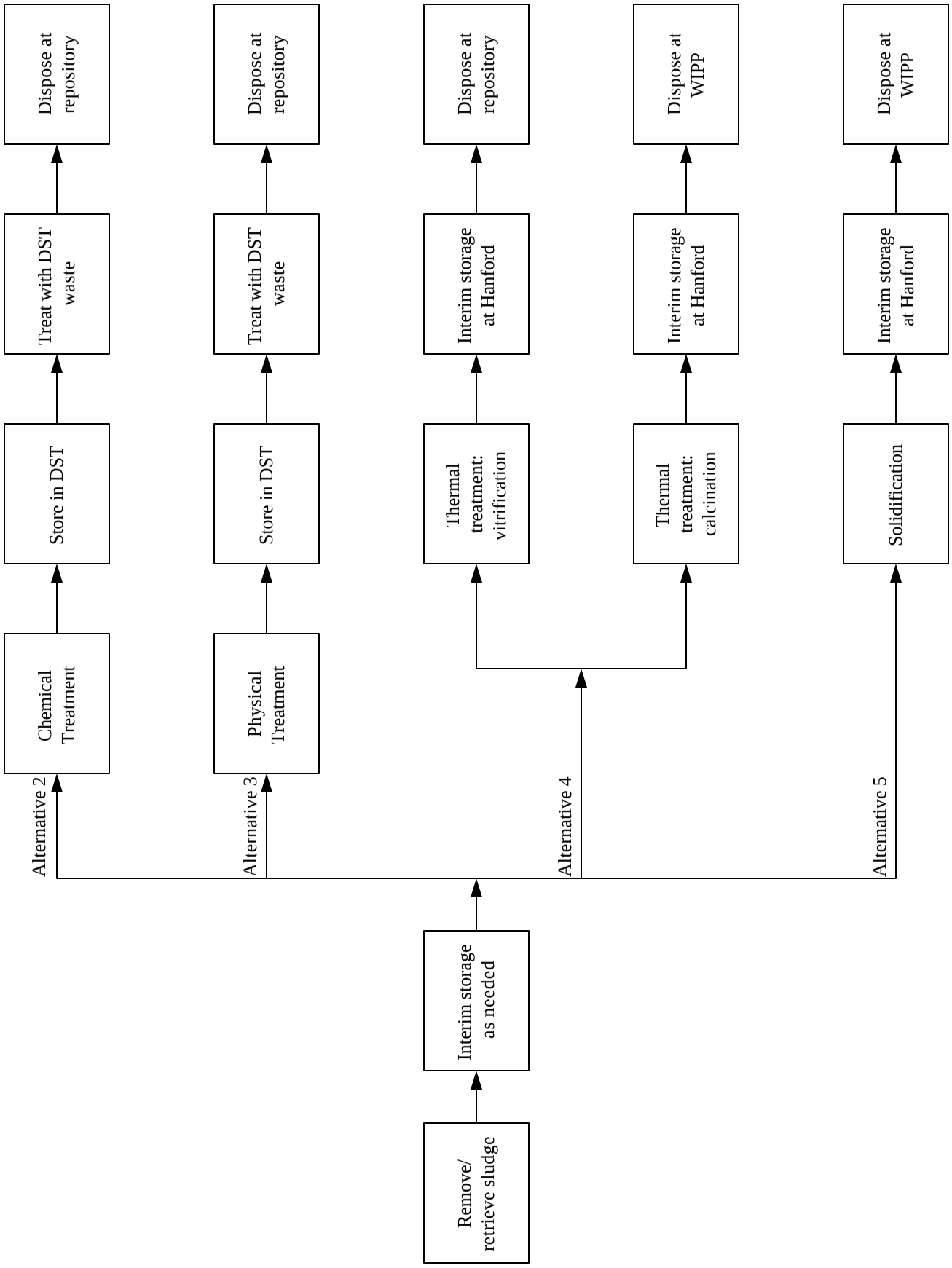
- Structural repairs will be made as necessary for future surveillance and maintenance needs.

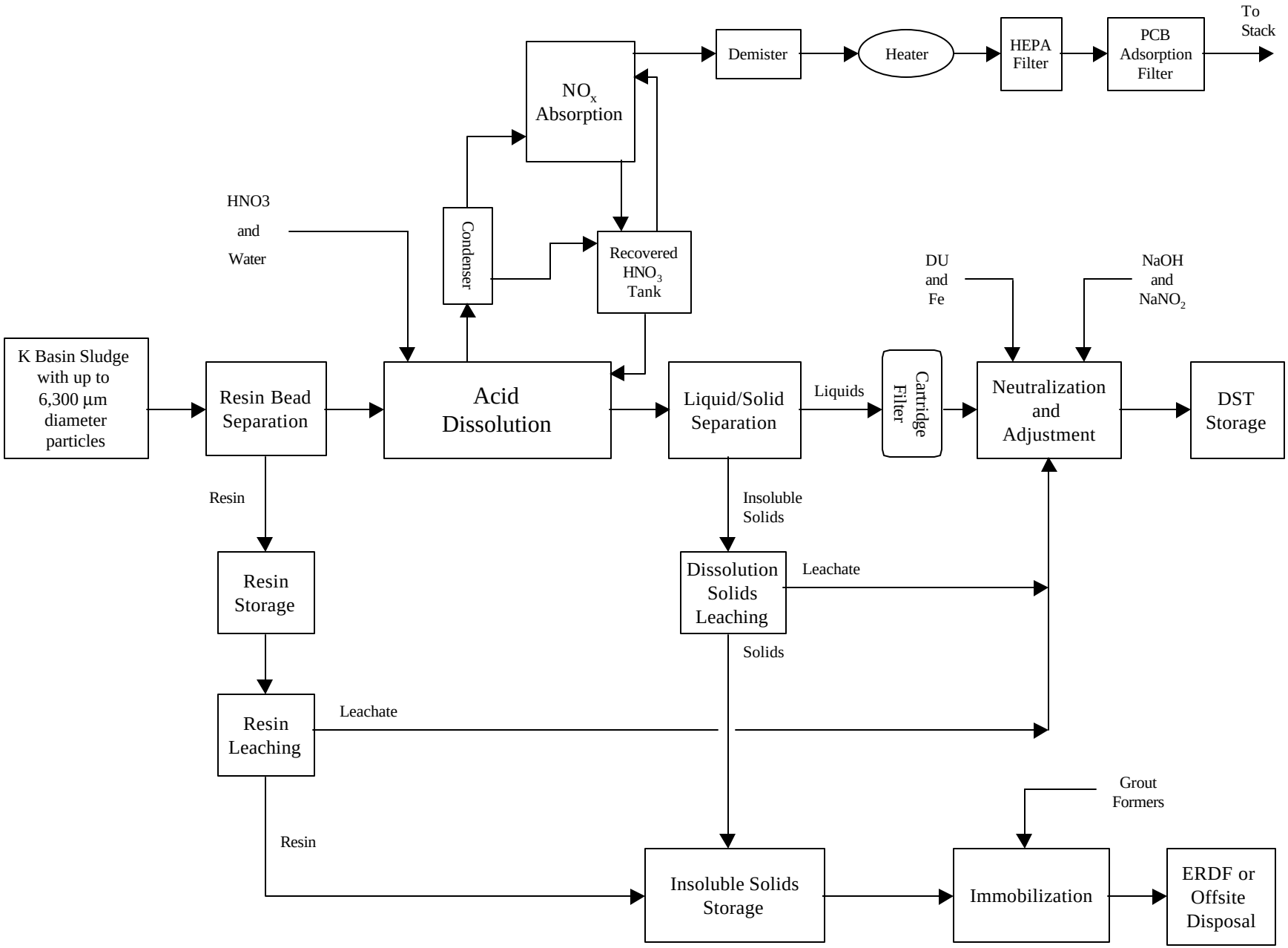
- Building penetrations will be sealed to prevent entry of animals, and personnel access controls will be installed.

Deactivation is several years in the future and activities needed to complete deactivation have not been fully defined. There will be an amendment to the CERCLA remedial design report and remedial action work plan (prepared following the ROD) to more fully describe the activities when deactivation planning is complete.

It is expected that the basins will still be radiologically contaminated at the end of deactivation, but activity levels cannot be estimated at this time. The contamination will be stabilized as part of deactivation to prevent releases to the environment. After deactivation, air and groundwater monitoring and controls to prevent public access will be continued as appropriate until such time as final remedial action is completed. Current access controls include signs along the river, an 8-foot fence, locked access to buildings containing the primary hazards, and routine patrols.

Figure 5-1. Sludge Management Pathways for Treatment Alternatives.

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Demister
Heater
HEPA Filter
PCB Adsorption Filter
NO_x Absorption
HNO3 and Water
Condenser
Recovered HNO_3 Tank
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K Basin Sludge with up to 6,300 µm diameter particles
Resin Bead Separation
Acid Dissolution
Liquid/Solid Separation
Liquids
Cartridge Filter
Neutralization and Adjustment
DST Storage
Resin
Insoluble Solids
Resin Storage
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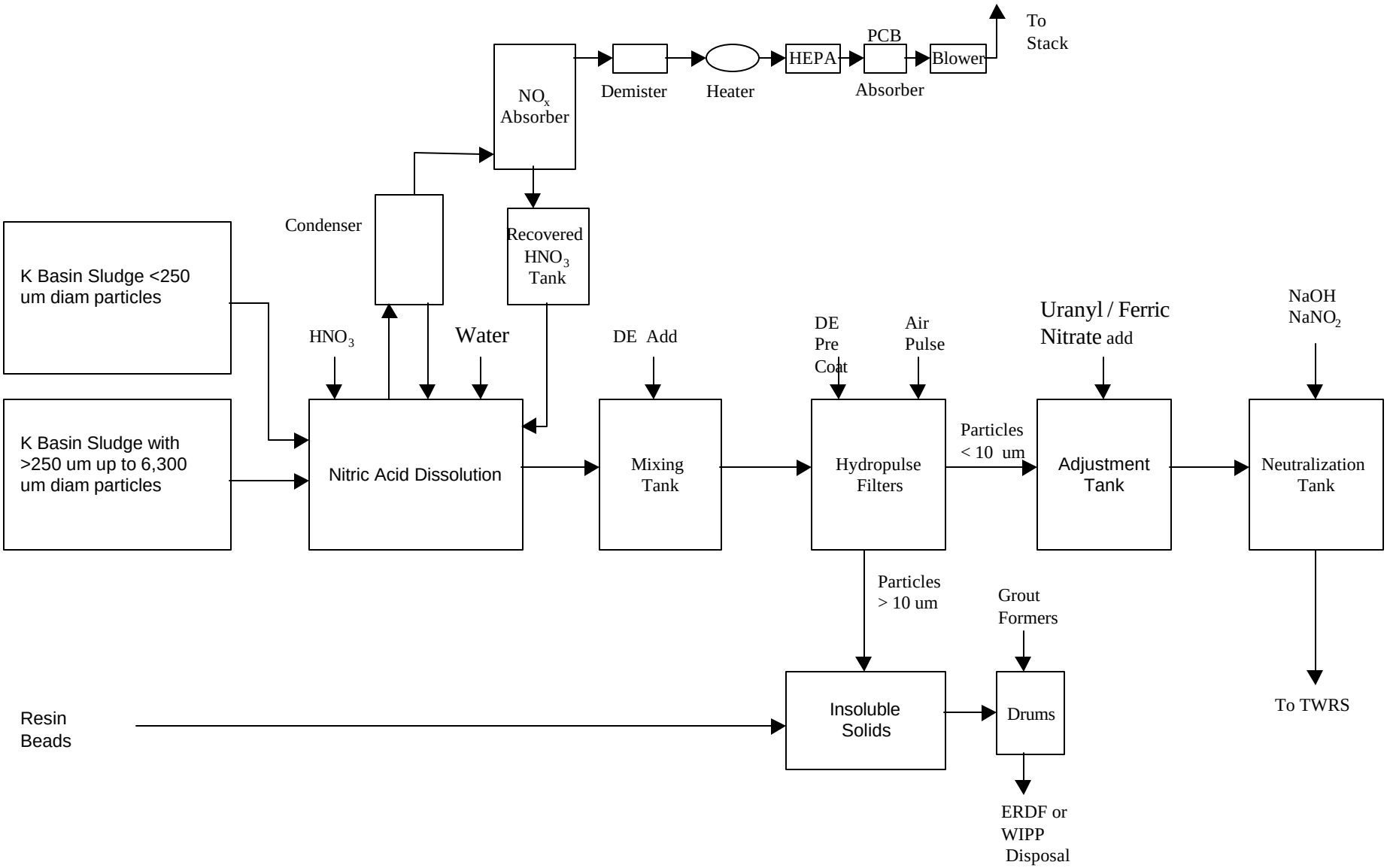
Immobilization
ERDF or Offsite Disposal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PCB
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Demister
Heater
Absorber
Condenser
Recovered HNO_3 Tank
K Basin Sludge <250 um diam particles
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HNO_3
Water
Nitric Acid Dissolution
DE Add
Mixing Tank
DE Pre Coat
Air Pulse
Hydropulse Filters
Particles < 10 um
Uranyl / Ferric Nitrate add
Adjustment Tank
NaOH
$NaNO_2$
Neutralization Tank
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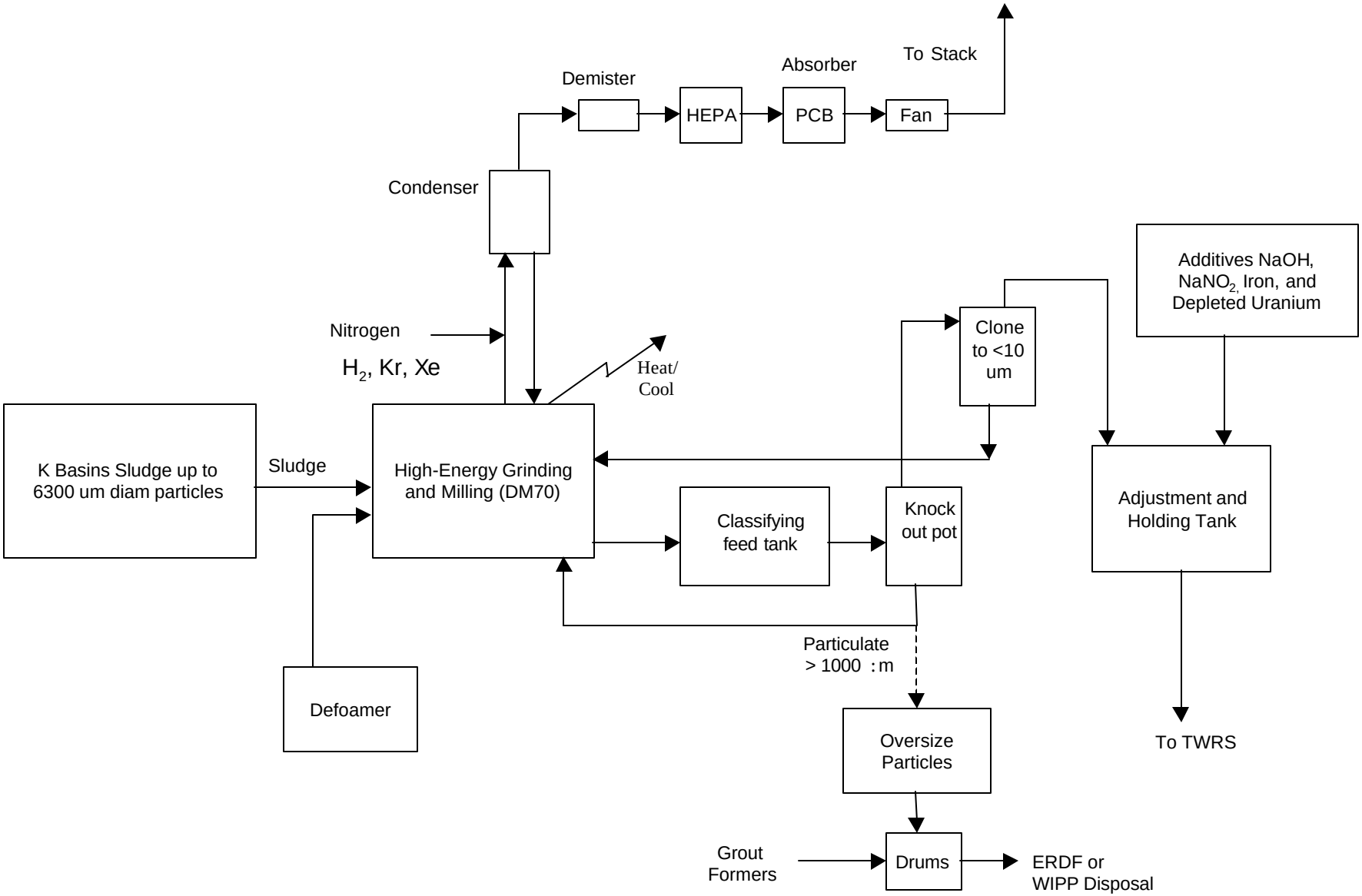
Particles > 10 um
Grout Formers
Resin Beads
Insoluble Solids
Drums
ERDF or WIPP Disposal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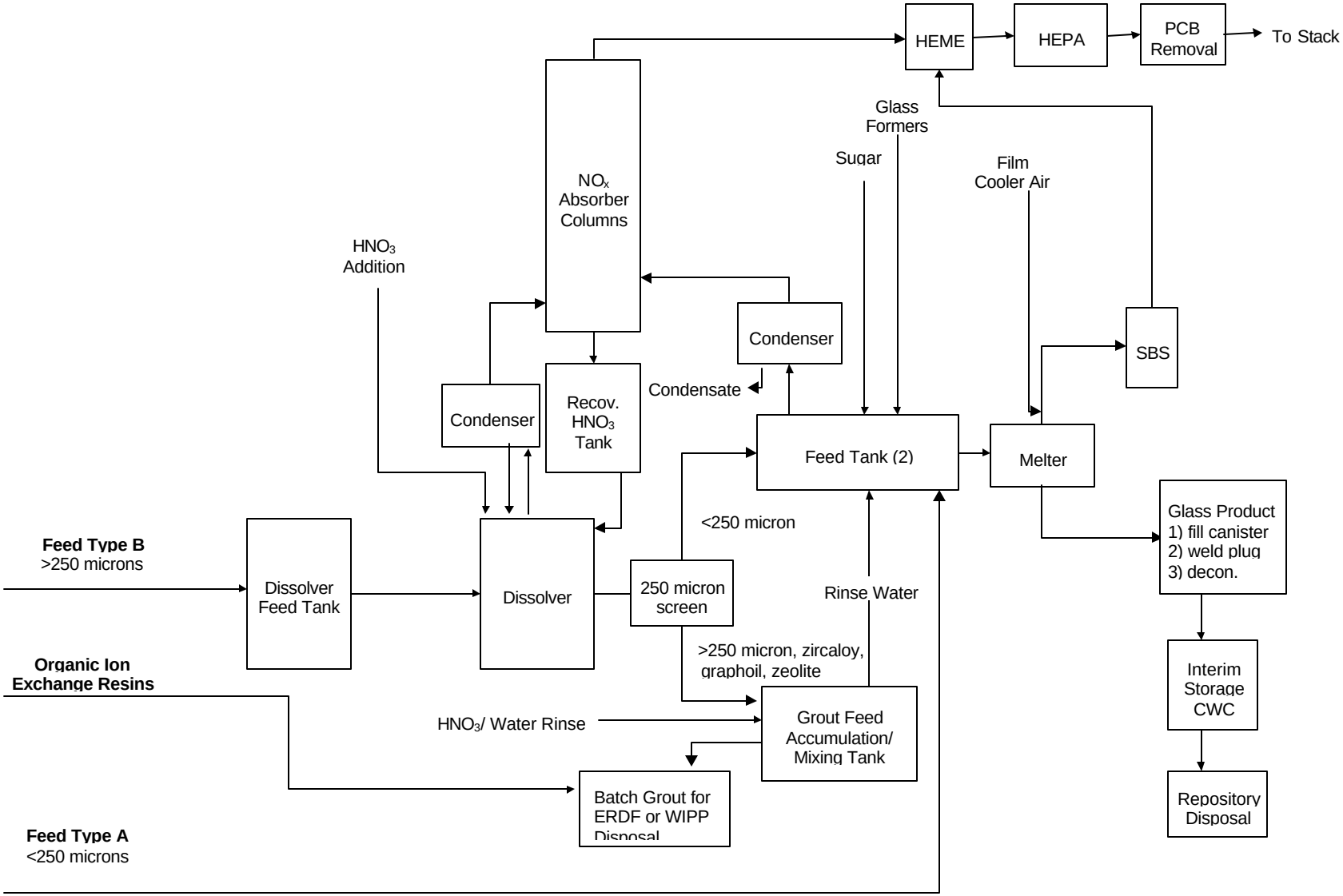
Absorber
Demister
HEPA
PCB
Fan
Condenser
Additives NaOH, $NaNO_2$, Iron, and Depleted Uranium
Nitrogen
H_2, Kr, Xe
Heat/ Cool
Clone to <10 um
K Basins Sludge up to 6300 um diam particles
Sludge
High-Energy Grinding and Milling (DM70)
Classifying feed tank
Knock out pot
Adjustment and Holding Tank
Particulate > 1000 :m
Defoamer
Oversize Particles
To TWRS
Grout Formers
Drums
ERDF or WIPP Disposal


HEME
HEPA
PCB Removal
To Stack
Glass Formers
Sugar
Film Cooler Air
NO_x Absorber Columns
HNO_3 Addition
Condenser
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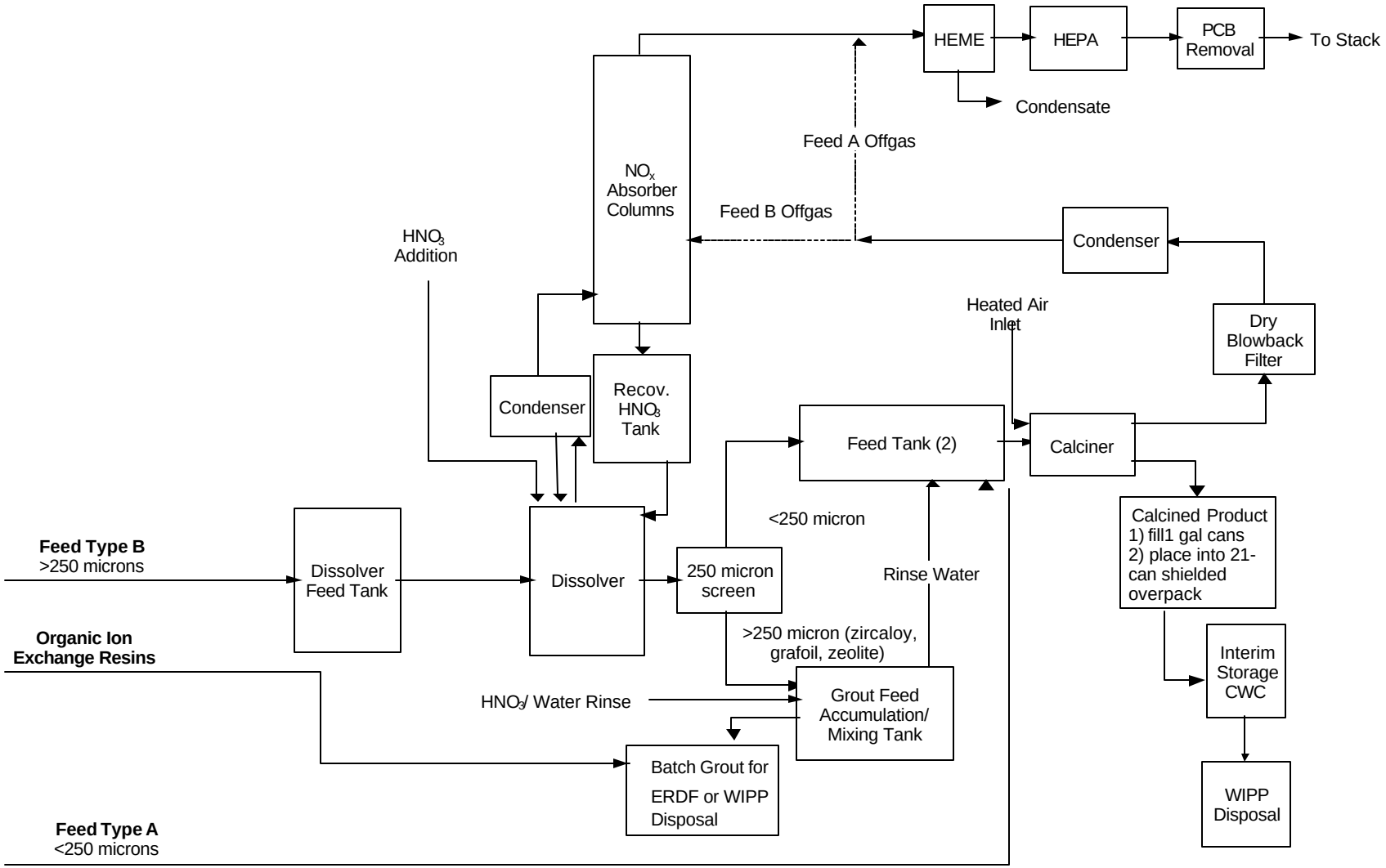
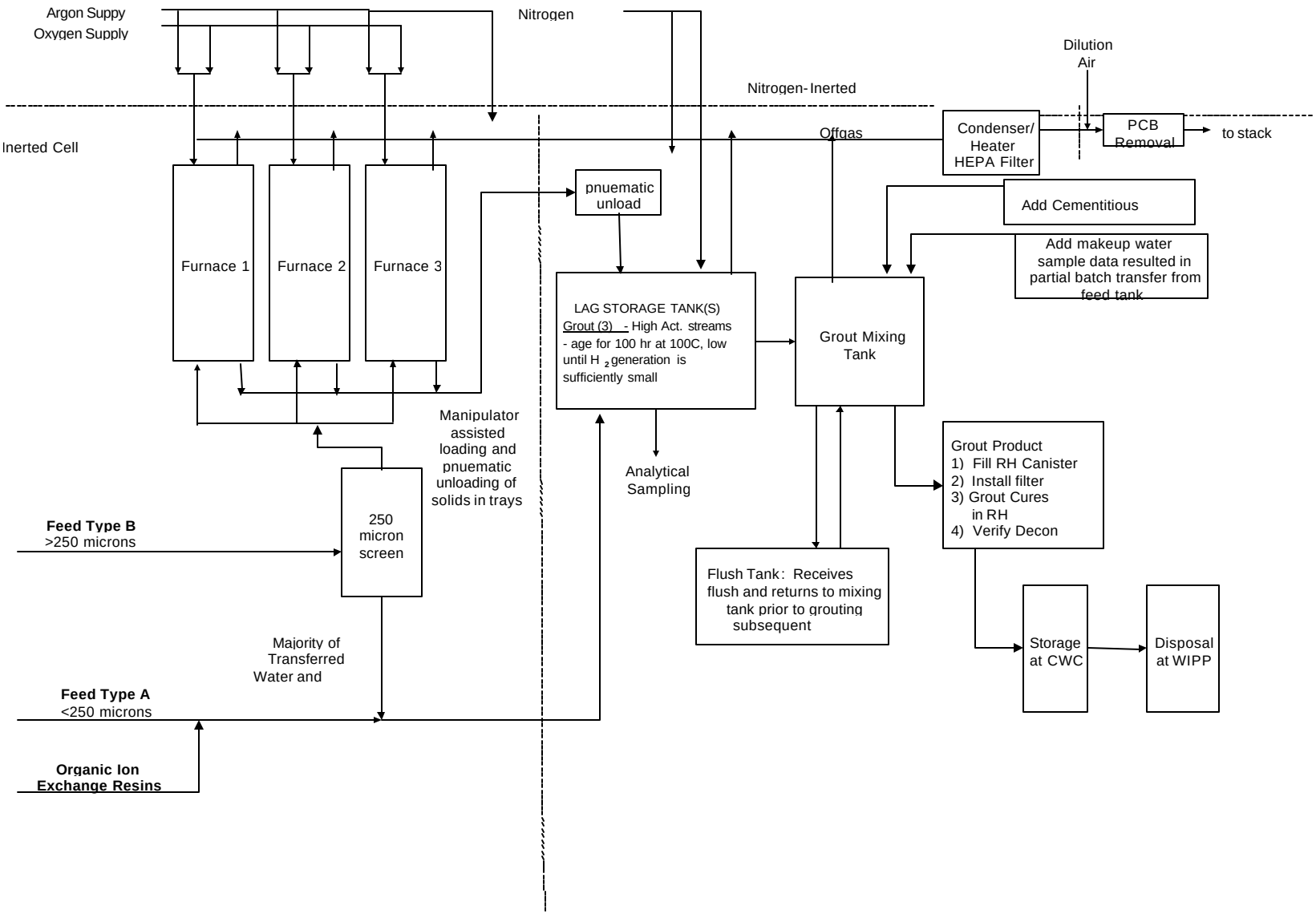
Condensate
Condenser
Recov. HNO_3 Tank
Feed Tank (2)
Melter
<250 micron
Feed Type B
>250 microns
Dissolver Feed Tank
Dissolver
250 micron screen
Rinse Water
Glass Product
1) fill canister
2) weld plug
3) decon.
Organic Ion Exchange Resins
>250 micron, zircaloy, graphoil, zeolite
Interim Storage CWC
HNO_3/ Water Rinse
Grout Feed Accumulation/ Mixing Tank
Batch Grout for ERDF or WIPP Disposal
Repository Disposal
Feed Type A
<250 microns


HEME
HEPA
PCB Removal
To Stack
Condensate
Feed A Offgas
NOx Absorber Columns
Feed B Offgas
HNO3 Addition
Condenser
Heated Air Inlet
Dry Blowback Filter
Condenser
Recov. HNO3 Tank
Feed Tank (2)
Calciner
<250 micron
Feed Type B
>250 microns
Dissolver Feed Tank
Dissolver
250 micron screen
Rinse Water
Calcined Product
1) fill1 gal cans
2) place into 21-can shielded overpack
Organic Ion Exchange Resins
>250 micron (zircaloy, grafoil, zeolite)
Interim Storage CWC
HNO3/ Water Rinse
Grout Feed Accumulation/ Mixing Tank
Batch Grout for ERDF or WIPP Disposal
WIPP Disposal
Feed Type A
<250 microns


Argon Suppy
Oxygen Supply
Nitrogen
Dilution Air
Nitrogen-Inerted
Inerted Cell
Offgas
Condenser/ Heater HEPA Filter
PCB Removal
to stack
pnuematic unload
Add Cementitious
Add makeup water sample data resulted in partial batch transfer from feed tank
Furnace 1
Furnace 2
Furnace 3
LAG STORAGE TANK(S)
Grout (3) - High Act. streams - age for 100 hr at 100C, low until H 2 generation is sufficiently small
Grout Mixing Tank
Manipulator assisted loading and pnuematic unloading of solids in trays
Analytical Sampling
Grout Product
1) Fill RH Canister
2) Install filter
3) Grout Cures in RH
4) Verify Decon
Feed Type B
>250 microns
250 micron screen
Flush Tank: Receives flush and returns to mixing tank prior to grouting subsequent
Storage at CWC
Disposal at WIPP
Majority of Transferred Water and
Feed Type A
<250 microns
Organic Ion Exchange Resins

6.0 DETAILED ANALYSIS OF ALTERNATIVES

CERCLA requires that remedial action alternatives be evaluated against nine specific criteria. These criteria serve as the basis for conducting detailed and comparative analyses and for the subsequent selection of appropriate remedial actions. The nine CERCLA evaluation criteria are:

1. Overall protection of human health and the environment
2. Compliance with ARARs
3. Long-term effectiveness and permanence
4. Reduction of toxicity, mobility, or volume through treatment
5. Short-term effectiveness
6. Implementability
7. Cost
8. State of Washington acceptance
9. Community acceptance.

The first two criteria, overall protection of human health and the environment and compliance with ARARs, are threshold criteria. Alternatives that do not protect human health and the environment or do not comply with ARARs (or justify a waiver) do not meet statutory requirements and are eliminated from further consideration in this FFS. The next five criteria (long-term effectiveness and permanence; reduction of toxicity, mobility, or volume through treatment; short-term effectiveness; implementability; and cost) are balancing criteria upon which the remedy selection is based. State of Washington acceptance and community acceptance will be further evaluated after public review of the Proposed Plan.

The detailed analysis in Sections 6.2 through 6.6 evaluates each alternative against these criteria and assigns a rating of one to three stars as follows:

* Does not meet the criterion very well or has significant disadvantages or uncertainty
** Performs moderately well against a criterion but with some disadvantages
*** Meets a criterion very well with no significant disadvantages.

There may be some criteria against which none of the alternatives perform very well. A qualitative assessment of a criterion is made based on engineering judgement when quantitative information is not available. The detailed analysis addresses the entire scope of the CERCLA action, but greater emphasis is placed on evaluating sludge treatment because environmental impacts associated with the SNF, water, and debris were previously analyzed in the K Basins EIS (DOE 1995).

In addition to the nine CERCLA criteria, NEPA values have been incorporated into this document. Assessment of these values is important to the integration of NEPA into CERCLA documents, as called for by both the DOE Secretarial Policy on NEPA (O'Leary 1994) and DOE Order 451.1A (DOE 1997). Appendix A evaluates the alternatives against NEPA values.

6.1 DESCRIPTION OF CERCLA CRITERIA

6.1.1 Overall Protection of Human Health and the Environment

This criterion determines whether adequate protection of human health and the environment, including preservation of natural systems and biological diversity, is achieved through implementation of the remedial alternative. Protection includes reduction of risk to acceptable levels (either by reduction of concentrations or the elimination of potential routes for exposure) and minimization of exposure threats introduced by actions during remediation. Environmental protection includes avoiding or minimizing impacts to natural, cultural, and historical resources. Additionally, this criterion evaluates the potential for human health risks, the extent of those risks, and whether there will be a net environmental benefit as a result of implementing the remedial alternative.

This first criterion is a threshold requirement and the primary objective of the remedial action program. As indicated in EPA guidance, there is overlap between this criterion and the criteria for compliance with ARARs, long-term effectiveness and permanence, and short-term effectiveness (EPA 1988).

6.1.2 Compliance with ARARs

This criterion addresses whether a remedial alternative attains the federal and State of Washington ARARs and to-be-considered (TBC) materials listed in Appendix B or whether a waiver is justified. When an ARAR is not met, the basis for justifying a waiver must be presented. No ARAR waiver is proposed for any of the alternatives identified in this FFS.

6.1.3 Long-Term Effectiveness and Permanence

This criterion addresses the results of a remedial action in terms of risks that remain at the site after RAOs are met. The primary focus of this evaluation is the extent and effectiveness of the controls that may be required to manage the risk posed by treatment residuals and/or untreated wastes. The following components of the criterion are considered for each alternative:

- Magnitude of residual risk to human and ecological receptors. This factor assesses the residual risk from untreated waste or treatment residuals after remedial activities are completed. The characteristics of the residual wastes are considered to the degree that they remain hazardous, taking into account their volume, toxicity, mobility, and propensity to bioaccumulate.

- Adequacy and reliability of controls. This factor assesses the adequacy and suitability of controls used to manage treatment residuals or untreated wastes that remain at the site. It also assesses the long-term reliability of management controls for providing continued protection from residuals, and it includes an assessment of the potential need for replacement of the technical components associated with an alternative.

Residual risk to natural and cultural resources after conclusion of remedial activities also is evaluated. Current environmental conditions are assessed against the alternative's long-term and permanent solutions. The assessment considerations are based on whether lasting environmental losses would be incurred for the sake of short-term cleanup gains, including whether environmental restoration and/or mitigation options would be precluded if a remedial alternative were to be implemented.

6.1.4 Reduction of Toxicity, Mobility, or Volume Through Treatment

This criterion addresses the degree to which a remedial alternative uses treatment to reduce the toxicity, mobility, or volume of hazardous substances. The evaluation focuses on the following factors for each of the alternatives:

- The treatment processes used and the materials treated
- Whether there is recycling, reuse, or waste minimization in the treatment process
- The type and quantity of treatment residuals that remain following treatment, and whether any special treatment actions will be needed
- Whether the alternative satisfies the statutory preference for treatment as a principal element.

6.1.5 Short-Term Effectiveness

This criterion evaluates the potential effects on human health and the environment during the construction and implementation phases of a remedial action. This criterion also considers the time required to achieve protection. The following factors are considered for each alternative:

- Health and safety of remediation workers and the public and reliability of protective measures taken
- Physical, biological, and cultural impacts that may result from the construction and implementation of the remedial action, and whether the impacts can be controlled or mitigated
- The amount of time for the RAOs to be met.

Short-term human health impacts are closely related to the duration of exposure to hazardous wastes and risks associated with removal of wastes. Typically, the greater the exposure time, the greater the risk. As low as reasonably achievable (ALARA) guidelines will be practiced during implementation of the remedial action to minimize worker risks.

6.1.6 Implementability

This criterion addresses the technical and administrative feasibility of implementing an alternative and the availability of the required services and materials. The following factors are considered for each alternative:

- Technical feasibility, such as the likelihood of technical difficulties in constructing and operating the alternative, the likelihood of delays due to technical problems, and uncertainties related to technologies

- Administrative feasibility, such as the ability to coordinate activities with other offices and agencies and the potential for regulatory constraints to develop

- Availability of services and materials, such as the availability of adequate treatment, storage capacity, and disposal services and the availability of necessary equipment, specialists, and provisions.

6.1.7 Cost

This criterion considers the cost of implementing a remedial alternative, including capital costs, operation and maintenance, and monitoring costs.

The K Basins cleanout is an unusual CERCLA action in two ways relative to cost. First, some of the project activities were initiated before CERCLA authority was imposed, so costs associated with those activities are “pre-CERCLA.” Second, many facilities needed to support the CERCLA action (e.g., the CVD) are not themselves regulated under CERCLA authority. To the extent possible, the cost criterion is presented so as to differentiate costs strictly attributable to CERCLA activities from those outside of CERCLA.

The cost estimates for the purposes of this FFS are presented as future-worth dollars and prepared from information that was available at the time the FFS was prepared. The actual cost of the project will depend on additional information gained during the remedial design phase, the final scope and design of the selected remedial action, the schedule of implementation, the competitive market conditions, and other variables.

6.1.8 State of Washington Acceptance

This criterion evaluates the technical and administrative issues and concerns that the State of Washington may have regarding a remedial alternative. The regulatory acceptance process involves a review and concurrence by the State of Washington. A preliminary evaluation of this criterion is provided in Section 7.8 based on the State's review of the draft FFS.

6.1.9 Community Acceptance

This criterion evaluates the issues and concerns the public may have regarding a remedial alternative. A preliminary evaluation of this criterion is provided in Section 7.9 based on input from the public to date on the SNF Project. This criterion will be addressed further following public review of the Proposed Plan.

6.2 ALTERNATIVE 1: NO ACTION

6.2.1 Overall Protection of Human Health and the Environment (Rating: *)

The No Action Alternative would fail to provide overall protection of human health and the environment and would not meet the objectives of the remedial action. It would not mitigate further deterioration of the SNF, preclude future releases of hazardous substances to soil beneath the K Basins, or treat basin contents to make them acceptable at interim storage/disposal facilities. This alternative would require continuing surveillance and maintenance of the basins, with increased maintenance as the basins age, and this would result in increased radiation exposure to workers.

6.2.2 Compliance With ARARs (Rating: NA)

New ARARs would not be invoked because no action would be taken. However, surveillance and maintenance activities at the K Basins would still be subject to currently applicable requirements if the No Action Alternative were selected

6.2.3 Long-Term Effectiveness and Permanence (Rating: *)

The No Action Alternative would not be effective in the long term. Rather, the risk would increase in the long term because SNF, sludge, debris, and water would remain in the K Basins where they could present a threat to the environment. The likelihood of a release to the environment would increase with time due to the increasing difficulty of maintaining the integrity of the basins. The No Action alternative would not be permanent in that action would ultimately be required, either in the form of major upgrades to maintain the integrity of the basins or cleanout of the basins.

6.2.4 Reduction in Toxicity, Mobility, and Volume Through Treatment (Rating: *)

There would be no treatment under the No Action alternative and thus no reduction of toxicity, mobility, or volume.

6.2.5 Short-Term Effectiveness (Rating: *)

The No Action Alternative would require no removal, transfer, or treatment of the hazardous substances in the basins. Therefore, the potential for releases and worker exposure would not

increase over current operations in the short term. However, the potential for impacts to the public, the environment, and workers would increase in the long term.

In 1993, routine surveillance and maintenance operations at the K Basins resulted in a collective dose to the offsite population within 80 km (50 MI) of 0.0051 person-rem. A comparable dose would be expected in the short term for each year that the No Action Alternative continues (DOE 1995), although it very likely could increase in the long term. The No Action Alternative would also fail to reduce occupational exposure and risks to workers. Although exposure and risks to workers can be mitigated via engineering and administrative controls, risks cannot be eliminated.

6.2.6 Implementability (Rating: *)

The No Action Alternative would fail to comply with decisions made via the K Basins EIS and ROD, milestones proposed under the Tri-Party Agreement, and commitments made to the regulatory agencies, oversight agencies, and the public. Thus, the No Action Alternative would not be administratively feasible. It might be technically feasible in the near term, but would ultimately require major upgrades to the basins that could be difficult and costly to implement.

6.2.7 Cost

The cost for the No Action Alternative would be approximately $20 M for each year that the SNF, sludge, debris, and water remain in the K Basins. This cost would support surveillance and routine maintenance at the basins, but would not include costs that would be incurred if the basins are upgraded for continued storage and costs to eventually cleanout and deactivate the basins.

6.3 ALTERNATIVE 2: CHEMICAL TREATMENT

6.3.1 Overall Protection of Human Health and the Environment (Rating: ***)

Alternative 2 would achieve overall protection of human health and the environment. The risk of further releases from the basins would be reduced significantly by removing SNF, sludge, water, and debris and deactivating the basins. SNF would be dried and placed in sealed MCOs to prevent further degradation. Sludge, water, and debris would be treated, as appropriate, to meet TWRS, ETF, and ERDF waste acceptance criteria. The removal and treatment processes would result in a temporary increase in worker exposure and a potential increase in public exposure, but in the long-term occupational and public exposure and potential adverse environmental impacts would be reduced.

6.3.2 Compliance With ARARs (Rating: ***)

ARARs are identified in Appendix B. Alternative 2 would be designed to comply with all ARARs and TBC materials. Key ARARs would include standards for liquid effluent discharge, radioactive waste management, dangerous waste management, PCB management, air emissions, and radiation protection.

The IWTS would treat basin water to meet ETF waste acceptance criteria for chemicals and radionuclides. The water in the basins is radioactive but does not designate as a mixed waste. Therefore, dangerous waste management requirements would not apply to the water. The water as-is in the basins is a PCB remediation waste. However, the IWTS would reduce the concentration of PCBs to less than 0.5 ppb, the decontamination standard for water for unrestricted use (40 CFR 761.79(b)(1)(iii)), so the water would no longer be regulated under TSCA. The ETF would be an appropriate receiving facility for the water because it is designed and operated in compliance with dangerous waste requirements, a radioactive air emissions approval (DOH 1995), and the discharge limits and monitoring requirements listed in the State of Washington-issued waste discharge permit (Ecology 1995). Ecology has previously determined that the ETF provides all known and reasonable treatment for evaporator process condensate. Prior to transferring K Basins water to the ETF, Ecology would be requested to make a similar determination for the K Basins water.

Debris would be designated in accordance with solid, dangerous, and radioactive waste and PCB management requirements and stored or disposed at facilities designed and operated to accept the assigned waste designation. Some of the debris such as underwater debris in the basins, sludge treatment system equipment, and off-gas filters would be designated as PCB remediation waste. This TSCA-regulated debris would be managed as follows:

- As the underwater debris is removed from the basins it would be drained of free-flowing liquid and rinsed with water to remove the majority of sludge adhering to the debris. Thereafter, the debris would be managed in accordance with applicable radioactive waste and dangerous waste requirements, but would no longer be designated or managed as a TSCA-regulated waste. The debris would not be sampled for PCBs because of the potential for radioactive exposure to workers.

- Sludge treatment system equipment would be decontaminated as appropriate for radioactive constituents then disposed at either the ERDF or the WIPP. The equipment would not be sampled for PCBs. However, for purposes of disposal the equipment still would be assumed to be PCB remediation waste.

- GAC filters and other filters used to remove PCBs from the off-gas would be disposed at either the ERDF or the WIPP. The filters would not be sampled for PCBs because of the potential for radioactive exposure to workers. However, for purposes of disposal the filters would be assumed to be PCB remediation waste.

DOE requests that EPA approve these debris management methods described above under the TSCA risk-based disposal approval (40 CFR 761.61(c)).

Debris that designates as a mixed waste would be treated to meet LDR standards prior to disposal. For debris that designates as a mixed waste, LDR treatment would be required to address underlying constituents, including PCBs. The LDR treatment standard for PCBs is 10 mg/kg (10 ppm). Because of the mass of the debris itself, it is assumed that residual PCB concentrations on the debris would not exceed this treatment standard.

The chemical treatment system would be required to treat the sludge sufficiently to meet the TWRS waste acceptance specifications for criticality control, corrosion, and particle size and prohibitions on pyrophoric materials, non-radiolytic gas generation, and TSCA-regulated material. In support of the last criterion, DOE requests that EPA approve the proposed chemical treatment processes (both baseline and modified) as adequate to exit TSCA regulation, in accordance with the TSCA risk-based disposal approval requirements (40 CFR 761.61(c)) and the information provided in Appendix C.

Assuming that the TSCA approval is granted, the sludge would be managed as a mixed radioactive waste. The mixed waste designation would result from TCLP metals. An existing DST would be an appropriate interim storage facility for mixed waste because the DSTs were designed to meet radioactive waste management standards and they have been determined by Ecology to satisfy dangerous waste storage requirements. Any other tank(s) used to store the treated sludge would be required to comply with the radioactive waste and dangerous waste requirements. Vitrification of the sludge via TWRS-P and disposal at the national geologic repository would meet radioactive waste management requirements for HLW waste. In addition, vitrification is the specified LDR treatment technology for mixed HLW that is designated for TCLP metals. Thus, vitrification would be expected to meet LDR treatment requirements.

The designation of OIER and insoluble solids depends on the chemical treatment option. Under the Baseline Chemical Treatment Alternative, the OIER and insoluble solids would be TSCA-regulated LLW and would likely be disposed at the ERDF. Under Modified Chemical Treatment, they would designate as a TSCA-regulated mixed LLW or mixed TRU waste and would be disposed at the ERDF (for LLW) or the WIPP (for TRU waste).[13] OIER and insoluble solids disposed at the ERDF would require treatment as appropriate to meet LDR standards for any constituents causing them to be designated as dangerous waste. They would also require treatment for RCRA underlying constituents, regardless of the designation of the OIER and insoluble solids, because the original K Basins sludge is a mixed waste designated for TCLP metals. PCBs are an underlying hazardous constituent in the sludge. The LDR standards for TCLP metals are specific leachate concentrations that could be met through solidification. The LDR standard for PCBs is a total concentration and would be met through treatment as

[13] Under Baseline Chemical Treatment, most of the toxic characteristic metals would likely be removed along with TRU constituents during the leaching step so the OIER/insoluble solids would be unlikely to designate as mixed waste. Modified Chemical Treatment would not include leaching processes so the OIER/insoluble solids could contain toxic characteristic metals at levels that would designate as dangerous waste.

appropriate. Pursuant to the WIPP Land Withdrawal Act Amendment (Public Law 104-201), waste disposed at the WIPP is not required to meet the LDR standards.

Air emissions generated during retrieval and removal of the sludge would be controlled by keeping the sludge wet and conducting above-water sludge transfers in double-contained piping. BACT and BARCT analyses would be performed during remedial design to identify controls for off-gas from the sludge treatment system. It is anticipated that radioactive particulate air emissions generated during sludge treatment would be controlled by HEPA filters, which have generally been demonstrated to meet BARCT. Controls for nitrous oxide (a regulated air pollutant) and chemical off-gases (toxic air pollutants) would be determined via the BACT analysis. PCB emissions would be controlled using GAC, a standard technology that would be required to meet the PCB emissions requirement of 10 micrograms per cubic meter.

The sludge treatment system would be designed to meet dangerous waste management unit standards. Any offsite transportation of wastes would be performed in compliance with U.S. Department of Transportation (DOT) and NRC requirements.

Summary (Rating: *).** The Chemical Treatment Alternative would meet all ARARs with no significant issues, assuming that the TSCA risk-based disposal approval is granted.

6.3.3 Long-Term Effectiveness and Permanence (Rating: ***)

Alternative 2 would be very effective in the long term. The risk of further releases from the basins would be reduced significantly and permanently by removing the SNF, sludge, water, and debris from the basins and deactivating the basins. The radioactive and chemical contaminants removed from the basins would be taken to more environmentally protective facilities several miles from the Columbia River. Removing the water from the basins would eliminate the major potential driving force for carrying contaminants to groundwater. Treatment of the sludge and pretreatment of the water would permanently reduce the risk associated with those streams. Deactivation of the basins would ensure that any remaining contamination is stabilized. DOE controls on public access to the 100-K Area would remain in place following the interim remedial action, until final remedial action is completed.

Residuals from the CERCLA action that could pose a potential risk to the environment would consist of the SNF, treated sludge, pretreated water, and debris. This risk would be minimized and controlled by transferring these residuals to existing or planned facilities that would provide a high degree of reliability with respect to protection of human health and the environment. SNF would be transferred to the CVD for drying and ultimately placed in the CSB for interim storage. The CVD and CSB are designed to standards comparable to NRC facilities, and thus provide a high degree of protection. The treated sludge would be transferred to an existing DST and ultimately vitrified and disposed at the national geologic repository. Vitrification followed by repository disposal is recognized as one of the most effective means of managing highly-radioactive wastes such as the K Basins sludge. Geologic disposal of such wastes minimizes the reliance on long-term active controls. The ERDF and the WIPP would be reliable

facilities for disposing of debris and wastes from sludge treatment because they are engineered to meet stringent landfill standards.

Summary (Rating: *).** The majority of the hazardous substances would be removed from the K Basins and placed into more protective facilities, thus permanently reducing the risk of further releases to the environment.

6.3.4 Reduction in Toxicity, Mobility, and Volume Through Treatment (Rating: *)

Alternative 2 would reduce the toxicity and mobility of hazardous substances slightly via treatment of the K Basins water and sludge, but there would be a significant increase in waste volume from the sludge treatment process.

The pretreatment process for basin water would significantly reduce radioactivity levels in the water. The contaminants removed from the water would be concentrated onto filters and ion exchange media where they would be less mobile and would present a smaller waste volume to manage. Treating the water at ETF (beyond the scope of the CERCLA action) would further reduce contaminant concentrations.

Under the Chemical Treatment Alternative, the treatment process would reduce the risk associated with the sludge by making it critically safe, reducing flammable gas generation, and eliminating the reactivity/pyrophoricity associated with metal fines. Treatment would also reduce toxicity by removing some of the PCBs, although the risk associated with the PCBs is already very low (Appendix C). The activity of the radionuclides in the sludge, which is the primary risk, would remain unchanged. There would be no reduction in the mobility of sludge contaminants as part of the Chemical Treatment Alternative. However, final treatment of the sludge via TWRS (beyond the scope of the CERCLA action) would significantly reduce the mobility of sludge contaminants by immobilizing them in a glass matrix.

The Chemical Treatment Alternative would increase the volume of treated sludge destined for interim storage by a factor of about 30, and would increase the final volume of material to be disposed by a factor of about 10.[14] Some of the volume increase would be due to the addition of water needed to slurry the sludge from the basins. Ultimately, this water would be evaporated in the TWRS system, and the condensate would be treated at the ETF and discharged to the soil column. The rest of the near-term volume increase and essentially all of the long-term volume

increase would be attributed to the addition of chemicals (primarily sodium as sodium hydroxide)

[14] The volume of settled sludge in the basins is about 51 m^3 (1,800 ft^3)and the volume of sludge removed as a slurry would be about 260 m^3 (9,200 ft^3), a five-fold increase. The volume of treated sludge would be 1,620 m^3 (57,200 ft^3) (Baseline Chemical Treatment) or 1,525 m^3 (54,000 ft^3) (Modified Chemical Treatment) (Numatec 1999). Assuming that the treated sludge is managed with the waste in Tank 105-AW, there would no incremental increase in the volume of HLW glass produced. However, there would be an incremental increase of 571 m^3 (20,100 ft^3) (Baseline Chemical Treatment) or 468 m^3 (16,500 ft^3) (Modified Chemical Treatment) in the volume of LAW glass produced (Numatec 1999).

and neutron absorbers during sludge treatment.

Chemical treatment would also generate secondary waste, primarily OIER and insoluble solids. The estimated volume of non-TRU waste would be 35 m^3 (1,240 ft^3) (Baseline) to 371 m^3 (13,100 ft^3) (Modified). The mobility of contaminants in the OIER and insoluble solids would be reduced significantly through solidification.

Summary (Rating: *). The Chemical Treatment Alternative would reduce toxicity significantly by reducing or eliminating hazards associated with criticality, flammable gas, and reactivity/pyrophoricity. There would be no reduction in mobility as part of the CERCLA action, but there would be a significant reduction in mobility when the sludge is treated with DST waste (beyond the scope of the CERCLA action). A major disadvantage would be that the sludge volume requiring interim storage would increase by a factor of 30 over the original volume of as-settled sludge, and the final volume of glass produced would be a factor of 10 times greater than the original volume.

6.3.5 Short-Term Effectiveness (Rating: **)

Risk to public and environment. Alternative 2 would present a potential risk to the public and the environment, primarily associated with the potential for airborne and liquid releases of contaminants. The primary risk would be associated with radioactive contaminants, where an airborne release to the environment could result in a dose to the offsite public.

The offsite dose associated with the routine removal of the SNF, sludge, water, and debris from the basins, drying the SNF, and transferring the SNF, sludge, water, and debris to facilities in the 200 Area was evaluated as part of the K Basins EIS. The dose to the maximally exposed individual (MEI) for these activities was estimated to be less than 0.1 mrem/year, which is less than 1% of the EPA and State of Washington standard of 10 mrem/year for radioactive air emissions. The collective dose to the offsite population was estimated at 0.59 person-rem over 2 years (DOE 1995).

The EIS analysis did not consider the routine impacts associated with airborne releases from a sludge treatment system. The chemical treatment system would produce an off-gas that contains chemical and radiological contaminants. To mitigate this, the treatment system would be designed with a ventilation system that designed to meet BACT and BARCT requirements. It is anticipated that the treatment system would include condensers and scrubbers (for nitrogen oxides and volatile emissions), HEPA filters (for particulate material), and GAC (for PCBs) that would treat the air prior to its discharge to the environment. Emissions would be monitored and controlled as appropriate. The treatment system would be located inside the CVD or another enclosed facility that would provide additional emissions control.

A conservative estimate of the potential abated dose from radioactive air emissions was made for the chemical treatment system. The estimate used the following assumptions:

- All of the sludge would be treated within one year.

- Treatment would take place in the 100-K Area.

- The potential release fraction for the sludge would be 1.00E-03. This is the default fraction for particulate material specified for preparation of an Notice of Construction (NOC) for radioactive air emissions under WAC 246-247.

- The off-gas treatment system would include at least one bank of HEPA filters with a removal efficiency rating of 99.95%. No credit is taken for other components of the off-gas treatment system.

These assumptions and the total sludge radionuclide inventory presented in Tables 2-1 and 2-2 were used to calculate the offsite dose using the Clean Air Act Assessment Package – 1988 (CAP 88)[15] model. The dose to the MEI for chemical treatment was estimated to be less than 0.02 mrem/year (less than 1% of the EPA and State of Washington standard of 10 mrem/year for radioactive air emissions). Emissions estimates would be refined during remedial design and NOCs with the refined estimates would be submitted to EPA and the State of Washington for approval prior to operation. BACT and BARCT analyses would be used to identify appropriate emissions controls and minimize airborne releases.

There would also be risks to the public and environment associated with upset conditions and non-routine releases from the chemical treatment system. Specific concerns and mitigation measures associated with the Chemical Treatment Alternative (Baseline and Modified) would include the following:

- Treatment would involve suspending or dissolving contaminants in chemical solutions. Leaks from vessels, piping, and other equipment could potentially transport the radioactive material to the environment. To mitigate this, the process equipment would be double-contained. The treatment system would be located in the CVD or another enclosed facility that would provide additional containment for liquid spills.

- The sludge contains significant quantities of fissile material (^{235}U and ^{239}Pu). A criticality would be unlikely; however, if one were to occur, it could result in airborne releases of contaminants. The treatment system design would incorporate features such as the use of soluble nuclear poisons and fissile material mass limits on the main process vessels to ensure criticality safety. Accumulation of a fissile mass in vessel heels would be prevented by inspection, tank level monitoring, and mass balance calculations.

[15] The CAP-88-PC software package is used to model air dispersion and dose for the purpose of demonstrating compliance with 40 CFR 61.03 (a) and WAC 246-247.

- Hydrogen would be generated both by radiolysis and by oxidation of metals and metal hydrides. At certain concentrations, hydrogen gas is flammable, and accumulation could result in a fire and airborne releases. The transport and treatment systems would be designed to dilute the off-gas to ensure that hydrogen does not accumulate to flammable levels.

- Chemical treatment would involve oxidizing uranium metal with nitric acid, an exothermic reaction that would produce hydrogen gas and nitrogen oxides. If the reaction were to be too vigorous, foaming could result. To prevent this, the chemical reaction rate would be controlled by controlling the rate of feed to the dissolver and controlling the temperature.

- The presence of OIER could potentially be a concern in the dissolver because nitrated OIER is very reactive if allowed to dry out. The treatment system would include a step to separate the OIER from the sludge before the sludge is transferred to the dissolver. Only relatively dilute acid would be used in the OIER leaching step included in the Baseline Chemical Treatment Alternative.

- Insoluble solids that would be centrifuged or filtered after dissolution would include zirconium, which is pyrophoric and which could ignite. The solids would be kept wetted in the centrifuge to preclude a pyrophoric reaction.

- Neutralization/precipitation of the dissolver solution and grouting of insoluble solids would produce significant amounts of heat. The process vessels would be equipped with cooling coils to mitigate excessive heat buildup.

Risks to Workers. Alternative 2 would present a potential risk to workers, primarily associated with radioactive exposure and chemical hazards. Risks associated with removing the SNF, sludge, water, and debris from the basins were discussed in the K Basins EIS (DOE 1995).

Key risks and mitigation measures associated with chemical treatment of the sludge would include the upset conditions identified above and the following:

- The sludge would present a high potential dose to workers during treatment and transportation. Preliminary shielding calculations show that the sludge would require a significant amount of shielding (up to 75 cm of concrete for the main process vessels) (Numatec 1999). To minimize worker dose during treatment, most facility operations would be performed remotely. However, contact maintenance could be required on significant fraction of the treatment system equipment. A combination of administrative and physical controls would be utilized to assure that personnel radiation exposures remain ALARA.

- The treatment process would use a number of non-radioactive process chemicals that could be hazardous to workers. These would include nitric acid, nitric/hydrofluoric acid, oxalic acid, iron, depleted uranium, sodium hydroxide, sodium nitrite, and grout formers

(dust hazard). These chemicals would be provided with spill containment and possibly with venting systems to control liquid and gaseous emissions.

- Physical hazards to workers would include pressurized vessels and piping, rotating equipment (pumps, centrifuge, and fans), vehicular traffic, and electrical hazards associated with equipment. There would also be construction hazards associated with installing the treatment system in an existing facility in which other operations are ongoing. The interface of construction and operating functions would be carefully considered to avoid degradation of the safety envelope of the existing facility and to avoid injuries to either construction or operating personnel.

Schedule. The schedule for Alternative 2 would be as follows:

- Begin SNF removal from basins: November 30, 2000
- Complete SNF removal from basins: December 31, 2003
- Begin sludge removal from basins: July 31, 2004
- Complete sludge removal from basins: August 31, 2005
- Complete water removal from basins and replacement: October 31, 2006
- Complete removal of SNF, sludge, debris, and water from the basins: July 31, 2007.

These dates have been established in Tri-Party Agreement Milestone M-34-00.

Summary (Rating: **). The Chemical Treatment Alternative would be relatively complex and there would be a moderate potential for upset conditions. However, the severity of an upset would be relatively low because the treatment system would be enclosed in a hot cell-like facility. In addition, the systems would utilize unit operations that have been successfully used in the nuclear industry for forty years. Thus, the process control and safety control technology is mature and well-established, and potential risks to the public and workers can be readily controlled and mitigated. Risks would be addressed by more detailed safety analysis reports and health and safety plans prior to final design, construction, and operation. The CERCLA action would be completed by July 2007, with the exception of deactivation activities that could continue beyond that time.

6.3.6 Implementability (Rating: **)

Technical Feasibility. The removal of SNF, sludge, water, and debris has been evaluated extensively and processes to accomplish removal have been identified. The facilities required to manage the SNF after it is removed from the basins are under construction. The systems needed to pretreat the water have been designed and are under construction. The ETF would be expected to be able to accommodate treatment of the basin water. The ERDF and the WIPP would be expected to be able to accommodate disposal of secondary wastes and debris that meet waste acceptance criteria.

The chemical treatment process for sludge would utilize mature technology and processes. Acid

dissolution and precipitation of uranium-bearing material have been used extensively in the fuel manufacturing and reprocessing industry, and nitric acid dissolution of uranium-based reactor fuel elements was performed at Hanford plants for over 40 years. The specific unit operations proposed for the K Basins sludge have been developed and tested in the laboratory using actual or simulated sludge (Westra et al. 1998). Modified Chemical Treatment would be somewhat less complex than Baseline Chemical Treatment because it would use fewer process steps (7 versus 11), but there is a high degree of confidence that either one would meet the TWRS criteria. The off-gas emission controls identified for chemical treatment would be based on standard technologies used in the nuclear industry. Solidification is a well-established technology for radioactive and mixed waste.

A key technical benefit associated with the Chemical Treatment Alternative would be that, once the treated sludge is accepted into TWRS, it would lose its unique identity. Thus, long-term issues associated with management of a unique waste form would be avoided.

The following issues have been identified related to the technical feasibility of chemically treating the sludge as follows:

- There is a concern as to whether Tank-105-AW could accommodate the volume of solids and total volume of slurry that would be generated under the Chemical Treatment Alternative. The estimated volume of slurry has been included in past waste volume projections for TWRS. However, recent changes in other Hanford programs (e.g., delay in privatized vitrification) have placed an additional burden on tank space. Therefore, it is possible that all waste generators would be requested to review waste volumes and minimize them where possible. From this standpoint, Modified Chemical Treatment would be preferable over Baseline Chemical Treatment because the volume of slurry would be about 25 percent less. In addition, the volume of solids in the treated sludge might exceed the solids limit of 100,000 gal imposed on K Basins sludge receipts into Tank 105-AW. This limit was established to control flammable gas retention in the tank (Carothers et al. 1997). TWRS has identified Tank 103-AW as an additional receiver tank for K Basins sludge, so this issue would not be expected to decrease the viability of the Chemical Treatment Alternative.

- It is very uncertain whether the 13-month sludge removal schedule established by the Tri-Party Agreement could accommodate the large number of transfers (203) from the sludge treatment facility to the DST under the Baseline Chemical Treatment Alternative. The scheduling of tank farm activities is dependent on many factors, including the weather and tank farm safety issues. This schedule risk would be somewhat less for the Modified Chemical Treatment Alternative, which would only require 175 transfers.

- There is uncertainty as to whether a chemical treatment system sized to treat the entire volume of sludge as it is removed from the basins could be installed in the CVD or another existing Hanford facility. If a new facility were to be required, there would likely be substantial cost impacts, and it would be unlikely that the entire volume of sludge could be treated in the 13-month removal window. This concern would diminish if only a fraction

of the sludge were to require extensive treatment or if some of all of the sludge could be interim stored between the time it is removed from the basins and the time it is treated.

Administrative Feasibility. Overall, this alternative would be administratively feasible because it would be consistent with proposed Tri-Party Agreement milestones and commitments made by DOE to the regulators, oversight agencies, stakeholders, and public.

Coordination would be required at the Hanford Site with both the ETF and TWRS. Coordination with ETF would be necessary to ensure that the pre-treated basin water can be received at the ETF in the time period required by the SNF Project, but no significant issues have been identified. Coordination would also be required with TWRS to ensure that the treated sludge meets TWRS requirements and to resolve the DST space and transfer scheduling issues identified as technical uncertainties.

Acceptance of the treated sludge at an existing DST would depend on EPA granting a risk-based disposal approval that allows the sludge to exit TSCA. Preliminary discussions with EPA have indicated that they would approve the request as presented in Appendix C. The only other significant permits or approvals required from outside agencies would be NOC approvals from DOH and Ecology. No significant issues related to these approvals are anticipated.

Summary (Rating: **). In general, the Chemical Treatment Alternative would perform moderately well against this criterion. There would be no significant administrative issues and the technologies that would be required for treatment are well-established and proven for K Basins waste. However, there is a significant technical issue related to scheduling transfers of treated sludge to TWRS. This issue would be a major disadvantage unless the schedule for removing sludge from the basins is modified or interim storage capacity for untreated sludge is developed. The latter would add to the cost of this alternative. The uncertainty about where the treatment system could be installed is another major disadvantage that would have cost and schedule impacts.

6.3.7 Cost

The SNF Project Baseline costs are provided in Table 6-1. The costs were developed on a future-worth basis. In addition to showing costs associated with the CERCLA action, costs for the overall SNF Project are provided because of the substantial regulator, stakeholder, and public interest in the total SNF Project costs. The total estimated cost for the CERCLA action excluding costs associated with sludge treatment and disposal would be about $689 million. The SNF Project Baseline includes a cost estimate for sludge treatment; however, this estimate was developed using preliminary information prior to preparing the Sludge Treatment Alternatives Analysis (Numatec 1999) or this FFS. The sludge treatment costs in the Baseline are lower than the current estimated costs shown below for Baseline Chemical Treatment. The total estimated

cost for the SNF Project including the preliminary sludge treatment estimate would be about $1.6 billion, plus $133 million for deactivation.

The cost that would vary among the alternatives would be the cost for sludge treatment, interim storage, and final disposal. For Alternative 2, these costs would be as follows (Numatec 1999):

Baseline Chemical Treatment

- Engineering and development: $ 18.8 M
- Procurement and construction: $ 37.7 M
- Operations: $ 24.9 M
- Total SNF cost for sludge: $ 81.5 M
- Final waste disposal[16]: $ 44.5 M
- **Total sludge cost: $125.9 M**

Modified Chemical Treatment

- Engineering and development: $ 18.3 M
- Procurement and construction: $ 36.2 M
- Operations: $ 24.8 M
- Total SNF cost for sludge: $ 79.4 M
- Final waste disposal: $ 37.0 M
- **Total sludge cost: $116.4 M**

These costs do not include contingency, escalation, transport costs to the treatment facility, project management, or regulatory and environmental support. Costs to decontaminate and decommission the sludge treatment system are included in the SNF Project baseline costs.

6.4 ALTERNATIVE 3: PHYSICAL TREATMENT

6.4.1 Overall Protection of Human Health and the Environment (Rating: ***)

Alternative 3 would achieve overall protection of human health and the environment. The risk of further releases from the basins would be reduced significantly by removing SNF, sludge, water, and debris and deactivating the basins. The SNF would be dried and placed in sealed MCOs to prevent further degradation. Sludge, water, and debris would be treated, as appropriate, to meet TWRS, ETF, ERDF, and WIPP waste acceptance criteria. The removal and treatment processes would result in a temporary increase in worker exposure and a potential increase in public exposure, but in the long-term occupational and public exposure and potential adverse environmental impacts would be reduced.

[16] Costs for interim storage and disposal of the sludge are not carried by the SNF Project.

6.4.2 Compliance With ARARs (Rating: ***)

Alternative 3 would be designed to comply with all ARARs and TBC materials. As in Alternative 2, the K Basins water pretreatment system would be required to meet ETF waste acceptance criteria, and debris would be designated in accordance with solid, dangerous, and radioactive waste and PCB management requirements and disposed at facilities approved to accept the assigned waste designation.

The physical treatment system would be required to treat the sludge sufficiently to meet the TWRS waste acceptance specifications for criticality control, corrosion, and particle size and prohibitions on pyrophoric materials, non-radiolytic gas generation, and TSCA-regulated material. In support of the last criterion, DOE requests that EPA approve the proposed physical treatment process as adequate to exit TSCA regulation, in accordance with the TSCA risk-based disposal approval requirements (40 CFR 761.61(c)) and the information provided in Appendix C.

Assuming that the TSCA approval is granted, the sludge would be managed as a mixed HLW. The mixed waste designation would result from TCLP metals. An existing DST would be an appropriate interim storage facility for mixed waste because the DSTs were designed to meet radioactive waste management standards and they have been determined by Ecology to satisfy dangerous waste storage requirements. Any other tank(s) used to store the treated sludge would be required to comply with the radioactive waste and dangerous waste requirements. Vitrification of the sludge via TWRS-P and disposal at the national geologic repository would meet radioactive waste management requirements for HLW waste. In addition, vitrification is the specified LDR treatment technology for mixed HLW that is designated for TCLP metals. Thus, vitrification would be expected to meet LDR treatment requirements.

Under the Physical Treatment Alternative, the ungrindable solids would be TSCA-regulated mixed LLW waste or mixed TRU waste and would be disposed at the ERDF (LLW) or the WIPP (TRU waste).[17] They would be treated to meet LDR standards as described for OIER and insoluble solids in Alternative 2.

As described in Alternative 2 (Section 6.3.2), the sludge treatment system would be designed to meet dangerous waste management unit standards and the off-gas treatment system would comply with air emissions standards for radionuclides, hazardous air pollutants, and PCBs. Any offsite transportation of wastes would be performed in compliance with DOT and NRC requirements.

Summary (Rating: *).** The Physical Treatment Alternative would meet all ARARs with no significant issues, assuming that the TSCA risk-based disposal approval is granted.

6.4.3 Long-Term Effectiveness and Permanence (Rating: ***)

[17] The determination of whether or not the OIER and ungrindable solids are mixed wastes would depend on the leachable concentration of toxic characteristic metals.

The evaluation of this criterion would be the same as for Alternative 2. The majority of the hazardous substances would be removed from the K Basins and placed into more protective facilities, thus permanently reducing the risk of further releases to the environment.

6.4.4 Reduction in Toxicity, Mobility, and Volume Through Treatment (Rating: **)

Alternative 3 would reduce the toxicity and slightly reduce the mobility of hazardous substances via treatment of the K Basins water and sludge, but there would be a moderate increase in waste volume from the sludge treatment process.

The pretreatment process for basin water would significantly reduce radioactivity levels in the water. The contaminants removed from the water would be concentrated onto filters and ion exchange modules where they would be less mobile and would present a smaller waste volume to manage. Treating the water at ETF (beyond the scope of the CERCLA action) would further reduce contaminant concentrations.

Under the Physical Treatment Alternative, the treatment process would reduce the risk associated with the sludge by making it critically safe, reducing the generation of flammable gas, and eliminating the reactivity/pyrophoricity associated with metal fines. Treatment would also reduce toxicity by removing some of the PCBs, although the risk associated with the PCBs is already very low (Appendix C). The radioactivity of the radionuclides in the sludge, which is the primary risk, would remain unchanged. There would be no reduction in the mobility of sludge contaminants as part of the Physical Treatment Alternative. However, final treatment of the sludge via TWRS (beyond the scope of the CERCLA action) would significantly reduce the mobility of sludge contaminants by immobilizing them in a glass matrix.

The Physical Treatment Alternative would increase the volume of treated sludge destined for interim storage by a factor of about 24, and would increase the final volume of material to be disposed by about 60 percent.[18] The near-term volume increase would be due primarily to the addition of water needed to slurry the sludge from the basins. Ultimately, this water would be evaporated in the TWRS system, and the condensate would be treated at the ETF and discharged to the soil column. There would be a small part of the near-term volume increase and essentially all of the long-term volume increase would be attributed to the addition of chemicals (primarily sodium as sodium hydroxide) and neutron absorbers during sludge treatment.

Physical treatment would also generate secondary waste, primarily OIER and ungrindable solids. The estimated volume of non-TRU waste would be about 22 m^3 (780 ft^3). The mobility of contaminants in the OIER and insoluble solids would be reduced significantly through

[18] The volume of settled sludge in the basins is about 51 m^3 (1,800 ft^3) and the volume of sludge removed as a slurry would be about 260 m^3 (9,200 ft^3), a five-fold increase. The volume of treated sludge would be 276 m^3 (9,740 ft^3) (Numatec 1999), but the addition of water would bring this to 1,208 m^3 (43,000 ft^3) for the transfer to the DST. Assuming that the treated sludge is managed with the waste in Tank 105-AW, there would no incremental increase in the volume of HLW glass produced. However, there would be an incremental increase of 69 m^3 (2,400 ft^3) (Baseline Chemical Treatment) in the volume of LAW glass produced (Numatec 1999).

solidification.

Summary (Rating: **). The Physical Treatment Alternative would reduce toxicity (pyrophoricity) significantly by reducing or eliminating hazards associated with criticality, flammable gas, and reactivity/pyrophoricity. There would be no reduction in mobility as part of the CERCLA action, but there would be a significant reduction in mobility when the sludge is treated with DST waste (beyond the scope of the CERCLA action). The sludge volume requiring interim storage would increase by a factor of 5 over the original volume of as-settled sludge, but the final volume of glass produced would only be 60 percent greater than the original volume so this would be a minor disadvantage.

6.4.5 Short-Term Effectiveness (Rating: **)

Risk to public and the environment. The risks to the public and the environment under Alternative 3 would be similar to Alternative 2. Airborne releases of contaminants could potentially occur while SNF, sludge, debris, and water are removed from the basins and transported to other Hanford facilities. These activities are the same as in Alternatives 2. Therefore, the dose to the MEI associated with these activities would be less than 0.1 mrem/year and the collective dose to the offsite population would be 0.59 person-rem over 2 years (DOE 1995). Airborne emissions during these activities would be controlled and monitored as appropriate.

Routine releases of airborne contaminants would also occur during sludge treatment. The grinding/milling system would be designed with a ventilation system that would incorporate appropriate off-gas control technologies to minimize airborne releases. In addition, the system would be located inside the CVD or another onsite enclosed facility that would provide additional emissions control. The potential abated dose to the public from routine releases would be similar to that calculated for the Chemical Treatment Alternative (Section 6.3.5).

Risks to the public associated with upset conditions and non-routine releases from the grinding/milling system would also be similar to the risks for the chemical treatment system described in Section 6.3.5. The potential for liquid releases would be mitigated through appropriate double-containment. Criticality safety would be ensured through the use of nuclear poisons and fissile material mass limits. The transport and treatment systems would be provided with off-gas dilution to prevent the accumulation of flammable levels of hydrogen gas. Nitration of OIER and would not be an issue because the grinding/milling system would not include an acid dissolution step. Ungrindable solids would be kept wet to mitigate pyrophoricity.

Grinding/oxidation of uranium metal and the potential for an uncontrolled reaction would be a particular concern in the Physical Treatment Alternative. Grinding would continually expose new surfaces of uranium and uranium hydride to oxidation in an aqueous environment. The oxidation process would generate significant amounts of heat and hydrogen gas, in addition to the frictional heat produced by the breakdown of the grinding medium. The reaction rate for this process is not well understood. The strategy to preclude a runaway reaction would include use of a nitrogen gas “blanket” in the grinder, use of a defoamer to reduce the suspension of small particles, and

flooding the grinder with water. This strategy would be refined during remedial design.

Risk to workers. Alternative 3 would present a potential risk to workers, primarily associated with radioactive exposure and chemical hazards. Risks associated with removing the SNF, sludge, water, and debris from the basins were discussed in the K Basins EIS (DOE 1995).

Risks and mitigation measures associated with treating the sludge through grinding/milling would be similar in some respects to chemical treatment. The sludge would present a high potential dose to workers that would be mitigated through shielding, remote operations, physical controls, and administrative controls to assure that personnel radiation exposures remain ALARA. The treatment process would use some non-radioactive process chemicals (depleted uranium, sodium hydroxide, and grout formers), but these would be used in relatively small quantities. Physical hazards to workers would include pressurized vessels and piping, vibrating equipment (grinder), vehicular traffic, and electrical hazards associated with equipment. Construction hazards would depend upon the location of the treatment facility.

The most significant worker safety issue associated with the grinding/milling treatment system would be the lack of nuclear industry experience with the process operations. Although the grinding/milling system would be only moderately complex, the grinding process has not been used in similar applications for radioactive materials. Thus, the process control and safety control technology is not well-established, and potential hazards to workers would need to be evaluated further. These hazards would be addressed by an appropriately administered health and safety plan.

Schedule. The schedule for Alternative 3 would be expected to be the same as for Alternative 2.

Summary (Rating: **). The Physical Treatment Alternative would be moderately complex. The potential for upset conditions is not well understood, but in any case the severity of an upset would be relatively low because the treatment system would be enclosed in a hot cell-like facility. The systems would utilize unit operations that have not been used historically in the nuclear industry, so the process control and safety control technology would require development. Risks would be addressed by more detailed safety analysis reports and health and safety plans prior to final design, construction, and operation. The CERCLA action would be completed by July 2007, with the exception of deactivation activities that could continue beyond that time.

6.4.6 Implementability (Rating: *)

Technical Feasibility. The removal of SNF, sludge, water, and debris has been evaluated extensively and processes to accomplish removal have been identified. The facilities required to manage the SNF after it is removed from the basins are under construction. The systems needed to pretreat the water have been designed and are under construction. The ETF would be expected to be able to accommodate treatment of the basin water. The ERDF and the WIPP would be expected to be able to accommodate disposal of secondary wastes and debris that meet waste acceptance criteria.

The physical treatment process presented in this alternative would utilize an innovative technology application. Treatment via grinding/milling has the potential to be a relatively simple method for reducing particle size to meet TWRS criteria. There would be a minimal number of process steps and transfers and chemical usage would be low. The volume of slurry to be stored in a DST would be moderate and thus unlikely to cause a tank space constraint. However, there are important technical concerns including the following:

- Grinding is a mechanical process that would require greater maintenance.

- Grinding/milling is not a proven method for size-reducing the uranium metal and zirconium alloy found in the K Basins sludge. Both of these are hard metals with a low friability, and effective grinding/milling operations are dependent upon the friability and hardness of the media to be processed. Metals that are not easily ground to fine particles include zirconium, hafnium, nickel, titanium, vanadium, and tantalum (Numatec 1999). However, various sources indicate that irradiated uranium metal may be more brittle than unirradiated uranium metal and that size reduction might be enhanced by concurrent oxidation (Numatec 1999). It is likely that, any case, it would require a long processing time to grind the largest particles sufficiently to meet the TWRS particle size criterion. This long processing time could make it difficult to meet the Tri-Party Agreement schedule for removal, unless the untreated sludge could be temporarily stored.

- There is some concern that, as particles are reduced to very small sizes, the oxidation rate would increase rapidly resulting in excessive generation of heat and hydrogen gas. Process controls to address this accelerated oxidation are uncertain.

- The ability to meet the TWRS criterion of less than 50 ppm PCBs is uncertain. Although certain materials such as polyurethane are known to adsorb PCBs, the effectiveness of using a polyurethane liner in the grinder for PCB treatment is unknown.

These technical uncertainties result in uncertainties in cost, schedule, and technical viability. It is likely that some size reduction could be achieved through grinding/milling, but it is unknown whether grinding/milling alone could meet the TWRS criteria. Further testing with K Basins sludge would be required to determine the technical feasibility of this technology and to identify

appropriate process and safety controls. This development program could impact the ability to meet the sludge removal schedule.

Other unit operations associated with the grinding/milling alternative would be expected to be technically feasible. The off-gas emission controls identified for physical treatment would be based on standard technologies used in the nuclear industry. Solidification is a well-established technology for radioactive and mixed waste.

As with the Chemical Treatment Alternative, a key advantage of the Physical Treatment Alternative would be that, once the treated sludge is accepted into TWRS, it would lose its unique identity. Thus, long-term issues associated with management of a unique waste form would be precluded.

The availability of DST space would be unlikely to be a problem for the Physical Treatment Alternative because the volume of solids produced would be well below previous forecasts. However, the issues of scheduling transfers to the DST and the viability of using CVD or another existing facility and treating the entire volume of sludge within the 13-month sludge removal window would be the same as in the Chemical Treatment Alternative.

Administrative Feasibility. The assessment of administrative feasibility would be the same as for the Chemical Treatment Alternative.

Summary (Rating: *). There is a high degree of uncertainty about the implementability of the Physical Treatment Alternative. There would be no significant administrative issues. However, the technology has not been demonstrated for similar applications, and the treatment system and process control technologies would require extensive development. There are also the issues of scheduling transfers of treated sludge to TWRS and whether the treatment system could be installed in the CVD or another existing facility. These issues would be a major disadvantage unless the schedule for removing sludge from the basins is modified or interim storage capacity for untreated sludge is developed. The latter would add to the cost of this alternative.

6.4.7 Cost

The processes to remove SNF, sludge, water, and debris from the K Basins, manage the SNF, water, and debris, and deactivate the basins are identical for Alternatives 2 through 5. Therefore, the costs for these activities, shown in Table 6-1 for Alternative 2, are the same for Alternative 3. Downstream costs to treat the basin water at ETF are also the same as in Alternative 2.

The cost that would vary among the alternatives would be the cost for sludge treatment, interim storage, and final disposal. For Alternative 3, these costs would be as follows (Numatec 1999):

- Engineering and development: $ 31.8 M
- Procurement and construction: $ 37.8 M
- Operations: $ 23.4 M
- Total SNF costs for sludge: $ 93.0 M

- Final waste disposal: $ 5.4 M
- **Total sludge cost: $ 98.4 M**

These costs do not include contingency, escalation, transport costs to the treatment facility, project management, or regulatory and environmental support. Costs to decontaminate and decommission the sludge treatment system are included in the SNF Project baseline cost.

6.5 ALTERNATIVE 4: THERMAL TREATMENT

6.5.1 Overall Protection of Human Health and the Environment (Rating: ***)

Alternative 4 would provide overall protection of human health and the environment. The risk of further releases from the basins would be reduced significantly by removing SNF, sludge, water, and debris and deactivating the basins. The SNF would be dried and placed in sealed MCOs to prevent further degradation. Sludge, water, and debris would be treated, as appropriate, to meet waste acceptance criteria of the national geologic repository, the WIPP, ETF, and ERDF. The removal and treatment processes would result in a temporary increase in worker exposure and a potential increase in public exposure, but in the long-term occupational and public exposure and potential adverse environmental impacts would be reduced.

6.5.2 Compliance With ARARs (Rating: ***)

Alternative 4 would be designed to comply with all ARARs and TBC materials. As in Alternative 2, the K Basins water pretreatment system would be required to meet ETF waste acceptance criteria, and debris would be designated in accordance with solid, dangerous, and radioactive waste and PCB management requirements and disposed at facilities approved to accept the assigned waste designation.

Vitrification. The vitrification process would be required to treat the sludge sufficiently to meet the national geologic repository waste acceptance criteria, which include prohibitions on RCRA-regulated waste and TSCA-regulated material. In support of the RCRA prohibition, vitrification is the specified technology for HLW that is designated for TCLP metals, so the glass form would not be RCRA-regulated for metals. The LDR treatment standards for PCBs as an underlying constituent would be met by vitrification, assuming approval of the LDR treatability variance requested in Appendix D.

In support of the TSCA prohibition, DOE requests that EPA approve the vitrification process as adequate to exit TSCA regulation, in accordance with the TSCA risk-based disposal approval requirements (40 CFR 761.61(c)) and the information provided in Appendix C.

Calcination. The calcination process would be required to treat the sludge sufficiently to meet the WIPP acceptance criteria, including the prohibition on HLW and SNF. Meeting this criterion would require a determination from DOE and the NRC that the sludge constitutes a TRU waste.

It is anticipated that the WIPP will be able to accept RCRA-regulated waste that has not been treated sufficiently to meet the LDR standards, based on amendments to the WIPP Land Disposal Act (Public Law 104-201). If the calcined product would be required to meet LDR standards, treatment beyond calcination might be necessary to immobilize TCLP metals. The LDR treatment standards for PCBs as an underlying constituent would be met by calcination, assuming approval of the LDR treatability variance requested in Appendix D.

It is also anticipated that the WIPP will be able to accept TSCA-regulated waste. However, this would require modification of the WIPP acceptance criterion that limits PCB concentrations for 50 ppm. In the event that the WIPP cannot accept TSCA-regulated waste, DOE requests that EPA approve the calcination process as adequate to exit TSCA regulation, in accordance with the TSCA risk-based disposal approval requirements (40 CFR 761.61(c)) and the information provided in Appendix C.

Common Features. Under the Thermal Treatment Alternative, the OIER and insoluble solids would be TSCA-regulated mixed LLW wastes or mixed TRU wastes and would be disposed at the ERDF (LLW) or the WIPP (TRU waste).[19] They would be treated to meet LDR standards as described for OIER and insoluble solids in Alternative 2.

As described in Alternative 2 (Section 6.3.2), the sludge treatment system would be designed to meet dangerous waste management unit standards and the off-gas treatment system would comply with air emissions standards for radionuclides, hazardous air pollutants, and PCBs. Any offsite transportation of wastes would be performed in compliance with DOT and NRC requirements.

Summary (Rating: *).** The Thermal Treatment Alternative would meet all ARARs, assuming that the TSCA risk-based disposal approval and the LDR treatability variance for thermally treated sludge are granted. One significant issue is radioactive designation. Disposal at the repository (Vitrification) or the WIPP (Calcination) would require an appropriate determination on the radioactive status from DOE. The determination would not affect the ability to meet ARARs (they will be met), but could affect implementability as discussed in Section 6.5.6.

6.5.3 Long-Term Effectiveness and Permanence (Rating: ***)

Alternative 4 would be very effective in the long term. The majority of the hazardous substances would be removed from the K Basins and placed into more protective facilities, thus permanently reducing the risk of further releases to the environment. The evaluation of this criterion would be the same as for Alternative 2 except with respect to the evaluation of sludge as a treatment residual. The risk associated with the thermally-treated sludge would be minimized and controlled by transferring the treated sludge to the CWC or CSB for interim storage and ultimately disposing of it at the WIPP or the national geologic repository. Geologic disposal of such highly radioactive waste minimizes the reliance on long-term active controls.

[19] The determination of whether or not the OIER and insoluble solids are mixed wastes would depend on the leachable concentration of toxic characteristic metals.

6.5.4 Reduction in Toxicity, Mobility, and Volume Through Treatment (Rating [Vitrification]: ***, Rating [Calcination]: **)

Alternative 4 would reduce the toxicity of hazardous substances via treatment of the K Basins water and sludge. Reduction in mobility and volume depend on the type of thermal treatment, and is evaluated separately for vitrification and calcination.

The pretreatment process for basin water would significantly reduce radioactivity levels in the water. The contaminants removed from the water would be concentrated onto filters and ion exchange modules where they would be less mobile and would present a smaller waste volume to manage. Treating the water at ETF (beyond the scope of the CERCLA action) would further reduce contaminant concentrations.

Vitrification. Under the Vitrification Alternative, the treatment process would reduce the risk associated with the sludge by reducing the generation of flammable gas and by eliminating the reactivity/pyrophoricity associated with metal fines. Treatment would also reduce toxicity by removing the majority of the PCBs, although the risk associated with the PCBs is already very low (Appendix C). The activity of the radionuclides in the sludge, which is the primary risk, would remain unchanged. Sludge contaminants would be effectively immobilized in the glass matrix, so there would be very significant reduction in mobility as part of the Vitrification Alternative. The Vitrification Alternative would decrease the volume of sludge by a factor of 50 percent.[20]

Vitrification would also generate secondary waste, primarily OIER and insoluble solids. The estimated volume of non-TRU waste would be about 40 m^3 and the estimated volume of TRU waste would be negligible. The mobility of contaminants in the OIER and insoluble solids would be reduced significantly through solidification.

Summary (Vitrification) (Rating: *).** The Vitrification Alternative would reduce toxicity by reducing or eliminating hazards associated with flammable gas and reactivity/pyrophoricity and would reduce mobility significantly by immobilization. The volume of treated sludge would be about 50 percent less than the original volume of as-settled sludge. Therefore, the Vitrification Alternative would perform very well against this criterion.

Calcination. Under the Calcination Alternative, the treatment process would reduce the risk associated with the sludge by reducing the generation of flammable gas and by eliminating the reactivity/pyrophoricity associated with metal fines. Treatment would also reduce toxicity by removing the majority of the PCBs, although the risk associated with the PCBs is already very low (Appendix C). The activity of the radionuclides in the sludge, which is the primary risk, would remain unchanged. There would be no reduction in mobility of the contaminants. Rather,

[20] The volume of settled sludge in the basins is about 50 m^3 (1,770 ft^3) and the volume of sludge removed as a slurry would be about 260 m^3 (9,200 ft^3) a five-fold increase. The volume of treated sludge in the form of glass would be 27 m^3 (950 ft^3)

the treated product potentially would be more dispersible than a slurry. The Calcination Alternative would decrease the volume of sludge by a factor of 75 percent.[21]

Calcination would also generate secondary waste, primarily OIER and insoluble solids. The estimated volume of non-TRU waste would be about 40 m^3 and the estimated volume of TRU waste would be negligible. The mobility of contaminants in the OIER and insoluble solids would be reduced significantly through solidification.

Summary (Calcination) (Rating: **). The Calcination Alternative would reduce toxicity by reducing or eliminating hazards associated with flammable gas and reactivity/pyrophoricity and would reduce volume significantly. The volume of treated sludge would be about 75 percent less than the original volume of as-settled sludge. There would be no reduction in mobility as part of the CERCLA action; rather, the calcined particles would be more dispersible than the original sludge.

6.5.5 Short-Term Effectiveness (Rating: **)

Risk to public and the environment. The risks to the public and the environment under Alternative 4 would be similar to Alternative 2. Airborne releases of contaminants could potentially occur while SNF, sludge, debris, and water are removed from the basins and transported to other Hanford facilities. These activities are the same as in Alternatives 2. Therefore, the dose to the MEI associated with these activities would be less than 0.1 mrem/year and the collective dose to the offsite population would be 0.59 person-rem over 2 years (DOE 1995). Airborne emissions during these activities would be controlled and monitored as appropriate.

Routine releases of airborne contaminants would also occur during sludge treatment. The thermal treatment system would be designed with a ventilation system that would incorporate appropriate off-gas control technologies to minimize airborne releases. In addition, the system would be located inside the CVD or another onsite enclosed facility that would provide additional emissions control. The potential abated dose to the public from routine releases would be similar to that calculated for Alternative 2 (Section 6.3.5). However, this abated dose would depend on the use of condensers and demisters to remove radionuclides volatilized at the high temperatures.

Some of the risks to the public associated with upset conditions and non-routine releases from the thermal treatment system would be similar to the risks for the chemical treatment system described in Section 6.3.5, in part because both vitrification and calcination would include acid dissolution as a pretreatment step. The potential for liquid releases would be mitigated through appropriate double-containment. Criticality safety would be ensured through fissile material mass limits. The transport and treatment systems would be provided with off-gas dilution to prevent the accumulation of flammable levels of hydrogen gas. The oxidation rate during acid dissolution

[21] The volume of settled sludge in the basins is about 50 m^3 (1,770 ft^3) and the volume of sludge removed as a slurry would be about 260 m^3 (9,200 ft^3), a five-fold increase. The volume of calcined product would be 16 m^3 (560 ft^3).

would be controlled by controlling the feed rate. The majority of the OIER would be separated from the sludge prior to acid dissolution of the sludge, to prevent nitration of organic resins. The sludge and insoluble solids would be kept wet to mitigate pyrophoricity.

Vitrification. The melting process would present a unique potential risk to the public and environment in that the high temperatures used in vitrification would create a higher potential for airborne emissions. In particular, vitrification would volatilize some key radionuclides such as Cs-137. A cold cap would be maintained on the melting process to minimize the loss of volatile materials.

Calcination. Risks unique to the Calcination Alternative would include the following:

- The sludge fraction containing particles smaller than 250 microns (.01 in) would require no pretreatment prior to calcination. If exposed to a strong acid solution, these particles could oxidize very rapidly, resulting in excess generation of heat, hydrogen gas, and foam. To avoid this, process controls would be in place to ensure that the small-particle feed is segregated from the acidic solution generated by the dissolution of large particles. Even without acid, calcination of finely divided uranium compounds represents a hazardous process with the potential for uranium fires in the calciner; this issue would require further development during remedial design to adequately control reaction rates.

- The calcined product would be a dispersible waste form. Transfer systems and container design would be developed to ensure control of the particulate material.

Risk to workers. Alternative 4 would present a potential risk to workers, primarily associated with radioactive exposure and chemical and thermal hazards. Risks associated with removing the SNF, sludge, water, and debris from the basins were discussed in the K Basins EIS (DOE 1995).

Risks and mitigation measures associated with the Thermal Treatment Alternative would be similar in some respects to the Chemical Treatment Alternative because the head-end of the thermal treatment system would involve acid dissolution. For example, large volumes of nitric acid would be used and would need to be appropriately contained. In addition, throughout the thermal treatment system the sludge would present a high potential dose to workers that would be mitigated through shielding, remote operations, physical controls, and administrative controls to assure that personnel radiation exposures remain ALARA.

Both vitrification and calcination would present unique risks to workers associated with electrical and thermal hazards. In vitrification, there would also be inhalation hazards associated with exposure to dusts from glass formers. Vitrification would also present the potential for increased worker dose in the event that an upset or failure in the melter unit results in solidifying glass in the melter or in the cell containing the melter. Responding to this type of upset condition could require that workers enter the cell before the system could resume operations.

Schedule. The schedule for Alternative 4 would be expected to be the same as for Alternative 2.

Summary (Rating: **). The Vitrification Alternative would be very complex and the Calcination Alternative would be moderately complex, and there would be a moderate potential for upset conditions in both. However, the severity of an upset would be relatively low because the treatment system would be enclosed in a hot cell-like facility. In addition, thermal treatment in general would utilize unit operations that have been successfully used in the nuclear industry for several years. Thus, the process control and safety control technology is fairly mature, and potential risks to the public and workers can be readily controlled and mitigated. Risks would be addressed by more detailed safety analysis reports and health and safety plans prior to final design, construction, and operation. The CERCLA action would be completed by July 2007, with the exception of deactivation activities that could continue beyond that time.

6.5.6 Implementability (Rating: *)

Technical Feasibility. The removal of SNF, sludge, water, and debris has been evaluated extensively and processes to accomplish removal have been identified. The facilities required to manage the SNF after it is removed from the basins are under construction. The systems needed to pretreat the water have been designed and are under construction. The ETF would be expected to be able to accommodate treatment of the basin water. The ERDF and the WIPP would be expected to be able to accommodate disposal of secondary wastes and debris that meet waste acceptance criteria.

Vitrification. Vitrification is a mature though relatively complex technology that has been proven to immobilize heavy metals and radionuclides. It is considered the preferred technology for highly radioactive waste that requires very long-term control and is the specified technology under RCRA for HLW that contains TCLP metals. Melters are in use at multiple DOE and foreign nuclear facilities. and foreign countries. No vitrification testing using actual or simulated K Basins sludge has been performed, and it is likely that such testing would be required during remedial design. This development program could impact the ability to meet the sludge removal schedule.

There are technical concerns regarding the application of vitrification to the K Basins sludge, and these would need to be resolved as part of the testing. These concerns include:

- The K Basins sludge feed streams exhibit a wide range of variability. Industry experience indicates that it is difficult to design a vitrification facility to accommodate substantial variability. In addition, waste form qualification may be difficult because of the variability of the feed.

- The uranium and plutonium content of the K Basins sludge is outside the normal range of industry experience.

- The sludge is expected to contain noble metals. Noble metals could form a conductive sludge on the bottom of the melter and eventually lead to shorting of electrodes. The melter would have to be designed with this constraint.

A key advantage of the Vitrification Alternative would be that borosilicate glass is the standard

waste form for HLW and would be the most likely waste form to be acceptable for repository disposal. However, acceptance would ultimately depend on waste form qualification and the resolution of waste designation issues, described under Administrative Implementability. Once the sludge is vitrified, it would be very difficult to rework. It would be important to determine prior to vitrification if the sludge might be disposed at the WIPP (rather than the repository), to ensure that the fissile material loading and total activity in the vitrified sludge meet WIPP acceptance criteria.

Calcination. Calcination is a mature, relatively simple technology that has been proven to oxidize metals and radionuclides. Calciners are in use at multiple DOE and foreign nuclear facilities. No calcination testing using actual or simulated K Basins sludge has been performed, and it is likely that such testing would be required during remedial design. This development program could impact the ability to meet the sludge removal schedule.

Technical concerns that would need to be resolved as part of the testing include:

- The calcined sludge would be a dispersible powder. Shipment to the WIPP would require approval of a new shipping package. Even with protective packaging, it is uncertain whether interstate transport of a dispersible radioactive material would be approved.

- Calcination would be a mechanical system, so it would be expected to require more maintenance than a chemical system. In addition, the calcined process would require substantial handling using manipulators in hot cells. To meet WIPP requirements, the calcined sludge would be distributed into over 4,000 3.8 L (1 gallon). These two factors would tend to place a significant load on the manipulators. Manipulators are generally designed for maintenance-only applications as opposed to routine processing applications.

- Acceptance of the calcined sludge at the WIPP would ultimately depend on waste form qualification and the resolution of waste designation issues, described under Administrative Implementability. The calcined sludge would be amenable to rework in the event that it was determined that some or all of it could not be disposed at the WIPP. Rework could require vitrifying the calcined product, which would substantially increase long-term costs.

Common features. The implementability of the headend dissolution process used in the Vitrification and Calcination Alternatives would be similar to that described for the Chemical Treatment Alternative; this pretreatment process would be expected to be technically feasible. The off-gas emission controls identified for thermal treatment would be based on standard technologies used in the nuclear industry. Solidification is a well-established technology for radioactive and mixed waste.

There would be significant uncertainty regarding whether a treatment system sized to treat all of the sludge within the 13-month sludge removal window could fit within the CVD or another existing. Inability to rely on the CVD or another existing facility would impact project cost and schedule.

There would also be uncertainty regarding the location to store the vitrified or calcined sludge. There are various storage alternatives at the Hanford Site, so this issue would not be expected to affect technical feasibility.

Administrative Feasibility. Overall, this alternative would be administratively feasible because it would be consistent with proposed Tri-Party Agreement milestones and commitments made by DOE to the regulators, oversight agencies, stakeholders, and public.

Coordination would be required at the Hanford Site with both the ETF and the Solid Waste Programs. Coordination with ETF would be necessary to ensure that the pre-treated basin water can be received at the ETF in the time period required by the SNF Project, but no significant issues have been identified. Coordination would also be required with the solid Waste Program to ensure that interim storage of the treated sludge can be accommodated.

Acceptance of the treated sludge at the repository or the WIPP is very dependent on the radioactive designation of the treated sludge. It has generally been assumed that the sludge would be a TRU waste. However, there is the potential that some or all of the sludge, particularly canister sludge and fuel wash sludge, would be considered to be SNF and thus fall under the definition of HLW in 10 CFR 60. Designation dramatically affects final disposal. The WIPP cannot accept HLW, and it is unlikely that the repository would accept TRU waste (although exceptions can be made on a case-by-case basis). The WIPP facility cannot make a determination at this time because it is still involved in negotiations with regulatory agencies. The calcined product could be reworked, if necessary, for repository disposal. It would be much more difficult to rework the vitrified product for WIPP disposal, so it would be important to know whether final disposal would be at the repository or the WIPP prior to beginning vitrification. In either case, rework would be likely to increase long-term costs for this alternative. Costs for rework have not been included in the costs for this alternative.

Another administrative challenge would be qualifying the vitrified sludge for the repository. The qualification process can be long and expensive. A cost estimate for waste form qualification has been incorporated into the cost estimate for this alternative, but there is substantial uncertainty in this estimate.

Disposal of the vitrified sludge at the repository would depend on EPA granting a risk-based disposal approval that allows the sludge to exit TSCA and a LDR treatability variance that allows the thermally treated sludge to exit RCRA regulation. Preliminary discussions with EPA have indicated that they would approve these requests as presented in Appendices C and D. The only other significant permits or approvals required from outside agencies would be NOC approvals from DOH and Ecology. No significant issues related to these approvals are anticipated.

Summary (Rating: *). There is substantial uncertainty about the implementability of the Thermal Treatment Alternative. Although both thermal technologies are well-established, they both would require additional development for application to the K Basins sludge. Vitrification would be especially sensitive to the wide range in sludge feed compositions. There is also

substantial uncertainty about administrative feasibility, primarily related to radioactive waste designation. The designation would limit the disposal location. Calcined sludge could be reworked, if necessary, but at a significant unplanned cost. Vitrified sludge would be difficult to rework, so a determination would be required before beginning vitrification. Even if the vitrified sludge were to be designated as HLW, the waste form qualification process would likely be extensive.

6.5.7 Cost

The processes to remove SNF, sludge, water, and debris from the K Basins, manage the SNF, water, and debris, and deactivate the basins are identical for Alternatives 2 through 5. Therefore, the costs for these activities, shown in Table 6-1 for Alternative 2, are the same for Alternative 4. Downstream costs to treat the basin water at ETF are also the same as in Alternative 2.

The cost that would vary among the alternatives would be the cost for sludge treatment, interim storage, and final disposal. For Alternative 4, these costs would be as follows (Numatec 1999):

Vitrification

- Engineering and development: $ 38.1 M
- Procurement and construction: $ 41.3 M
- Operations: $ 22.7 M
- Total SNF costs for sludge: $102.1 M
- Final waste disposal: $ 19.4 M
- **Total sludge costs: $121.5 M**

Calcination

- Engineering and development: $ 22.3 M
- Procurement and construction: $ 37.2 M
- Operations: $ 21.5 M
- Total SNF costs for sludge: $ 80.9 M
- Final waste disposal: $ 0.2 M
- **Total sludge costs: $ 81.1 M**

These costs do not include contingency, escalation, transport costs to the treatment facility, project management, or regulatory and environmental support. Costs to decontaminate and decommission the sludge treatment system are included in the SNF Project baseline costs.

6.6 ALTERNATIVE 5: PHYSICAL TREATMENT VIA SOLIDIFICATION

6.6.1 Overall Protection of Human Health and the Environment (Rating: ***)

Alternative 5 would provide overall protection of human health and the environment. Essentially all hazardous substances that are not fixed to the structures of the K Basins would be removed and transferred to facilities that are more protective, thereby reducing the potential for further releases from the basins. The SNF would be dried and placed in sealed MCOs to prevent further degradation. Sludge, water, and debris would be treated, as appropriate, to meet waste acceptance criteria of the WIPP, ETF, and ERDF. The removal and treatment processes would result in a temporary increase in worker exposure and a potential increase in public exposure, but in the long-term occupational and public exposure and potential adverse environmental impacts would be reduced.

6.6.2 Compliance With ARARs (Rating: ***)

Alternative 5 would be designed to comply with all ARARs and TBC materials. As in Alternative 2, the K Basins water pretreatment system would be required to meet ETF waste acceptance criteria, and debris would be designated in accordance with solid, dangerous, and radioactive waste and PCB management requirements and disposed at facilities approved to accept the assigned waste designation.

The solidification process would be required to treat the sludge sufficiently to meet the WIPP acceptance criteria, including the prohibition on HLW and SNF. Meeting this criterion would require a determination from DOE and the NRC that the sludge constitutes a TRU waste.

It is anticipated that the WIPP will be able to accept RCRA-regulated waste that has not been treated sufficiently to meet the LDR standards, based on amendments to the *WIPP Land Disposal Act* (Public Law 104-201). If waste were to be required to meet LDR standards before receipt at the WIPP, it is likely that solidification would be adequate to immobilize TCLP metals. The LDR treatment standards for PCBs as an underlying constituent also would be met by thermal pretreatment, assuming approval of the LDR treatability variance requested in Appendix D.

It is also anticipated that the WIPP will be able to accept TSCA-regulated waste. However, this may require modification of the WIPP acceptance criterion that limits PCB concentrations for 50 ppm. In the event that the WIPP cannot accept TSCA-regulated waste, DOE requests that EPA approve the solidification process as adequate to exit TSCA regulation, in accordance with the TSCA risk-based disposal approval requirements (40 CFR 761.61(c)) and the information provided in Appendix C.

As described in Alternative 2 (Section 6.3.2), the sludge treatment system would be designed to meet dangerous waste management unit standards and the off-gas treatment system would comply with air emissions standards for radionuclides, hazardous air pollutants, and PCBs. Any offsite transportation of wastes would be performed in compliance with DOT and NRC requirements.

Summary (Rating: *).** The Solidification Alternative would meet all ARARs, assuming that the TSCA risk-based disposal approval (if necessary) and the LDR treatability variance for treated sludge are granted. One significant issue is radioactive designation. Disposal at the WIPP would require a determination from DOE and the NRC that the sludge is TRU waste. The determination would not affect the ability to meet ARARs (they will be met), but could affect implementability as discussed in Section 6.6.6.

6.6.3 Long-Term Effectiveness and Permanence (Rating: ***)

Alternative 5 would be very effective in the long term. The majority of the hazardous substances would be removed from the K Basins and placed into more protective facilities, thus permanently reducing the risk of further releases to the environment. The evaluation of this criterion would be the same as for Alternative 2 except with respect to the evaluation of sludge as a treatment residual. The risk associated with the solidified sludge would be minimized and controlled by transferring the treated sludge to the CWC or CSB for interim storage and ultimately disposing of it at the WIPP. Geologic disposal of such highly radioactive waste minimizes the reliance on long-term active controls.

6.6.4 Reduction in Toxicity, Mobility, and Volume Through Treatment (Rating: **)

Alternative 5 would reduce the toxicity and significantly reduce the mobility of hazardous substances via treatment of the K Basins water and sludge, but there would be a moderate increase in waste volume from the sludge treatment process.

The pretreatment process for basin water would significantly reduce radioactivity levels in the water. The contaminants removed from the water would be concentrated onto filters and ion exchange modules where they would be less mobile and would present a smaller waste volume

to manage. Treating the water at ETF (beyond the scope of the CERCLA action) would further reduce contaminant concentrations.

Under the Solidification Alternative, the treatment process would reduce the risk associated with the sludge by reducing the generation of flammable gas and by eliminating the reactivity/pyrophoricity associated with metal fines. Treatment would also reduce toxicity by removing some of the PCBs, although the risk associated with the PCBs is already very low (Appendix C). The activity of the radionuclides in the sludge, which is the primary risk, would remain unchanged. Solidification would result in a substantial reduction in the mobility of sludge contaminants. The Solidification Alternative would increase the volume of treated sludge by a factor of over 6.[22] This volume increase would be due to the addition of solidifying agents.

Solidification would generate negligible quantities of secondary waste.

Summary. The Solidification Alternative would reduce toxicity by reducing or eliminating hazards associated with flammable gas and reactivity/pyrophoricity, reduce mobility significantly, and increase volume significantly. The volume of treated sludge would be about a factor of 6 greater than the original volume of as-settled sludge.

6.6.5 Short-Term Effectiveness (Rating: **)

Risk to public and the environment. The risks to the public and the environment under Alternative 5 would be similar to Alternative 2. Airborne releases of contaminants could potentially occur while SNF, sludge, debris, and water are removed from the basins and transported to other Hanford facilities. These activities are the same as in Alternatives 2. Therefore, the dose to the MEI associated with these activities would be less than 0.1 mrem/year and the collective dose to the offsite population would be 0.59 person-rem over 2 years (DOE 1995). Airborne emissions during these activities would be controlled and monitored as appropriate.

Routine releases of airborne contaminants would also occur during sludge treatment. The thermal treatment system would be designed with a ventilation system that would incorporate appropriate off-gas control technologies to minimize airborne releases. In addition, the system would be located inside the CVD or another onsite enclosed facility that would provide additional emissions control. The potential abated dose to the public from routine releases would be similar to that calculated for Alternative 2 (Section 6.3.5).

Some of the risks to the public associated with upset conditions and non-routine releases from the thermal treatment system would be similar to the risks for the chemical treatment system described in Section 6.3.5. The potential for liquid releases would be mitigated through

[22] The volume of settled sludge in the basins is about 50 m^3 (1,770 ft^3) and the volume of sludge removed as a slurry would be about 260 m^3 (9,200 ft^3) a five-fold increase. The volume of solidified sludge would be 315 m^3 (11,100 ft^3) (Numatec 1999).

appropriate double-containment. Criticality safety would be ensured through fissile material mass limits. The transport and treatment systems would be provided with off-gas dilution to prevent the accumulation of flammable levels of hydrogen gas. The majority of the OIER would be separated from the sludge prior to acid dissolution of the sludge, to prevent nitration of organic resins. The sludge would be kept wet until grouted to mitigate pyrophoricity.

Some of the risks associated with solidification would be similar to those for calcination, because large-size particles would be pretreated in furnaces. Thermal treatment processes would be designed to control oxidation rates to prevent excess hydrogen gas generation. This would be achieved in part limiting the batch size in a furnace. The pre-treated product would be a dispersible waste form, and transfer systems would be developed to ensure control of the particulate material.

Risk to workers. Alternative 5 would present a potential risk to workers, primarily associated with radioactive exposure and chemical and thermal hazards. Risks associated with removing the SNF, sludge, water, and debris from the basins were discussed in the K Basins EIS (DOE 1995).

Risks and mitigation measures associated with the Solidification Alternative would be similar in some respects to the Chemical Treatment and Thermal Treatment Alternatives. In general, the high potential dose to workers that would be mitigated through shielding, remote operations, physical controls, and administrative controls to assure that personnel radiation exposures remain ALARA. Stabilizing agents that could present an inhalation hazard would need to be appropriately contained.

A risk unique to the Solidification Alternative would be the potential workers dose associated with the use of manipulators to perform sludge transfers in the furnace system.

Schedule. The schedule for Alternative 5 would be expected to be the same as for Alternative 2.

Summary (Rating: **). The Solidification Alternative would be moderately complex, and there would be a moderate potential for upset conditions in both. However, the severity of an upset would be relatively low because the treatment system would be enclosed in a hot cell-like facility. In addition, solidification would utilize unit operations that have been successfully used in the nuclear industry for several years. Thus, the process control and safety control technology is mature, and potential risks to the public and workers can be readily controlled and mitigated. Risks would be addressed by more detailed safety analysis reports and health and safety plans prior to final design, construction, and operation. The CERCLA action would be completed by July 2007, with the exception of deactivation activities that could continue beyond that time.

6.6.6 Implementability (Rating: *)

Technical Feasibility. The removal of SNF, sludge, water, and debris has been evaluated extensively and processes to accomplish removal have been identified. The facilities required to manage the SNF after it is removed from the basins are under construction. The systems needed to pretreat the water have been designed and are under construction. The ETF would be

expected to be able to accommodate treatment of the basin water. The ERDF and the WIPP would be expected to be able to accommodate disposal of secondary wastes and debris that meet waste acceptance criteria.

Solidification is a mature, relatively simple technology that has been used to stabilize a wide range of waste containing metals and radionuclides. Solidification is in use at multiple DOE and foreign nuclear facilities, and was used to treat sludge from the N Reactor basins. There are several commercially-available vendors (Numatec 1999). The solidification process presented in this alternative would require minimal equipment and maintenance and almost no gas generation. However, the process would be complicated by the need for thermal pretreatment of large particles. No solidification testing using actual or simulated K Basins sludge has been performed, and it is likely that such testing would be required during remedial design. This development program could impact the ability to meet the sludge removal schedule.

Technical concerns that would need to be resolved as part of the testing include the following:

- The batch calcining pretreatment process would be operator intensive and would require the use of manipulators. Use of manipulators in this type of application for daily operations is not common and would require special attention to the manipulator design.

- Acceptance of the solidified sludge would ultimately depend on waste form qualification and the resolution of waste designation issues, described under Administrative Implementability. The solidified sludge would be difficult to rework in the event that it was determined that some or all of it could not be disposed at the WIPP. Rework could require crushing and vitrifying the solidified sludge, which would substantially increase long-term costs.

The implementability of the headend furnace process used in the Solidification Alternative would be similar to that described for the Calcination Alternative, and no significant issues are expected with implementation. However, the batch calcination process (versus continuous feed calcination) would be used for pretreatment would be much more labor intensive. The off-gas emission controls identified for solidification would be based on standard technologies used in the nuclear industry.

There would be significant uncertainty regarding whether a treatment system sized to treat all of the sludge within the 13-month sludge removal window could fit within the CVD or another existing facility. Inability to rely on the CVD or another existing facility would impact project cost and schedule. There would also be uncertainty regarding the location to store the solidified sludge. There are various storage alternatives at the Hanford Site, so this issue would not be expected to affect technical feasibility.

Administrative Feasibility. Overall, this alternative would be administratively feasible because it would be consistent with proposed Tri-Party Agreement milestones and commitments made by DOE to the regulators, oversight agencies, stakeholders, and public.

Coordination would be required at the Hanford Site with both the ETF and the Solid Waste Programs as described for the Thermal Treatment Alternative. Acceptance of the solidified sludge at the WIPP would require approval from DOE. If some or all of the sludge could not be accepted at the WIPP, substantial rework could be involved, because borosilicate glass is the only currently authorized waste form that can be disposed at the repository.

The only other significant permits or approvals required from outside agencies would be NOC approvals from DOH and Ecology. No significant issues related to these approvals are anticipated.

Summary (Rating: *). There is substantial uncertainty about the implementability of the Solidification Alternative. Although solidification is a well-established technology, it would require additional development for application to the K Basins sludge. There is also substantial uncertainty about administrative feasibility, primarily related to radioactive waste designation. The designation would limit the disposal location. It would be difficult to rework solidified sludge.

6.6.7 Cost

The processes to remove SNF, sludge, water, and debris from the K Basins, manage the SNF, water, and debris, and deactivate the basins are identical for Alternatives 2 through 5. Therefore, the costs for these activities, shown in Table 6-1 for Alternative 2, are the same for Alternative 5. Downstream costs to treat the basin water at ETF are also the same as in Alternative 2.

The cost that would vary among the alternatives would be the cost for sludge treatment, interim storage, and final disposal. For Alternative 5, these costs would be as follows (Numatec 1999):

- Engineering and development: $ 26.0 M
- Procurement and construction: $ 35.9 M
- Operations: $ 25.8 M
- Total SNF costs for sludge: $ 87.7 M
- Final waste disposal: $ 6.1 M
- **Total sludge costs: $ 93.8 M**

These costs do not include contingency, escalation, transport costs to the treatment facility, project management, or regulatory and environmental support. Costs to decontaminate and decommission the sludge treatment system are included in the SNF Project baseline costs.

Table 6-1. Costs for Alternative 2[a]. (2sheets)

Category	CERCLA Cost[b] ($M)	Non-CERCLA Cost ($M)	Total ($M)
Project Management and Integration[c]	127.7	129.9	257.6
Basin Maintenance and Operation[d]	153.4	168.9	322.3
Basin Facility Projects	8.9	40.3	49.2
SNF Retrieval (Design/Modification/Construction)	10.8	43.2	54.0
SNF Cask Transportation System and MCO Acquisition	65.1	43.8	109.0
SNF Retrieval (Operations)	165.2	31.2	196.3
Cold Vacuum Drying Facility (Design/Modification/Construction)[e]	f.	72.0	72.0
Cold Vacuum Drying (Operations)	f.	44.7	44.7
CSB Facility (Design/Modification/Construction)	f.	151.7	151.7
CSB Facility (Operations)	f.	51.4	51.4
Sludge Retrieval/Removal (Design/Modification/Construction)	12.6	7.2	19.8
Sludge Retrieval/Removal (Operations)	6.0	0	6.0
Sludge Transport/Offloading (Design/Modification/Construction)	4.6	0.3	4.9
Water Treatment (Design/Modification/Construction)	13.5	26.2	39.7
Debris Removal (Design/Modification/Construction)	11.8	5.1	16.9
Debris Removal (Operations)	12.1	1.6	13.7
Site-Wide Spent Fuel Activities[g]	f.	25.0	25.0
Contingency[h]	97.1	9.1	106.2
Total, Common Elements[i]	688.8	851.6	1540.4
Sludge Treatment[j] (Design/Modification/Construction)	36.6	5.7	42.3
Sludge Treatment/Transport (Operations)[i]	3.7	0	3.7
Total[k, l]	**729.1**	**857.3**	**1,586.4**

a. From SNF Project Baseline as of March 31, 1999, rounded to the nearest $100,000.
b. Excludes costs incurred before CERCLA authority is implemented (assumed to be October 1, 1999) and costs outside the scope of the CERCLA interim remedial action.
c. Includes Project Fee.
d. Includes maintenance and operation both before and after fuel removal.
e. Includes costs expended on evaluation of hot conditioning system.
f. Not in scope of CERCLA action.

Table 6-1. Costs for Alternative 2[a]. (2sheets)

g. Includes 327 fuel transfer, N Basin fuel movement, 200 Area interim storage area design/construction, design/move fuel to 200 ISA, and operation/maintenance of the 200 ISA.
h. Contingency only applies to fiscal year 1999 and beyond. For convenience, it is shown as a CERCLA cost. It would actually be distributed across both CERCLA and non-CERCLA costs.
i. Subtotal reflects costs common to all of the treatment alternatives.
j. Sludge treatment costs currently in the SNF Project Baseline were estimated based on preliminary information prior to preparation of the Sludge Treatment Alternatives Analysis (Numatec 1999) and this FFS. Baseline costs will be revised as appropriate when a preferred alternative is identified and developed.
k. The SNF project has transferred $133.5 million transition budget into the SNF project scope for deactivation. These deactivation costs are not reflected in the table. The total cost including deactivation is $1,719.7 million.
l. Does not include the cost to dispose of the treated sludge, which is outside the scope of the SNF Project.

7.0 COMPARATIVE EVALUATION OF ALTERNATIVES

A summary of the ratings for each alternative is provided in Table 7-1.

7.1 OVERALL PROTECTION OF HUMAN HEALTH AND THE ENVIRONMENT

The No Action Alternative would fail to protect human health and the environment. The remaining alternatives would all provide overall protection of human health and the environment by removing hazardous substances from the K Basins and transferring them to facilities that are more protective, thereby reducing the potential for further degradation of the SNF and future releases from the basins.

7.2 COMPLIANCE WITH APPLICABLE OR RELEVANT AND APPROPRIATE REQUIREMENTS

The No Action Alternative would not invoke new ARARs because no action would be taken; however, surveillance and maintenance activities at the K Basins would still be subject to currently applicable requirements if the No Action Alternative were selected as the preferred alternative. The remaining alternatives would all meet ARARs assuming certain approvals under TSCA and variances under RCRA are obtained from EPA. For the Chemical, Physical, and Thermal Treatment Alternatives, and potentially for the Solidification Alternative, this assumes that EPA grants a risk-based disposal approval per 40 CFR 761.61(c) and Appendix C so that the sludge is not regulated under TSCA following treatment. It also assumes that EPA grants a LDR treatability variance per 40 CFR 268.44 and Appendix D for the thermal treatment of the sludge under the Thermal Treatment Alternative and for thermal pretreatment under the Solidification Alternative.

7.3 LONG-TERM EFFECTIVENESS AND PERMANENCE

The No Action Alternative would not be effective or permanent because it would not address the risks at the K Basins. The remaining treatment alternatives would be equally capable of providing a high level of long-term effectiveness and permanence. The contaminants associated with the SNF, sludge, water, and debris would be removed from the K Basins and placed at more environmentally protective facilities. The basin water would be removed, thus eliminating the primary driving force for contaminant migration. After deactivation, the basins would be left in a condition where they would present minimal threat to the environment. Final remediation of the basins will be undertaken as part of a later CERCLA action.

None of the alternatives provide for immediate disposal of the sludge, but in all cases the treated sludge would be transferred to facilities that are designed to provide safe interim storage and minimize the potential of an environmental release. The Thermal Treatment (Vitrification) and

Solidification Alternatives might be somewhat more effective than the Chemical Treatment, Physical Treatment, and Thermal Treatment (Calcination) Alternatives because an immobilized waste form would result from treatment. Interim storage of an immobilized waste form, versus a slurry or calcined particles, would reduce the risk of releases to the environment.

7.4 REDUCTION OF TOXICITY, MOBILITY, OR VOLUME THROUGH TREATMENT

The No Action Alternative would involve no treatment. The remaining alternatives would all provide treatment of the K Basins water and sludge, and therefore, would be substantially better than the No Action Alternative. The water treatment system would be the same under all of the alternatives except No Action, so the alternatives would be equally effective in reducing the toxicity associated with contaminated water. The alternatives vary significantly in how they would perform against this criterion with respect to sludge treatment.

The Thermal Treatment (Vitrification) Alternative would perform best. Vitrification would reduce both toxicity (flammable gas generation and reactivity/pyrophoricity) and mobility significantly and reduce volume by 50 percent over the original volume of as-settled sludge.

The Physical Treatment, Thermal Treatment (Calcination), and Solidification Alternatives would all perform moderately well, but not as well as vitrification. They would all reduce toxicity (flammable gas generation and reactivity/pyrophoricity) significantly, and physical treatment would reduce the potential for criticality. Solidification would perform much better than physical treatment or calcination in reducing mobility, but would perform worse in reducing volume (the volume would increase by a factor of 6). Calcination would perform much better than physical treatment or solidification in reducing volume (volume would be reduced by about 75 percent) but would not reduce mobility and would generate a dispersible waste form. Physical treatment would not reduce mobility as part of the CERCLA action (mobility would eventually be reduced via processing with DST waste) and the volume of sludge requiring interim storage would increase be a factor of 5; however, the final volume of glass made from the sludge (after DST processing) would only be slightly greater than the original volume of as-settled sludge.

Neither option under the Chemical Treatment Alternative would perform well against this criterion. Chemical treatment would reduce toxicity (flammable gas generation and reactivity/pyrophoricity) and the potential for a criticality. However, it would not reduce mobility as part of the CERCLA action (mobility would eventually be reduced significantly via processing with DST waste) and both the interim and final volumes of waste produced would be several times greater than the original volume of as-settled sludge.

7.5 SHORT-TERM EFFECTIVENESS

With the exception of the No Action Alternative, the alternatives would perform equally well against the criterion of short-term effectiveness.

Risk to public and the environment. All of the treatment alternatives have the potential to impact the public and environment through airborne releases during removal and treatment activities, but none of the alternatives are expected to pose unacceptable risks. Control measures for the removal and transfer of SNF activities are well established. The potential for upset conditions may vary between alternatives depending on the type of sludge treatment, but the consequences of an upset condition would be similar because the contaminant inventory would be the same.

Risk to workers. None of the alternatives would be expected to pose unacceptable short-term risks to site workers. The primary risk to workers is the risk associated with exposure to radiation; this risk would be similar for all alternatives. Other risks would include chemical, physical and thermal hazards. These risks would be mitigated through engineering and administrative controls.

Environmental impact. None of the alternatives would be expected to result in short-term impacts to the environment.

Schedule. All of the alternatives except the No Action Alternative were developed to meet the same schedule, specified in Milestone M-34 of the Tri-Party Agreement.

7.6 IMPLEMENTABILITY

The No Action Alternative is performs poorly against this criterion because it would fail to comply with the K Basins EIS and ROD, Tri-Party Agreement schedules, and commitments made to the regulators, oversight agencies, stakeholders, and public.

None of the treatment alternatives would perform especially well against this criterion in treating 100 percent of the sludge volume because of technical and/or administrative uncertainties. The options under the Chemical Treatment Alternative would perform better than most. Chemical treatment is a mature technology that is well established in the nuclear industry. Laboratory tests using actual K Basins have demonstrated that chemical treatment could achieve the goal of meeting DST acceptance criteria. Once the treated sludge is blended with DST waste, there would be no specific issues associated with downstream waste management. However, a key uncertainty with the Chemical Treatment Alternative is whether the DST system can accommodate the large number of waste transfers to a DST within the Tri-Party Agreement schedule for sludge removal. From this standpoint, the Modified Chemical Treatment Alternative would be slightly better than the Baseline Chemical Treatment Alternative because it would require somewhat fewer transfers.

All of the other treatment alternatives have significant disadvantages. Physical treatment would rely on the application of technologies that have not been used for similar waste types and there is significant uncertainty as to whether grinding/milling alone could achieve the DST waste acceptance criteria for the entire range of sludge. There is also uncertainty about the process

control, especially in grinding to very small particle sizes, and uncertainty about the time required to grind the largest particles and whether this would accommodate the Tri-Party Agreement schedule. Significant development work would be required to determine if these issues could be resolved.

Vitrification, calcination, and solidification are better than physical treatment in the near term because they are all mature technologies that are well established in the nuclear industry. However, they have not been tested using actual or simulated K Basins sludge and development work would be required. These alternatives are potentially worse than physical treatment in the long term because of the uncertainty about sludge designation (TRU waste versus HLW). This determination has a significant effect on final disposal options. If the sludge is determined to be TRU waste, it could not be disposed at the national geologic repository. Conversely, if the sludge is determined to be HLW, it could not be disposed at the WIPP. It would be difficult to rework vitrified sludge; therefore, it would be important to determine which criteria apply (repository or WIPP) before beginning vitrification. Likewise, it would be difficult to rework solidified sludge to meet repository acceptance criteria.. It would be easier to rework the calcined sludge, but there would be a potentially significant cost impact. Furthermore, it is uncertain whether either a solidified (grouted) or calcined waste form would qualify for repository disposal. There is an additional uncertainty as to whether calcined sludge, which would be a dispersible particulate waste, could be transported to the WIPP or repository in any case without further processing.

There is an uncertainty associated with all of the treatment alternatives regarding whether a treatment system sized to treat the entire volume of sludge within the 13-month sludge removal window could be located inside the CVD or another existing facility. The need for a new facility would significantly affect cost and schedule, as could resolution of other uncertainties.

7.7 COST

The alternatives do not vary significantly in overall cost of the CERCLA action, but they do vary significantly in the costs associated with sludge. Costs are summarized in Table 7-1. Near-term costs (development, construction, and operation of the sludge treatment system) range from $79 M to $102 M, with the Chemical Treatment Alternative and Solidification Alternative being on the low end and the Thermal Treatment (Vitrification) Alternative being on the high end. Long-term costs (waste storage and disposal) range from $0.2 M to $44.5 M, with the Physical Treatment Alternative, Thermal Treatment (Calcination) Alternative, and Solidification Alternative being on the low end and the Chemical Treatment Alternative being on the high end.

Because of the difficulty in assessing and comparing costs for disposal at the WIPP versus at the national geologic repository, there is substantial uncertainty in the long-term costs.

7.8 STATE OF WASHINGTON ACCEPTANCE

All of the alternatives except No Action would satisfy the State of Washington's preference that the contents of the K Basins be removed and placed in more protective facilities. The State of Washington also concurs with the appropriate use of chemical, physical, and thermal treatment and solidification for sludge treatment

7.9 COMMUNITY ACCEPTANCE

All of the alternatives except No Action would satisfy the public's preference that the contents of the K Basins be removed and placed in more protective facilities. Community acceptance of the sludge treatment process will be evaluated after public review of the Proposed Plan.

7.10 SUMMARY

In summary, the No Action Alternative would fail to meet the requirements for the CERCLA action. The other alternatives would all provide overall protection of human health and the environment, comply with ARARs, and be effective in the long term. All of the alternatives except No Action would achieve a substantial risk reduction by removing SNF, sludge, water, and debris from the K Basins, transferring these materials to environmentally protective facilities, and deactivating the basins. In all of the treatment alternatives, the sludge would be treated to meet the acceptance criteria and all other applicable requirements at the interim storage and final disposal facilities. However, none of the treatment alternatives would perform well against all of the CERCLA criteria for the entire volume of sludge and range in sludge composition.

There is a high degree of confidence that Chemical Treatment would be able to meet the DST acceptance criteria for the entire range of K Basins sludge. However, the acid dissolution/caustic precipitation process is probably more extensive treatment than necessary for some of the sludge, it would produce a large waste volume, and the cost would be very high. Some of the sludge might be able to meet the DST criteria with very little treatment, such as simple separation and chemical adjustment. Physical Treatment (grinding and physical separation processes) could be a simple way to reduce the size of some particles. However, there is a high degree of technical uncertainty as to whether Physical Treatment would be effective for the full range of particle sizes in the sludge. It is likely that vitrification or calcination could effectively treat smaller particles, but there is uncertainty about radioactive designation, especially with certain sludge fractions, that could affect disposal options. Some of the sludge might designate as HLW and require disposal at the national geologic repository. The repository is most likely to accept a glass form, so Calcination and Solidification might be poor options for this fraction. On the other hand, Calcination and/or Solidification might be very cost-effective for disposal of sludge fractions that

are designated as TRU waste and that can be disposed at the WIPP. Finally, it would be very difficult to design and construct a treatment system large enough to treat 100 percent of the sludge volume using any single treatment alternative in time to treat the sludge immediately after as it is removed from the K Basins. The uncertainties in all of the alternatives could impact cost and schedule.

A hybrid of sludge treatment technologies appears to offer the greatest opportunity for a simple and cost-effective process that meets the Tri-Party Agreement schedule. A hybrid system could involve physically separating the sludge into different fractions based on characteristics such as particle size and radioactivity. Each fraction eventually would be treated using the technology or technologies that are most appropriate and cost-effective for that fraction. If a sludge fraction is already close to meeting the DST waste acceptance criteria or solid waste disposal criteria, it could undergo minimal treatment (such as chemical adjustment, simple grinding, or solidification) as it is removed from the basins or shortly thereafter. Any sludge fraction that would require more extensive treatment (such as chemical dissolution or thermal treatment) to meet the criteria of a double-shell tank, the WIPP, or the repository could be placed into interim storage in the 200 Area upon removal from the basins beginning on or before 2004 with minimal treatment, allowing for more extensive treatment at a later date. Although the treatment elements are defined in this FFS, the apportionment of these elements to specific sludge fractions has not been defined.

Figure 7-1. Summary of Evaluation of Alternatives.

Criterion[1]	Alt. 1: No Action	Alt. 2: Chemical Treatment		Alt. 3: Physical Treatment	Alt. 4: Thermal Treatment		Alt. 5: Solidification
		Baseline	Modified		Vitrification	Calcination	
Overall protection	*	***	***	***	***	***	***
Compliance with ARARs[2]	NA	***	***	***	***	***	***
Long-term effectiveness	*	***	***	***	***	***	***
Reduction in toxicity, mobility, and volume	*	*	*	**	***	**	**
Short-term effectiveness	*	**	**	**	**	**	**
Implementability	*	**	**	*	*	*	*
Cost: CERCLA action[3]	NA	$689 M	$689 M	$689 M	$689 M	$689 M	$689 M
Sludge[4]	NA	$126 M	$116 M	$ 98 M	$122 M	$ 81 M	$ 94 M
Total	NA	$815 M	$805 M	$787 M	$811M	$770 M	$783 M

[1] State and community acceptance were not rated on the star system. They are discussed in the text.
[2] Assumes approval of the TSCA risk-based disposal approval and RCRA treatability variance.
[3] Excludes costs associated with sludge treatment and disposal.
[4] Includes costs to design, construct, and operate a sludge treatment system; and to dispose of the treated sludge. Does not include contingency, escalation, transport to final disposal facility, project management, regulatory support, or decontamination/decommissioning.

Note: * Does not perform well against this criterion or there is significant uncertainty about performance.
** Performs moderately well against this criterion.
*** Performs very well against this criterion.

NA = Not applicable.

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APPENDIX A

NATIONAL ENVIRONMENTAL POLICY ACT OF 1969 VALUES ANALYSIS

A1.0 NATIONAL ENVIRONMENTAL POLICY ACT OF 1969 VALUES EVALUATION

The *National Environmental Policy Act of 1969* (NEPA) process is intended to help federal agencies make decisions that are based on understanding environmental consequences and take actions that protect, restore, and enhance the environment. Secretarial policy and U.S. Department of Energy (DOE) Order 451.1 require that *Comprehensive Environmental Response, Compensation, and Liability Act* (CERCLA) documents incorporate NEPA values such as analysis of cumulative, offsite, ecological, and socioeconomic impacts to the extent practicable in lieu of preparing separate NEPA documentation for CERCLA activities.

A1.1 DESCRIPTION OF NEPA VALUES

Several of the CERCLA evaluation criteria involve consideration of environmental resources, but the emphasis is frequently directed at the potential effects of chemical contaminants on living organisms. The NEPA regulations (40 CFR 1502.16) specify evaluation of the environmental consequences of proposed alternatives. These include potential effects on transportation resources, air quality, cultural and historical resources, noise, visual and aesthetic effects, environmental justice, and the socioeconomic aspects of implementation. The NEPA process also involves consideration of several issues such as cumulative impacts (direct and indirect), mitigation of adversely impacted resources, and the irreversible and irretrievable commitment of resources. The NEPA-related resources and values that have been considered in this alternatives evaluation include the following:

- Transportation impacts. This value considers impacts on local traffic (i.e., traffic at the Hanford Site) and traffic in the surrounding region resulting from the interim remedial action.

- Air quality. This value considers potential air quality concerns associated with emissions generated during the interim remedial action.

- Natural, cultural, and historical resources. This value considers impacts on wildlife, wildlife habitat, archeological sites or artifacts, or historically-significant properties in the 100-K Area resulting from the interim remedial action.

- Noise, visual and aesthetic effects. This values considers increases in noise levels or impaired visual or aesthetic values in the 100-K Area during or following the interim remedial action.

- Socioeconomic impacts. This value considers impacts pertaining to employment, income, other services (e.g., water and power utilities), and how the implementation of the interim remedial action affects the availability of services and materials

- Environmental justice. Environmental justice, as mandated by Executive Order 12898 (Clinton 1994), refers to fair treatment of all races, cultures, and income levels with respect to laws, policies, and government actions. This value considers whether interim

remedial action taken at the K Basins would have inappropriately or disproportionately high and adverse human health or environmental effects to minority or low-income populations.

- Cumulative impacts (direct and indirect). Implementing interim remedial action at the K Basins may have cumulative impacts on human health or the environment when considered together with other activities in the 100 Area, at the Hanford Site, or in the region. This value considers those cumulative impacts.

- Mitigation. If adverse impacts cannot be avoided, remedial action planning should minimize them to the extent practicable. This value identified required mitigation activities.

- Irreversible and irretrievable commitment of resources. This value evaluates the use of nonrenewable resources for the K Basins remedial action and the effects that resource consumption would have on future generations. When a resource (e.g., energy, minerals, water, or wetland) is used or destroyed and cannot be replaced within a reasonable amount of time, its use is considered irreversible. An example would be consumables such as fuel and chemicals that might be used in treatment systems. Because irreversible commitments cannot always be avoided, the evaluation examines the nature and amount of resources that would be irreversibly committed.

A1.2 K BASINS IMPACT STATEMENT

The K Basins environmental impact statement (EIS) (DOE 1996a) and record of decision (ROD) (61 FR 10736) evaluated the environmental impacts associated with the management of spent nuclear fuel (SNF) stored in the K Basins. It also addressed, in less detail, management of the sludge, water, and debris in the basins. The preferred alternative selected in the ROD was to remove the SNF, sludge, water, and debris from the basins and transport them to facilities in the 200 Area. The preferred alternative included a process for conditioning the SNF prior to interim storage.

Alternatives related to SNF that were evaluated in the K Basins EIS included no action; enhanced K Basin storage; new wet storage; drying/passivation (conditioning) with dry storage; calcination with dry storage; onsite processing; and foreign processing. The analysis of these alternatives considered such aspects as potential accidents; socioeconomics; cultural, geologic, air, water, and ecological resources; transportation; health and safety; and site services. The preferred alternative for handling the SNF has evolved as additional information has been acquired on the SNF and potential conditioning options. A Supplement Analysis was prepared in which it was determined that proposed modifications to the SNF conditioning process were bounded by the analysis in the original EIS and no further NEPA review was required (DOE 1998).

For all of the alternatives analyzed in the K Basins EIS, management of the sludge, basin water, and debris were included as part of the analysis. Sludge management options consisted of (1) the no action alternative, (2) removal and transfer to a double-shell tank in the 200 Area, and (3) removal and transfer to solid waste management facilities in the 200 Area. Water

management options consisted of (1) the no action alternative and (2) pretreatment at the basins using existing filtering and ion exchange treatment methods followed by transportation to the 200 Area Effluent Treatment Facility (ETF) for final treatment and disposal. The alternatives for handling the debris were 1) the no action alternative and 2) standard removal techniques, decontamination, and volume reduction where possible, and disposal at appropriate burial grounds. The scope of the proposed actions for basin water and debris has not changed substantially from the EIS with the clarification that the Environmental Restoration Disposal Facility will be used for disposal of debris that designates as LLW or mixed waste. The water and debris management are not re-evaluated in this focused feasibility study (FFS). However, the sludge treatment requirements were not fully defined at the time the K Basins EIS was prepared. Consequently, alternatives for handling sludge are the focus of this FFS. This integrated NEPA values analysis for sludge treatment builds on the previous K Basins EIS analysis for the SNF alternatives, since the actions for sludge removal and handling are similar in effects to those for SNF, but on a smaller scale.

Overall, the K Basins ROD determined that environmental impacts under normal operating conditions were neither very large nor varied greatly among alternatives (61 Federal Register [FR] 10736). Although the No Action Alternative would have fewer environmental impacts in the near term, over the long term, the preferred alternative would protect public health and the environment because it would remove the SNF from aging facilities and place it into a safer configuration.

Health impacts to the public from the action were estimated by considering the effects on the maximally exposed individual (MEI). The MEI is a hypothetical member of the public who lives at a location and has a lifestyle such that it is unlikely that other members of the public could receive a higher radiation dose. This individual's diet, home, and other factors are chosen to maximize the combined doses from all reasonable pathways of exposure to radionuclides from project activities. In reality, this combination of maximized parameters is unlikely to apply to any one individual. However, the dose to the MEI is useful for establishing an upper bound on potential exposure to any member of the public. Expected average impacts to the surrounding general public are also evaluated, and are provided as the regional collective dose to all people (approximately 380,000) living within a radius of 80 km (50 miles) from the project site.

None of the alternatives evaluated in the EIS resulted in a dose to the MEI that exceeded 0.01 mrem/year (DOE 1996a). For comparison, the *Hanford Site Environmental Report* (Dirkes and Hanf 1998) reported that the potential radiological doses from Hanford Site operations to the hypothetical offsite MEI during calendar year 1997 was 0.01 mrem. The national average dose from background sources is 300 mrem/year and the current DOE radiation limit for an individual member of the public is 100 mrem/year (Dirkes and Hanf 1998).

The potential collective consequences of removing SNF, sludge, debris, and water from the K Basins and staging the SNF in the 200 Area were estimated at 0.59 person-rem to the population living within 80 km (50 miles) (DOE 1996a). For comparison, the potential collective dose to the local population from Hanford operations was 0.2 person-rem in 1997 (Dirkes and Hanf 1998). The total dose received in a year by this same population from natural background radiation was about 110,000 person-rem (DOE 1996a).

Several accident scenarios and potential impacts from those scenarios were evaluated in the K Basins EIS. The EIS postulated a design basis accident in which a fire results in airborne releases of a fraction of the SNF inventory. The EIS assumed that about 10 canisters of SNF were in the CVD at the time and assigned release fractions to the volatile, semi-volatile, and nonvolatile radionuclides.

The K Basins EIS concluded that offsite impacts from activities addressed in the EIS would be comparable to impacts from overall Hanford Site operations.

Because of ongoing vegetation control programs, the area within the reactor building fenceline of the 100-K Area is virtually devoid of vegetation, and consequently the use by wildlife is minor. The large amount of ground disturbance during initial facility construction has eliminated any near-surface, tangible, cultural or archeological resources that might have been present within the 100-K Area before the site was built. Because the resources at the 100-K Area have already been severely affected, the alternatives analyzed in the K Basins EIS were not expected to have any significant cumulative effects on the environmental, cultural, or historic resources in the area. Subsequent to preparation of the EIS, certain facilities in the 100-K Area were identified as eligible for listing on the National Register of Historic Places. Mitigation efforts for these facilities have been completed, so impacts on historical resources are not anticipated.A1.3NEPA Values Related TO Sludge Treatment

As concluded in the K Basins EIS, the No Action Alternative would have fewer impacts in the short term. There would be no change to air quality, no direct impact on cultural or ecological resources, and labor needs would continue at current levels. However, over the long term, the No Action Alternative would present an increased threat to the environment because continued storage of the hazardous substances the K Basins presents a threat of a release to the environment. Further, without treatment to meet interim storage facility acceptance criteria, sludge would remain in the K Basins.

A1.3.1 Transportation Impacts

The primary transportation impact would be associated with transportation of the sludge, first as a slurry to the treatment system then as a slurry (Chemical Treatment and Physical Treatment Alternatives) or a dry waste (Thermal Treatment and Solidification Alternatives) to the interim storage location. All sludge transport to interim storage facilities would take place on the Hanford Site. A slurry transport system has been designed to mitigate the potential for a release during transport. If Alternative 4 or 5 were to be selected, a dry materials transport system would be similarly designed. A transportation safety analysis would be performed prior to any sludge transport activities. The analysis would identify the need for specific precautions (e.g., road closures) to be taken. Increases in the work-force traffic related to sludge treatment would be expected to be minor.

A1.3.2 Air Quality

Sludge treatment would result in potential near-term impacts to air quality, but these impacts could be mitigated through appropriate engineering controls. The primary impacts would be associated with routine air emissions and non-routine releases that could result in airborne contamination. Local and regional air quality are not expected to be significantly affected by

routine air emissions because off-gas treatment systems would be employed as appropriate to control potential emissions. In particular, off-gas treatment would address radioactive particulate, volatile radionuclides, hazardous air pollutants, and PCBs. The potential dose to the MEI from sludge treatment as proposed under the Chemical Treatment Alternative was estimated at less than 0.02 mrem/year, and the potential dose associated with other treatment alternatives would be expected to be comparable.

Potential impacts associated with non-routine releases postulated for the sludge treatment system are expected to be bounded by the accidents described in the K Basins EIS for SNF conditioning, because the radioactive sludge is only an estimated one percent of the original mass of the SNF. Only a small fraction of the sludge inventory would be treated at one time. For this FFS, a similar accident is postulated whereby an event occurs during sludge treatment that results in airborne releases of a fraction of the sludge inventory in the CVD. All sludge treatment would occur within an environmentally-protective facility either in the 100-K Area (such as the CVD) or in the 200 Area. A very conservative assumption is that a maximum 10 percent of the total volume of sludge (i.e., 5 m^3 on a settled solids basis) is present at the sludge treatment system at any one time. If the same release fractions for volatile, semi-volatile, and nonvolatile radionuclides are applied to the sludge as were used for the SNF, the release estimates for individual radionuclides would be lower for a sludge accident by at least an order of magnitude. Therefore, the SNF fire scenario in the conditioning facility bounds a fire scenario involving sludge treatment at CVD.

A1.3.3 Natural, Cultural, and Historical Resources

Natural and cultural resources within the main core of the 100-K Area are minimal. However, certain facilities within that area have been identified as eligible for listing on the National Register of Historic Places. Mitigation work on these facilities has been completed. A treatment system would likely be located inside existing facilities, thus no impacts to cultural and ecological resources from new construction would be expected. If a new facility were required, it would likely be constructed in a previously disturbed area such as within the main core of the 100-K Area or in developed areas of the 200 Area.

The proposed sludge treatment would take place within one-quarter mile of the Columbia River, which has been nominated for Wild and Scenic status *and evaluated in the Comprehensive River Conservation Study and Final Environmental Impact Statement for the Hanford Reach* (NPS 1994). The National Park Service would be consulted during design of the treatment facility as required by the *Hanford Reach Study Act* (Public Law 100-605, as amended by Public Law 104-333) to ensure that the treatment system selected would not adversely affect the attributes of the river or adjacent shoreline.

A1.3.4 Noise, Visual, and Aesthetic Effects

Sludge treatment operations could increase noise levels or impair visual and aesthetic values in the 100-K Area during treatment. However, treatment would only occur for about one year, and would likely occur inside a facility that is already constructed in the 100-K Area.

A1.3.5 Socioeconomic Impacts

The treatment alternatives would require more labor in the short term than the No Action Alternative but would reduce the long-term need for maintenance. The labor force required to construct and operate a treatment system would be drawn from current Hanford Site contractors and the local labor force. No significant socioeconomic impacts would be expected.

A1.3.6 Environmental Justice

Because offsite impacts would be expected to be minimal and the sludge would be treated and removed from the 100-K Area, it is not expected that treatment would disproportionately affect any group.

A1.3.7 Cumulative Impacts

Cumulative impacts of sludge treatment are considered together with impacts from past and foreseeable future actions at and near the Hanford Site. Authorized current and future activities in the 100 Areas include the removal and drying of SNF from the K Basins; soil and groundwater remediation; interim safe storage of reactors; and surveillance, maintenance, decontamination, and decommissioning of facilities. Other Hanford Site activities that might be ongoing during sludge treatment include storage and vitrification of tank wastes, deactivation and decontamination of reprocessing facilities, and operation of the Washington Public Power Supply System commercial reactor. A privately-owned radioactive and mixed waste treatment facility is planned adjacent to the southern boundary of the Hanford Site and is in the process of obtaining permits and approvals. Other activities that are being considered at or near the Hanford Site but which are not currently authorized include the construction and operation of an aluminum smelter in the 400 Area.

Two areas of concern with respect to cumulative impacts are air quality and waste management. Air quality limits at the Hanford Site boundary are not expected to be approached as a result of current or future activities that are currently authorized. The air quality analysis presented for the Chemical Treatment Alternative indicates that implementation of this alternative would not result in these limits being exceeded, even in conjunction with other Site activities. Estimates would be expected to be comparable for the other treatment alternatives.

Waste management impacts associated with sludge treatment and interim storage center on the availability of DST and solid waste storage facilities. DST space is constrained, and it would be both a schedule and cost impact to Hanford programs to provide new DSTs. The Baseline Chemical Treatment Alternative would be likely to have the greatest impact on DST space. The anticipated volume of treated sludge under the Baseline Chemical Treatment Alternative would be as high as 1,620 m^3 (over 400,000 gal), including water used to facilitate pumping the sludge. This volume has been included in tank space planning. However, changes to other Site programs could affect the ability of the DST system to receive the treated sludge. The volume of treated sludge would be small compared to current volumes of solid waste stored at other Hanford waste management facilities and no specific constraints have been identified.

A1.3.8 Irreversible and Irretrievable Commitment of Resources

Sludge treatment would require energy resources and the consumption of chemicals. However, these needs would not be expected to be a significant commitment of resources.

A1.3.9 Summary

Sludge treatment would result in some impacts to public health and the environment. However, the overall environmental impacts under normal operating conditions would not be very large nor would they vary greatly among the treatment alternatives. Although the No Action Alternative would have fewer environmental impacts in the near term, over the long term, removing the sludge from the K Basins and treating it as necessary for interim storage at another facility would protect public health and the environment because it would place the sludge into a safer configuration.

APPENDIX B

APPLICABLE OR RELEVANT AND APPROPRIATE REQUIREMENTS

B1.0 APPLICABLE OR RELEVANT AND APPROPRIATE REQUIREMENTS

Applicable or relevant and appropriate requirements (ARARs) are standards, requirements, criteria, or limitations promulgated under federal or State of Washington environmental laws that must be met or waived for actions conducted under the *Comprehensive Environmental Response, Compensation, and Liability Act of 1980* (CERCLA). A requirement may be "applicable" or "relevant and appropriate," but not both. Only the substantive (versus administrative) provisions of ARARs must be met for those actions conducted entirely onsite (CERCLA Sec. 121(d)(2)). "Onsite" is defined under CERCLA as the area of contamination and working areas in close proximity to the area of contamination. Such onsite actions are exempted from obtaining federal, State of Washington, and local permits (CERCLA Sec. 121(e)(1)). To-be-considered (TBC) materials are non-promulgated environmental standards, criteria, or guidance such as federal and State of Washington advisories and U.S. Department of Energy (DOE) orders and policies that may be referenced to the extent necessary for the response action to be adequately protective. As part of the ongoing environmental compliance program at Hanford and project requirements for the spent nuclear fuel (SNF) project, a Standards/Requirements Identification Document (S/RIDs) process was applied to the SNF project and a S/RIDs was completed (PHMC 1998). The purpose of the S/RIDs process is to identify requirements relevant to the project and clearly connect the requirements to implementing procedures. The S/RIDs process encompasses promulgated laws and regulations as well as DOE policies, orders, and guidance. The S/RIDs will be coordinated with the ARARs identified here, as appropriate.

ARARs are typically grouped into one of three categories: chemical specific, location specific, and action specific. Chemical-specific ARARs are usually health- or risk-based numerical values or methodologies that result in establishment of numerical values. These values establish the acceptable amount or concentration of a hazardous substance that can remain in or be discharged to the environment. Location-specific ARARs are restrictions placed on the concentration of hazardous substances or the conduct of activities because they occur in special or sensitive locations or environments. Action-specific ARARs are those that place either technology-based or activity-based requirements on remedial action.

Under CERCLA, the no-action alternative invokes no ARARs. Potential ARARs for Alternatives 2 through 5 include standards for radioactive and dangerous waste management, polychlorinated biphenyl (PCB) management, effluent discharge, air emissions control, and radiation protection. Because the scope of the interim remedial action does not include remediation of subsurface structures or soil or groundwater contamination, environmental media cleanup standards have not been identified as ARARs. Waste acceptance criteria at various storage, treatment, and disposal facilities may be considered TBC materials. Waste acceptance criteria were presented in Chapter 4.

Key provisions of the various ARARs are described in the following sections. Table B-1 provides a listing of the federal ARARs and TBC materials and Table B-2 provides a listing of the State of Washington ARARs and TBC materials.

B1.1 RADIOACTIVE WASTE MANAGEMENT STANDARDS

The *Atomic Energy Act* (AEA) (42 U.S.C. 2011 et seq.) authorizes the U.S. Department of Energy (DOE), the U.S. Environmental Protection Agency (EPA), and the U.S. Nuclear Regulatory Commission (NRC) to set standards and restrictions governing SNF and radioactive waste. The *Waste Isolation Pilot Plant Land Withdrawal Act* (LWA) (Public Law 102-579) and the *National Defense Authorization Act for Fiscal Year 1997* (Public Law 104-201) provide for the construction and operation of the Waste Isolation Pilot Plant (WIPP).

Key implementing regulations pertinent to designating and managing SNF and radioactive waste generated by the K Basins interim remedial action include:

- DOE Order 5400.5: establishes DOE requirements for protection of the public from radiation hazards that may result from DOE activities. The DOE Order has been proposed for promulgation at 10 *Code of Federal Regulations* (CFR) 834. The primary standard for protection is 100 mrem effective dose equivalent to members of the public in a year. The Order also adopts the “as low as reasonably achievable” (ALARA) process in planning and carrying out all DOE activities and the "best available technology" (BAT) as the appropriate level of treatment for liquid wastes containing radioactive material. This DOE Order and the proposed rule are TBC materials.

- 10 *Code of Federal Regulations* (CFR) 20: establishes NRC requirements for protection against radiation hazards that may result from discharges to the air and water. One requirement is that the total effective dose equivalent to individual members of the public must not exceed 100 mrem/year. This regulation is not legally applicable to DOE facilities but is relevant and appropriate for radioactive releases to the air and water.

- 10 CFR 61: establishes NRC requirements for land disposal of radioactive waste (excluding high-level and transuranic [TRU] waste). Subpart C of this regulation contains performance objectives. The objectives specify that LLW disposal sites must provide protection of the general population from releases of radioactivity, protection of individuals from inadvertent intrusion, and stability of the disposal site after closure. This regulation is not legally applicable to DOE facilities but is relevant and appropriate for the disposal of low-level waste (LLW) and mixed waste (such as debris or sludge treatment residuals) generated by the interim remedial action.

- 40 CFR 191: establishes EPA requirements for management of SNF, high-level waste, and TRU waste. This regulation is applicable to DOE facilities. Subpart B addresses disposal of SNF and high-level and TRU waste and contains disposal requirements including the expectation that containment will be provided for 10,000 years. It is an ARAR for SNF and TRU waste (such as sludge, and potentially, debris) generated by the interim remedial action.

B1.2 DANGEROUS WASTE MANAGEMENT STANDARDS

The Resource Conservation and Recovery Act of 1976 (RCRA) governs the identification, storage, treatment, and disposal of hazardous waste and the hazardous component of mixed waste. Authority to implement portions of RCRA has been delegated to the State of Washington; the State of Washington implements RCRA via the *Hazardous Waste Management Act* and *Washington Administrative Code* (WAC) Chapter 173-303. Under the State of Washington authority, the term dangerous waste is used instead of hazardous waste, and the definition of dangerous waste encompasses a larger universe of wastes. When a waste is both a dangerous waste and a radioactive waste, it is designated as a mixed waste.

It is assumed that the sludge will be regulated as a mixed waste due to concentrations of toxicity characteristic metals. This is a conservative assumption based on total concentrations of cadmium, chromium, and lead in the KE Basin floor and pit sludge, which are substantially higher than dangerous waste toxicity characteristic designation limits (Makenas 1996). The sludge has not been analyzed using the toxicity characteristic leaching procedure (TCLP). Some debris might also designate as mixed waste. Basin water is not expected to designate as mixed waste.

Facilities to treat, store, and dispose of the sludge must meet substantive dangerous waste management requirements that include the following:

- Tank-based sludge treatment and storage systems must be double contained, provided with appropriate leak detection capabilities, and cathodically protected.

- Tanks must be inspected daily and subjected to periodic integrity testing. New tanks must undergo a structural integrity assessment.

- Containers must be in good condition, compatible with the waste, closed except when adding/removing waste, handled in a manner that will not cause a release, and provided with at least 30 inches of aisle space.

- Container storage areas must provide containment sufficient to hold spills and leaks and prevent run-on.

- Storage container areas inspected weekly.

Mixed waste is subject to land disposal restrictions (LDR) that depend on the waste designation and waste type (e.g., certain types of debris like concrete have separate requirements). In general, wastes must be treated to either specific contaminant levels or by specific technologies prior to disposal. If basin sludge or basin debris designates as a mixed waste, it will most likely designate because of toxicity characteristic metals. Waste that is designated as characteristic waste due to the leachable concentrations of metals is subject to Phase IV of the LDR, which requires treating the waste to meet universal treatment standards for both the characteristic constituent and underlying constituents. PCBs are an underlying constituent in the sludge.

B1.3 PCB MANAGEMENT STANDARDS

The *Toxic Substances Control Act* (TSCA) and its implementing regulation (40 CFR 761) govern the storage, treatment, and disposal of materials and wastes containing greater than 50 ppm of PCBs. The 1998 PCB Disposal Amendments added specific provisions relative to PCB bulk waste, PCB remediation waste, and decontamination. A key provision of the amendments is the definition of "PCB remediation waste," a definition that does not depend on the current concentration of PCBs in the waste if the spill occurred after 1978. Because it is unknown when PCBs were introduced into the K Basins sludge, the sludge and water and the debris contacting the sludge are managed as PCB remediation waste. The sludge and debris would be bulk PCB remediation waste and the water would be liquid PCB remediation waste.

The PCB Disposal Amendments provide three mechanisms for managing and disposing of PCB remediation waste, self-implementing, performance-based, and risk-based. Under the self-implementing option, PCB remediation waste can exit TSCA regulation after it has been decontaminated to meet specific cleanup levels (40 CFR 761.61(a)). Key cleanup levels that may be pertinent to the K Basins CERCLA action include the following:

- Bulk PCB remediation waste: $\leq$ 1 ppm (high exposure, no further conditions)
- Non-porous surfaces: $\leq$ 10 $\mu g/100\ cm^2$ (high exposure, no further conditions)
- Liquid PCB remediation waste: $\leq$ 0.5 $\mu g/L$ (no further conditions)

Use of the self-implementing option requires verification via sample collection and analysis.

Under the performance-based option, PCB remediation waste can exit TSCA regulation if it has been decontaminated by prescribed methods (40 CFR 761.61(b)). No verification sampling is required.

Under the risk-based disposal approval, EPA may determine that sampling, management, or disposal methods other than those identified in the previous two options do not present a risk to human health or the environment (40 CFR 761.61(c)). A risk-based disposal discussion in support of DOE's request for a risk-based disposal approval is presented in Appendix C.

A PCB remediation waste that does not exit TSCA under one of these approaches is still regulated under TSCA.

B1.4 EFFLUENT DISCHARGE STANDARDS

The federal *Clean Water Act of 1988* (CWA) and the State of Washington *Water Pollution Control Act* regulate discharges to waters of the United States and waters of the State of Washington, respectively. The State of Washington law is implemented via WAC Chapter 173-216 and controls direct and indirect discharges to waters of the State of Washington, including effluent discharges to the soil column. This control consists of setting concentration limits for soil column discharges, establishing requirements for monitoring, and requiring application of all known, available, and reasonable methods of treatment.

B1.5 AIR EMISSION STANDARDS

The federal *Clean Air Act* (CAA) and the *Washington Clean Air Act* regulate both radioactive and non-radioactive airborne emissions. EPA administers the federal radioactive emissions requirements and the Washington State Department of Health (DOH) administers the State of Washington radioactive emissions requirements. Implementing regulations found in 40 CFR 61, Subpart H, and WAC Chapter 246-247 limit radionuclide airborne emissions from all combined operations at the Hanford Site to 10 mrem/year effective dose equivalent to the hypothetical offsite maximally exposed individual. WAC 246-247 Chapter requires verification of compliance, typically through either continuous or periodic confirmatory air sampling depending on the potential unabated dose, and application of best available radionuclide control technology (BARCT). EPA and DOH determine whether the federal and State of Washington requirements have been met through review and approval of Notices of Construction (NOC) submitted by the party proposing a new or modified activity.

Ecology administers the non-radioactive airborne emissions requirements. Implementing regulations, found in WAC Chapter 173-400, establish emission limits for visibility, particulate matter, fugitive odor, and hazardous air pollutants. The regulations establish standards for the control and/or prevention of the emission of non-radioactive air contaminants, including the application of best available control technologies (BACT) for new sources of regulated and toxic air emissions. Ecology also uses an NOC process to determine whether requirements have been met.

Both radioactive and nonradioactive air emissions NOCs have already been submitted to the regulatory agencies for activities conducted at the K Basins in preparation for the cleanout or for which substantial planning had been performed prior to the implementation of CERCLA. These NOCs and conditions in the agency approvals will be binding on the K Basin interim remedial action. Activities for which NOCs addressing the scope of the CERCLA action have been submitted and approvals received are as follows:

- Fuel removal, water treatment, and cask loadout at KE Basin
- Fuel removal, water treatment, and cask loadout at KW Basin
- Chiller bay modifications at KE Basin
- Demolition for multi-canister overpack (MCO)/cask at KE Basin
- Demolition for MCO/cask at KW Basin
- Corridor 7 modifications at KE/KW Basins
- Hydrolasing of piping at KE Basin
- Fuel hanger removal at KE/KW Basins

- Vestibule modifications at KE/KW Basins
- Sludge pumping of SW Loadout Pit at KW Basin
- Shipments of SNF from the 327 Building
- Air sparging in KW Basin
- KE and KW drain valve mitigation

The approvals specify emissions controls and monitoring requirements for each activity based on the potential unabated offsite dose.

B1.6 WASTE TRANSPORTATION STANDARDS

The U.S. Department of Transportation (DOT) Requirements for Hazardous Materials (49 CFR Parts 100 to 179) establish standards for packaging and shipping hazardous materials on public highways. The DOT standards, including all administrative requirements, would be strictly applicable to the offsite transport of any SNF, sludge, water, and debris. The performance requirements in these standards are relevant and appropriate for transportation on the Hanford Site.

The DOT performance requirements include specifications on the type of transport container and appropriate marking and labeling.

B1.7 RADIATION PROTECTION STANDARDS

Under the authority of the AEA, DOE's Occupational Radiation Protection Rule (10 CFR 835) establishes radiation protection standards, limits, and program requirements for protecting workers and visitors from ionizing radiation resulting from the conduct of DOE activities. It also requires that measures be taken to maintain radiation exposure as low as reasonably achievable. This regulation is applicable to any actions taken with respect to the K Basins and the radioactive materials therein.

Table B-1. Identification of Potential Federal ARARs and TBCs for the K Basins Interim Remedial Action. (5 sheets)

ARAR Citation	Applicable, Relevant and Appropriate, or To Be Considered	Requirement	Rationale for Use
CHEMICAL-SPECIFIC			
Comprehensive Response, Compensation, and Liability Act of 1980 (CERCLA), 42 USC 9601, et seq. Designation, Reportable Quantities, and Notification, 40 CFR 302	Applicable	Specifies reportable quantities for releases of CERCLA hazardous substances. Sets forth the notification requirements for releases of these substances.	Hazardous substances are present in the K Basins and could be inadvertently released during remedial action.
Resource Conservation and Recovery Act of 1976 (RCRA), 42 USC 6901, et seq. Land Disposal Restrictions, 40 CFR 268	Applicable	Specifies numerical standards to which some restricted wastes must be treated prior to land disposal.	Dangerous wastes subject to the land disposal restrictions will be generated as part of the K Basins remedial action.
Radiation Protection of the Public and the Environment, 10 CFR 834 (proposed at 58 FR 16268) and DOE Order 5400.5	To be considered	Would promulgate standards presently found in DOE Order 5400.5 by setting radiation standards for protection of the public in the vicinity of DOE facilities. Identifies derived concentration guidelines (DCGs) as reference values for estimating potential dose and determining compliance. Annual effective dose equivalent is set at 100 mrem. Where residual radioactive materials remain, requires evaluation impacts beyond the 1,000-year time period identified in the existing DOE Order.	The K Basins remedial action might result in releases to the environment.
Toxic Substances Control Act (TSCA), 15 USC 2601 et seq. Regulation of PCBs, 40 CFR 761	Applicable	Specifies numerical standards under which certain materials and wastes are regulated under TSCA. In general, materials with PCB concentrations $\geq$ 50 ppm are regulated under TSCA. Specifies treatment and decontamination numerical standards to exit TSCA regulation.	PCBs have been detected above regulated levels in KE Basin sludge.
LOCATION-SPECIFIC			
National Historic Preservation Act of 1966, 16 USC 470	Applicable	Requires that historically significant properties be protected. Requires that agencies undertaking projects must evaluate impacts to properties listed on or eligible for inclusion on the National Register of Historic Places. An eligibility determination provides a site the same level of protection as a site listed on the National Register of Historic Places. The regulations implementing the act require that the lead agency for a project identify, evaluate, and determine the effects of the project on any cultural resource sites that may be within the area impacted by the project and resolve negative impacts.	Certain properties in the 100-K Area may be eligible for listing on the National Register.

Table B-1. Identification of Potential Federal ARARs and TBCs for the K Basins Interim Remedial Action. (5 sheets)

ARAR Citation	Applicable, Relevant and Appropriate, or To Be Considered	Requirement	Rationale for Use
Archeological and Historic Preservation Act, 16 USC 469a	Potentially applicable	Requires that actions conducted at the site must not cause the loss of any archeological and historic data. This act mandates preservation of the data and does not require protection of the actual facility. Where a site is determined to be eligible for the National Register and mitigation is unavailable, artifacts and data will be recovered and preserved prior to commencement of the action.	Archeological and historic sites in the 100 Area are not expected to be impacted by the K Basins remedial action. Cultural resource surveys will be conducted prior to field activities to confirm this.
Endangered Species Act of 1973, 16 USC 1531, et seq.	Potentially applicable	This act prohibits federal agencies from jeopardizing threatened or endangered species or adversely modifying habitats essential to their survival. If waste site remediation is within sensitive habitat or buffer zones surrounding threatened or endangered species, mitigation measures must be taken to protect this resource.	No threatened or endangered species or sensitive habitats are expected to be impacted by the K Basins remedial action. Ecological resource surveys will be conducted prior to field activities to confirm this
Hanford Reach Study Act, Public Law 100-605, as amended	Applicable	Provides for a comprehensive Columbia River conservation study. New federal and non federal projects and activities are required, to the extent practicable, to minimize direct and adverse affects on the values for which the river is under study and to use existing structures.	The K Basins CERCLA action will take place near the Columbia River. The National Park Service will be consulted regarding activities to avoid, minimize, and provide mitigation for any direct and adverse effects on the river.
ACTION-SPECIFIC			
Atomic Energy Act of 1954, as amended, 42 USC 2011, et seq.			
Nuclear Regulatory Standards for Protection Against Radiation, 10 CFR 20	Relevant and appropriate	Establishes standards for protecting the public against radiation arising from the use of regulated materials at NRC-licensed facilities. Specifies that exposure from releases cannot exceed 100 mrem/yr total effective dose equivalent or 2 mrem/hr from external exposure in unrestricted areas.	This standard is not applicable because the Hanford Site is not NRC licensed. However, the regulation is relevant and appropriate because remedial actions will involve radioactive material.
Licensing Requirements for Land Disposal of Radioactive Waste, 10 CFR 61	Relevant and appropriate	Establishes the performance requirements and technical design standards for facilities intended for land disposal of radioactive waste. Generally prohibits near-surface disposal of greater-than-Class-C waste.	This standard is not applicable to Hanford Site disposal facilities because they are not NRC licensed. However, the regulation is relevant and appropriate because K Basin radioactive waste will likely be disposed at Hanford facilities. It is applicable for any K Basins radioactive wastes that will be disposed offsite at NRC-licensed facilities.
Environmental Radiation Protection Standards for Nuclear Power Operations, 40 CFR 190	Relevant and appropriate	Specifies the levels below which normal operations of the uranium fuel cycle are determined to be environmentally acceptable. The standard sets dose equivalents from the facility that are not to exceed 25 mrem/yr to whole body, 75 mrem/yr to thyroid, or 25 mrem/yr to any other organ.	These standards are not applicable because the K Basins action does not involve operation of a uranium fuel cycle. However, the standards are relevant and appropriate because they address acceptable dose to the public resulting from radioactive operations.
Environmental Radiation Protection Standards for the Management and Disposal of Spent Nuclear Fuel, High-Level and Transuranic	Applicable	Establishes standards for management and disposal of spent nuclear fuel, high-level waste, and transuranic wastes at facilities operated by the DOE.	The requirements are applicable because SNF will be managed and transuranic wastes will be generated during the K Basins remedial action.

Table B-1. Identification of Potential Federal ARARs and TBCs for the K Basins Interim Remedial Action. (5 sheets)

ARAR Citation	Applicable, Relevant and Appropriate, or To Be Considered	Requirement	Rationale for Use
Radioactive Waste, 40 CFR 191			
Waste Isolation Pilot Plant Land Withdrawal Act, Public Law 102-579	Applicable	Transfers ownership around the WIPP to DOE, establishes EPA as the regulatory authority for whether the WIPP meets applicable environmental requirements, and authorizes underground experiments using radioactive waste.	This law is applicable because TRU waste is likely to be generated during remedial action and will require disposal at the WIPP.
Land Withdrawal Act Amendment, Public Law 104-201	Applicable	States RCRA land disposal restrictions do not apply to waste disposed at the WIPP.	This law is applicable because RCRA-regulated TRU waste may be generated during remedial action and will require disposal at the WIPP.
Resource Conservation and Recovery Act, as amended, 42 USC 6901			
Generator Standards, 40 CFR 262	Not applicable	Establishes requirements for facilities that generate hazardous waste.	Authority to implement this element of RCRA has been delegated to the State of Washington (see Table B-2).
Standards Applicable to Transporters of Hazardous Waste, 40 CFR 263	Not applicable	Establishes standards applicable to transporters of hazardous wastes.	Authority to implement this element of RCRA has been delegated to the State of Washington (see Table B-2).
Standards for Owners and Operators of TSD Units, 40 CFR 264 and 265	Not applicable	Sets standards for owners and operators of hazardous waste treatment, storage, and disposal facilities.	Authority to implement this element of RCRA has been delegated to the State of Washington (see Table B-2).
Land Disposal Restrictions, 40 CFR 268	Applicable	These requirements prohibit the placement of restricted hazardous wastes in land-based units such as landfills, surface impoundments, and waste piles until treated to standards considered protective for disposal. Specific treatment standards are included in the requirements.	Waste subject to the land disposal restrictions is likely to be generated during the K Basin remedial action.
Toxic Substances Control Act (TSCA), 15 USC 2601 et seq.			
Regulation of PCBs, 40 CFR 761	Applicable	Specifies storage, treatment, and disposal requirements for materials and waste containing PCBs at regulated levels. The 1998 PCB Disposal Amendments provide specific requirements for management of PCB remediation waste and decontamination.	Waste that meets the definition of PCB remediation waste will be generated during the K Basin remedial action.
Clean Air Act of 1977, as amended 42 USC 7401, et seq.			
National Ambient Air Quality Standards, 40 CFR 50	Potentially applicable	Establishes release limits for airborne releases of specific criteria pollutants.	Criteria pollutants may be generated as a result of remedial action at the K Basins.
Ambient Air Quality Monitoring, 40 CFR 58	Potentially applicable	Presents the criteria and requirements for ambient air quality monitoring and reporting for operators of new sources of air pollutants.	If a sludge treatment system is required as part of the K Basins remedial action, it may meet the regulatory definition of a new source.
Standards of Performance for New Stationary Sources, 40 CFR 60	Potentially applicable	Provides standards for new stationary sources or modifications of existing sources.	If a sludge treatment system is required as part of the K Basins remedial action, it could meet the regulatory definition of a new stationary source.
National Emission Standard for Hazardous Air Pollutants (NESHAP),	Applicable	Provides general requirements and listings for emissions at a regulated facility. Establishes emission standards for hazardous air pollutants	Hazardous air pollutants, including radionuclides, are likely to be generated as a result of remedial action at the K

Table B-1. Identification of Potential Federal ARARs and TBCs for the K Basins Interim Remedial Action. (5 sheets)

ARAR Citation	Applicable, Relevant and Appropriate, or To Be Considered	Requirement	Rationale for Use
40 CFR 61		including radionuclides. Subpart H sets emission limits from the entire facility to ambient air that are not to cause any member of the public to receive an effective dose equivalent of 10 mrem/yr. The definition of facility includes all buildings, structures, and operations at one contiguous site.	Basins.
National Emission Standards for Asbestos, Standard for Demolition and Renovation, 40 CFR 61.145 – 150	Potentially applicable	Defines regulated asbestos-containing materials and establishes removal requirements based on quantity present and handling requirements. Also specifies handling and disposal requirements for regulated sources having the potential to emit asbestos.	Asbestos may be removed as part of deactivation activities under the K Basins remedial action.
Atomic Energy Act of 1954, as amended, 42 USC 2011, et seq.			
Licensing Requirements for the Land Disposal of Radioactive Waste, 10 CFR 61	Relevant and appropriate	Requires that radioactive waste disposal systems be designed to limit the annual dose equivalent beyond the facility boundary below 25 mrem to the whole body, 75 mrem to the thyroid, or 25 mrem to any other organ are relevant and appropriate to remedial actions that include land disposal or release radioactive effluent. Inadvertent intruder requirements for land disposal units are also contained in this regulation	Radioactive waste generated by the K Basins remedial action must be disposed in a facility that meets these requirements.
Packaging and Transportation of Radioactive Material, 10 CFR 71	Relevant and appropriate	Establishes requirements for packaging, preparation for shipment, and transportation of licensed radioactive material.	The regulations are only applicable for NRC-licensed plants and facilities where material is transported outside the confines of the plant. The Hanford Site is not a NRC-licensed plant; however, potentially radioactive waste will be generated by the k Basins remedial action. Subparts of this regulation are relevant and appropriate for packaging, testing, and preparation of packages containing radioactive material.
Environmental Radiation Protection Standards for the Management and Disposal of Spent Nuclear Fuel, High-Level, and Transuranic Radioactive Wastes, 40 CFR 191	Applicable	Establishes requirements for disposal of SNF, high-level waste, and TRU waste. Precludes near-surface disposal of these materials. Requires that radionuclide release to the environment for a period of 10,000 years after disposal shall have a likelihood of less than one chance in ten of exceeding specified levels.	SNF and TRU waste will be generated by the K Basins remedial action and must be disposed at a facility that meets these requirements.
Department of Energy Occupational Radiation Protection, 40 CFR 835	Applicable	Sets occupational dose limits for adults. Total effective dose equivalent is equal to 5 rem/yr	Workers will be exposed to radiation as a result of the K Basins remedial action.
Hazardous Materials Transportation Act, 49 USC 1801, et seq.			
Hazardous Materials Regulation, 49 CFR 171	Potentially applicable	Establishes standards for classifying, packaging, marking, and labeling hazardous materials that will be transported on public roadways.	Hazardous materials may be transported off the Hanford Site in connection with the K Basins remedial action.
Hazardous Materials Tables, Hazardous Materials Communications Requirements, and Emergency Response	Potentially applicable	Includes tables used to identify requirements for labeling, packaging, and transportation based on categories of waste types. Small quantities of radioactive wastes are not subject to the requirements of the standard if activity levels are	Hazardous materials may be transported off the Hanford Site in connection with the K Basins remedial action.

Table B-1. Identification of Potential Federal ARARs and TBCs for the K Basins Interim Remedial Action. (5 sheets)

ARAR Citation	Applicable, Relevant and Appropriate, or To Be Considered	Requirement	Rationale for Use
Information Requirements, 49 CFR 172		below limits established in paragraph 173.421, 173.422, or 173.424. Specific performance requirements are established for packages used for shipping and transport of hazardous materials.	

Table B-2. Identification of Potential State of Washington ARARs and TBCs for the K Basins Interim Remedial Action. (3 Sheets)

ARAR Citation	Applicable, Relevant and Appropriate, To Be Considered	Requirement	Rationale for Use
CHEMICAL-SPECIFIC			
Hazardous Waste Management Act, Ch. 70.105 RCW			
Designation of Waste, WAC 173-303-070 through 110	Applicable	Establishes the numerical criteria and methodology to determine if solid waste requires management as dangerous waste.	Dangerous waste will likely be generated as a result of the K Basins remedial action.
State of Washington Radiation Protection Requirements, Ch. 70.98 RCW			
Radiation Protection Standards, WAC 246-221	Relevant and appropriate	Establishes annual average concentration limits for radioactive releases in gaseous and liquid effluent released to unrestricted areas for licensed facilities. Sets occupational dose limits and dose limits for members of the public.	This regulation is not applicable because the Hanford Site is not a licensed facility. However, it is relevant and appropriate to releases from the K Basins remedial action.
Washington Clean Air Act, Ch. 70.94 RCW and Ch. 43.21A RCW			
Ambient Air Quality Standards and Emission Limits for Radionuclides, WAC 173-480	Applicable	Requires that the most stringent federal or State of Washington ambient air quality standard for radionuclides are enforced. WAC 173-480 defines the standard as a maximum accumulated dose equivalent of 25 mrem/yr to the whole body or 75 mrem/yr to any critical organ. However, the standard of 10 mrem/yr under 40 CFR 61 Subpart H is more stringent.	The K Basins remedial action will result in radionuclide air emissions.
Radiation Protection - Air Emissions, WAC 246-247	Applicable	Establishes limits for airborne radionuclide emissions. Ambient air emissions are not to exceed amounts that result in an effective dose equivalent of 10 mrem/yr to any member of the public.	The K Basins remedial action is likely to produce radioactive air emissions.
LOCATION-SPECIFIC			
Department of Game Procedures, WAC 232-012	Potentially applicable	Defines the requirements that the Department of Game must take to protect endangered or threatened wildlife.	No threatened or endangered species or sensitive habitats are expected to be impacted by the K Basins remedial action. Ecological resource surveys will be conducted prior to field activities to confirm this.
National Area Preserves, RCW 79.70			

Table B-2. Identification of Potential State of Washington ARARs and TBCs for the K Basins Interim Remedial Action. (3 Sheets)

ARAR Citation	Applicable, Relevant and Appropriate, To Be Considered	Requirement	Rationale for Use
Washington Natural Heritage Program	To be considered	Program serves as an advisory council to the Washington State Department of Natural Resources, Fish and Wildlife, the Parks and Recreation Commission, and other State of Washington agencies managing State of Washington-owned land or natural resources. Develops a list of State of Washington endangered, threatened, and sensitive plants developed by the program, along with program-recommended levels of protection to assist resource managers. Designations provided to plants are advisory and do not specify a regulatory level of protection.	No threatened or endangered plant species or sensitive habitats are expected to be impacted by the K Basins remedial action. Ecological resource surveys will be conducted prior to field activities to confirm this.
ACTION-SPECIFIC			
Hazardous Waste Management Act, 70.105 RCW			
Land Disposal Restrictions, WAC 173-303-140 through 141	Applicable	Identifies dangerous wastes that are restricted from land disposal, describes requirements for State of Washington-only restricted wastes, and defines the circumstances and treatment standards under which a prohibited waste may be disposed.	The K Basins remedial action is likely to generate dangerous or mixed waste that will require disposal.
Requirements for Generators and Transporters of Dangerous Waste, WAC 173-303-160 through 270	Applicable	Defines generator and transporter requirements including container storage, safe management of dangerous wastes, personnel training, emergency preparedness, packaging, and manifesting.	The K Basins remedial action is likely to generate dangerous or mixed waste.
General Requirements for Dangerous Waste Management Facilities, WAC 173-303-280 through 395	Applicable	General requirements include siting standards, emergency preparedness, security, inspections, contingency planning, waste analysis, and management of containers.	The K Basins remedial action is likely to require management of dangerous or mixed waste, including potentially treatment of sludge that designates as mixed waste.
Treatment, Storage, and Disposal Facility Requirements, WAC 173-303-600 through 695	Applicable	Specifies design and operating requirements for units that will store, treat, or dispose of dangerous waste. Specific unit requirements are included for containers and tanks.	The K Basins remedial action is likely to generate dangerous or mixed waste that will require storage, treatment, and disposal.
Water Pollution Control/Water Resources Act, Ch. 90.48 RCW/Ch. 90.54 RCW			
State of Washington Waste Discharge Program, WAC 173-216	Potentially applicable	Establishes requirements for discharges to the groundwater or surface waters of the State of Washington. Specific discharges prohibited under the program are identified.	The K Basins remedial action will likely require treatment and disposal of contaminated basin water. Disposal will be subject to the 216 requirements.

Table B-2. Identification of Potential State of Washington ARARs and TBCs for the K Basins Interim Remedial Action. (3 Sheets)

ARAR Citation	Applicable, Relevant and Appropriate, To Be Considered	Requirement	Rationale for Use
Washington Clean Air Act, Ch. 70.94 RCW and Ch. 43.21A RCW			
General Regulations for Air Pollution, WAC 173-400	Applicable	Requires that all sources of air contaminants meet emission standards for visible, particulate, fugitive, odors, and hazardous air emissions. Requires that all emission units use reasonably available control technology and perform source testing and monitoring.	The K Basins remedial action is likely to result in the emission of hazardous air pollutants.
Controls for New Sources of Air Pollution, WAC 173-460	Potentially applicable	Requires that new sources of air emissions provide emission estimates for toxic air contaminants listed in the regulation. Requires that emissions be quantified and used in risk modeling to evaluate ambient impacts and establish acceptable source impact levels. Establishes requirements to use best available control technology, quantify toxic emissions, and demonstration that human health is protected.	The K Basins remedial action, particularly some sludge treatment options, may result in the emission of toxic air contaminants.
Ambient Air Quality Standards and Emission Limits for Radionuclides, WAC 173-480	Applicable	Requires emission controls for new and modified emission units to use best available radionuclide control technology.	The K Basins remedial action will result in radionuclide air emissions.
Radiation Protection - Air Emissions, WAC 246-247	Applicable	Requires confirmatory air sampling for radioactive emissions.	The K Basins remedial action is likely to produce radioactive air emissions.

APPENDIX C

RISK BASED APPROACH FOR PCBs

C1.0 RISK BASED APPROACH FOR PCBS

C1.1 INTRODUCTION

Polychlorinated biphenyls (PCBs) are one of the contaminants present in the K Basins sludge. The source of the PCBs and the date when they were introduced into the sludge are unknown. There are no known, authorized uses of PCBs in the basins. It is assumed that the PCBs came to be present in the sludge as a result of a spill or release of material containing PCBs at an unknown concentration. Based on this information, the sludge meets the definition of a PCB remediation waste.1

Regulations governing the management and disposal of PCBs under the *Toxic Substances Control Act* (TSCA) are contained in Title 40, *Code of Federal Regulations* (CFR), Part 761. The PCB Disposal Amendments of 1998 contained in this regulation identify three approaches to establishing requirements for the disposal of PCB remediation waste. One of these approaches is the risk-based disposal approval (40 CFR 761.61(c)). Under the risk-based disposal approval, a party is allowed to request approval for a sampling, cleanup, or disposal method that differs from the methods prescribed elsewhere in the regulations. The U.S. Environmental Protection Agency (EPA) may grant approval if it determines that the proposed risk-based method will not pose an unreasonable risk of injury to health or the environment.

As part of the K Basins interim remedial action, the Department of Energy, Richland Operations Office (DOE) is requesting a risk-based disposal approval to address PCBs in the K Basins sludge. The demonstration that the PCBs do not present an unreasonable risk is based on the following points:

- The concentration and total mass of PCBs in the K Basins sludge are low
- PCB treatment is included in all of the proposed sludge treatment alternatives

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1 40 CFR 761.3 of the TSCA regulations defines PCB remediation waste as "waste containing PCBs as a result of a spill, release, or other unauthorized disposal, at the following concentrations: Materials disposed of prior to April 18, 1978, that are currently at concentrations of $\geq$ 50 ppm PCBs, regardless of the concentration of the original spill; materials which are currently at any volume or concentration where the original source was $\geq$ 500 ppm PCB beginning on April 18, 1978, or $\geq$ 50 ppm beginning on July 2, 1979; and materials which are currently at any concentration if the PCBs are from a source not authorized for use under this part. PCB remediation waste means soil, rags, and any other debris generated as a result of any PCB spill cleanup, including but not limited to: (1) Environmental media containing PCBs, such as soil and gravel; dredged materials, such as sediments, settled sediment fines, and aqueous decantate from sediment; (2) Sewage sludge containing < 50 ppm PCBs and not in use according to 761.20(a)(4); PCB sewage sludge; commercial or industrial sludge contaminated as a result of a spill of PCBs including sludges located in or removed from any pollution control device; aqueous decantate from an industrial sludge; (3) Buildings and other man-made structures, such as concrete or wood floors or walls contaminated from a leaking PCB or PCB-Contaminated transformer, porous surfaces and non porous surfaces."

- The treated sludge will require safe storage and long-term isolation because of the highly radioactive contaminants, regardless of residual PCB contamination

- The risks associated with worst-case scenarios of releasing PCBs to the environment are low.

These points are discussed in more detail in the following sections.

C1.2 CONCENTRATION AND QUANTITY OF PCBs

PCBs have been detected in the K Basins sludge in several sampling events. Seven samples collected at different locations on the main floor and in the pits of the K East (KE) Basin in late 1995 were analyzed for semi-volatile organic compounds. PCBs were detected in three of these samples. These three samples were further analyzed to confirm and quantify the PCB detections. The highest concentration detected was 0.000225 g/cm^3 (140 ppm) on a settled solids basis (Pearce et al. 1998). PCBs were also detected in samples collected from fuel canisters in the KE Basin and in samples collected from canisters in the K West (KW) Basin. The concentrations detected in the canisters were a maximum of 0.0000018 g/cm^3 (1.1 ppm) on a settled solids basis in the KE Basin canister sludge and a maximum of 0.000015 g/cm^3 (5.7 ppm) on a settled solids basis in the KW Basin canister sludge (Pearce et al. 1998). Floor and pit sludge from the KW Basin has not been analyzed.

Using the maximum detected PCB concentration of 0.000225 g/cm^3 and a total estimated settled sludge volume of 51 m^3, the total mass of PCBs in the basins would be 11 kg (25 lb). However, it is very unlikely that the mean concentration of PCBs in the sludge exceeds the detected maximum concentration; it is more likely that the mean concentration is lower than the maximum detected. . Based on the maximum PCB concentration detected at each basin location and the volume of sludge at that location (Table C1-1), the volume-weighted mean concentration of PCBs in the sludge is 0.00011 g/cm^3. Using the volume-weighted mean concentration, the total mass of PCBs in the sludge is likely to be about 5.6 kg (12 lb

C1.3 STORAGE OF PCB WASTES

Under all of the treatment alternatives, PCB remediation waste (untreated sludge and/or treatment residuals) will be stored at the Hanford Site. Storage would most likely occur in containers or tanks designed for storage of radioactive waste. Specific storage methods will be detailed during remedial design.

C1.4 SLUDGE TREATMENT

All of the sludge treatment alternatives include processes that would treat the PCBs to reduce the concentration of PCBs in the treated sludge. In four of the alternatives, the PCB treatment is incidental to the treatment needed to meet other requirements. In two alternatives, additional

features are added to the treatment system specifically to treat PCBs. The PCB treatment provided by each of the alternatives is as follows:

- **Baseline Chemical Treatment**. Laboratory studies have been conducted to determine the fate of PCBs when K Basins sludge is treated using the baseline chemical treatment process (Mong et al. 1998). Based on those studies, PCBs would be removed from the sludge by a combination of three mechanisms:

  - The process would include steps to separate insoluble solids from the bulk sludge. Some of the PCBs would separate out with the insoluble solids. The insoluble solids would be leached to reduce the radionuclide content then grouted and disposed at either the Environmental Restoration Disposal Facility (ERDF) (if the solids meet the ERDF waste acceptance criteria) or the Waste Isolation Pilot Plant (WIPP). The ERDF is authorized to accept PCBs as long as the waste otherwise meets the ERDF waste acceptance criteria (BHI 1998). The WIPP is authorized to accept PCBs up to 50 ppm (DOE 1996b); it is anticipated that this limit will be eliminated in the future.

  - Some of the PCBs would plate onto the treatment system equipment. The equipment would be disposed at the ERDF when it is no longer in service.

  - Some of the PCBs would volatilize during the acid dissolution process. The off-gas treatment system would be provided with a granular activated carbon (GAC) absorption unit to capture PCBs such that the PCB concentration in the stack emissions would be less than 10 $\mu g/m^3$. The spent absorber would be disposed at ERDF.

  PCBs that are not removed via one of these three mechanisms would remain in the treated sludge and be transferred to Tank Waste Remediation System (TWRS).

- **Modified Chemical Treatment**. The modified chemical treatment process would be similar to baseline chemical treatment except that (1) there would be less aggressive separation of the insoluble solids from the main sludge stream and (2) the insoluble solids would not be leached to remove radionuclides. Based on the laboratory studies for the baseline chemical treatment process, it is expected that some of the PCBs would remain with the insoluble solids, some would plate onto the treatment system equipment, and some would volatilize during the acid dissolution process and be captured on GAC in the off-gas treatment system. The insoluble solids would be grouted and disposed at the ERDF or the WIPP. The PCB-contaminated equipment and GAC would be disposed at the ERDF.

- **Grinding/Milling**. Under the proposed grinding process, PCBs would be removed from the sludge by adsorption onto a polyurethane liner applied to the inner surface of the grinder. PCBs are known to sorb onto polyurethane, so it would be expected that some PCBs in the sludge would collect on the liner (Numatec 1999). The liner would later be disposed with the contaminated equipment sludge treatment equipment in the ERDF.

Some PCBs might volatilize during treatment. The off-gas treatment system would include a GAC absorption unit to capture PCBs so that the PCB concentration in the stack emissions would be less than 10 $\mu g/m^3$. Those PCBs not removed by the liner or volatilization would remain with the treated sludge and be transferred to TWRS.

- **Vitrification**. Under the proposed vitrification process, PCBs would likely be treated via two mechanisms. Some of the PCBs would be volatilized during the acid dissolution of larger particles. Those PCBs that remain in the sludge that is fed to the melter would likely volatilize or be destroyed by the high temperatures in the melter. The off-gas treatment system would include a GAC absorption unit to capture PCBs so that the PCB concentration in the stack emissions would be less than 10 $\mu g/m^3$. Any residual PCBs would be disposed at the national geologic repository or the WIPP as part of the vitrified sludge.

- **Calcination**. Under the proposed calcination process, PCBs would likely be treated via two mechanisms. Some of the PCBs would be volatilized during the acid dissolution of larger particles. Those PCBs that remain in the sludge that is fed to the calciner would likely volatilize at the high temperatures in the calciner. The off-gas treatment system would include a GAC absorption unit to capture PCBs so that the PCB concentration in the stack emissions would be less than 10 $\mu g/m^3$. Any residual PCBs would be disposed at the WIPP as part of the calcined sludge.

- **Grouting**. Under the proposed grouting process, PCBs would be treated via volatilization during thermal pre-treatment to oxidize the sludge. Particles less than 250 microns would be heated at 100^oC for several hours, and particles greater than 250 microns would be heated at temperatures up to 500^oC. The off gas treatment system would include a GAC absorption unit to capture PCBs so that the PCB concentration in the stack emissions would be less than 10 $\mu g/m^3$. Any residual PCBs would be disposed at the WIPP as part of the grouted sludge.

C1.5 MANAGEMENT OF TREATED SLUDGE AND RESIDUAL PCBS

Under all of the alternatives, the treated sludge could contain residual PCBs. However, the sludge would also be a highly radioactive waste that would be regulated as either a high-level waste (HLW) or transuranic (TRU) waste. By law, HLW and TRU waste require long-term isolation at the national geologic repository or the WIPP, respectively. The requirements for the repository and the WIPP are at least as restrictive as those for a TSCA chemical waste landfill for PCB disposal. Points of comparison include the following:

- Both the repository and the WIPP are required to provide a reasonable expectation that waste placed in them is effectively contained for 10,000 years (40 CFR 191.13(a)). No specific performance periods are identified for TSCA landfills.

- Both the repository and the WIPP will be located well below the ground surface. The WIPP is located about 850 feet below the surface, and similar or greater depths are expected for the repository. A TSCA landfill is typically a near-surface facility with only a few feet of cover.

- Both the repository and the WIPP will be located in geologically stable formations. The WIPP has been constructed in a salt formation expected to be stable for at least one-quarter million years. An appropriately stable formation will also be selected for the repository. TSCA landfills must be located in relatively impermeable and stable formations such as clay beds (40 CFR 61.75).

- The repository and the WIPP have specific requirements to maintain active institutional controls for as long as practicable, to monitor the sites, to designate the sites with permanent markers, and to use both natural and engineered barriers (40 CFR 191.14). Comparable requirements are not specified for TSCA landfills.

- The repository and the WIPP must be designed such that they do not cause exceedance of groundwater protection standards for 10,000 years (40 CFR 191.24(a)(1)). To protect groundwater, TSCA landfills must have a permeability less than 1×10^{-7} cm/sec (to minimize leaching), must be surrounded by a minimum of three groundwater monitoring wells, and must include a monitored leachate collection system.

Based on this comparison, the design and operation for the radioactive waste facilities are at least as stringent as, if not more stringent than, those for a TSCA chemical waste landfill. Therefore, it can be expected that PCBs that remain in the treated sludge when the sludge is disposed will be managed in a protective manner.

C1.6 WORST-CASE IMPACTS

An evaluation was performed to demonstrate that if the PCBs in the K Basins sludge were not controlled and were released to the environment there would be little risk to human health or the environment. For this hypothetical worst-case analysis, scenarios that represent two extremes were postulated:

- **Scenario A.** All of the PCBs in the K Basins sludge are emitted to the atmosphere during sludge treatment. This scenario assumes that the sludge treatment occurs in the 100-K Area and that all of the PCBs are volatilized with no treatment of the off-gas. (In reality, only a fraction of the PCBs would volatilize during treatment, and all of the sludge treatment off-gas systems would include treatment to capture PCBs.) This scenario was used to calculate the risk to an industrial worker and to a nearby recreational user.

- **Scenario B.** All of the PCBs remain in the K Basins sludge after treatment, the sludge is transferred to the 200 Area, and all of the PCBs are emitted to the atmosphere during further processing in the 200 Area. This scenario assumes that all of the PCBs are

volatilized with no treatment of the off-gas. (In reality, only a fraction of the PCBs would volatilize during further processing, and the processing system would likely have off-gas treatment for organic contaminants present in other wastes.) This scenario was used to calculate the risk to an industrial worker in the vicinity of the processing facility.

These scenarios and the potential receptors are illustrated in Figure C1-1.

C1.6.1 Evaluation of Scenario A

Methodology. The approach for evaluating this scenario consisted of the following:

- Calculate the maximum PCB concentration in ambient air at ground level that would be observed anywhere in the 100-K Area. This is the maximum concentration to which a worker would be exposed.

- Calculate the worker risk associated with exposure at the maximum concentration, assuming the worker spends all of his time at the point of maximum concentration for the entire time PCBs are being emitted, and compare to industrial standards.

- Calculate the maximum PCB concentration in ambient air that would be observed at the 100-K Area shoreline. This is the maximum concentration to which the recreational user would be exposed.

- Calculate the risk to the recreational user at the 100-K Area shoreline, assuming the user is exposed at the maximum concentration for the entire time PCBs are being emitted, and compare to EPA human health risk levels.

Calculation of ambient air concentrations. The concentrations of PCBs in ambient air are calculated in Attachment C-1. Key assumptions include the following:

- Treatment system feed rate2: 160 kg (dry solids)/hr
- As-settled sludge solids content[3]: 0.931 g dry solids/cm^3 settled solids
- PCB concentration3: 0.000225 g/cm^3 settled solids
- Air flow through ventilation system: 100 ft^3/min
- All PCBs volatilize and are emitted within the first hour of treatment

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2 This is a conservative maximum feed rate. The total mass of dry solids in the K Basins sludge is about 34,000 kg. This mass could be processed in one year by treating 214 batches of 160 kg dry solids each. The feed rate would depend on the treatment technology. For example, the feed rate for an acid dissolution process would be about 20 kg/hr, requiring a total of 8 hours to feed a complete batch. In contrast, the feed rate for a grinding/milling process could be 160 kg/hour (i.e., an entire batch of sludge would be fed to the process at once). A slower feed rate would increase the duration of PCB emissions but would decrease the concentration to which an individual would be exposed. Conversely, a higher feed rate would result in a shorter exposure duration but exposure to higher concentrations.

3 This is the maximum PCB concentration detected in the sludge, and the solids content of that sludge fraction, from Pearce, et al. (1998).

- Stack height4: 10 m

The results are as follows:

- PCBs emitted per hour: 38.7 g/hr
- Maximum concentration exiting the stack: 227.6 mg/m^3
- Maximum PCB concentration at ground level in 100-K Area: 20.4 µg/m^3
- Maximum PCB concentration at 100-K shoreline: 2.96 µg/m^3

Industrial risk. The risk to someone working in the 100-K Area was calculated based on the following:

- Maximum concentration of PCBs in ambient air at ground level in 100-K Area: 20.4 µg/m^3

- Receptor on-site 8 hrs/day, 250 days/year, located at point of maximum exposure; PCB emissions occur for one hour per day5

- Exposure period: 20 years6

- Upper-bound cancer slope factor for inhalation of evaporated congeners from the Integrated Risk Information System (IRIS) database (www.epa.gov/iris): 0.4 per (mg/kg)/day

- Other risk calculation parameters are from Table A-2 of the *Hanford Site Risk Assessment Methodology* (HSRAM)

Under this exposure scenario, the incremental cancer risk to a 100-K Area worker would be 1.99E-05. Calculations are provided in Attachment C-3.

The assumed exposure period of 20 years is very conservative in that sludge treatment is actually completed within one to two years. A more reasonable exposure scenario would assume an exposure period of one to two years. The risk calculated under this more reasonable scenario would be 9.93E-07.

Comparison to industrial standards. The maximum PCB concentration to which a worker would be exposed under Scenario A would be 20.6 µg/m^3. The Occupational Safety and Health Administration (OSHA) exposure limit for an 8-hour daily exposure to airborne PCBs is 0.5

4 The maximum exposure concentration depends on the stack height. Stack height was varied from 5 to 30 m in the analysis to illustrate the impacts (Attachment C-2). The results are based on the lowest reasonable stack height, 10 m (30 feet).
5 Exposure is assumed to occur for one hour per day because all PCBs in a batch are assumed to volatilize within the first hour of treatment, maximizing the concentration to which an individual would be exposed.
6 The actual sludge treatment campaign would be expected to last about 13 months. A 20-year exposure duration is used because that is the standard industrial worker exposure period and accounts for a worker's potential exposure to PCBs during the remainder of his/her career.

mg/m^3 (500 $\mu g/m^3$), or about 25 times the maximum worst-case exposure in the 100-K Area. The incremental cancer risk of 1.99E-05 would be within the EPA *Comprehensive Environmental Response, Compensation and Liability Act of 1980* (CERCLA) generally acceptable risk range of 10^{-4} to 10^{-6}.

Recreational risk. The risk to a member of the public located at the 100-K shoreline was calculated based on the following:

- Concentration of PCBs in ambient air at the 100-K Area shoreline: 2.96 $\mu g/m^3$
- Receptor is exposed 100 days per year; PCB emissions occur for one hour per day every day the receptor is present7
- Exposure occurs for 30 years8
- Upper-bound cancer slope factor for inhalation of evaporated congeners from IRIS (www.epa.gov/iris): 0.4 per (mg/kg)/day
- Other risk calculation parameters are from Table A-5 of HSRAM

Under this exposure scenario, the incremental cancer risk to a member of the public would be 1.66E-06. Calculations are provided in Attachment C-3.

The assumed exposure period of 30 years is very conservative in that sludge treatment is completed within one to two years. A more reasonable exposure scenario would assume an exposure period of one to two years. The risk calculated under this more reasonable scenario would be 5.52E-08.

Comparison to human health standards. The incremental cancer risk to a member of the public would be 1.66E-06. This would be within the EPA CERCLA generally acceptable risk range of 10^{-4} to 10^{-6}.

C1.6.2 Evaluation of Scenario B

Methodology. The approach for evaluating this scenario consisted of the following:

- Calculate the maximum PCB concentration in ambient air at ground level that would be observed in the vicinity of a system processing K Basins sludge in the 200 Area. This is the maximum concentration to which a worker would be exposed.

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7 This is very conservative in that it assumes that (1) a recreational user spends 100 days immediately at the 100-K Area shoreline, (2) the sludge treatment system is operated each of those 100 days, and (3) the user is present during the one hour that all PCBs are volatilized.

8 The actual sludge treatment campaign would be expected to last about 13 months. A 30-year exposure duration is used because that is the standard exposure period used for human health assessments.

- Calculate the worker risk associated with exposure at the maximum concentration, assuming the worker spends all of his time at the point of maximum concentration for the entire time K Basins sludge is being processed, and compare to industrial standards.

Calculation of ambient air concentrations. The concentrations of PCBs in ambient air are calculated in Attachment C-4. Key assumptions include the following:

- Processing system feed rate9: 640 kg (dry solids)/hr
- As-settled sludge solids content[8]: 0.931 g dry solids/cm^3 settled solids
- PCB concentration10: 0.000225 g/cm^3 settled solids
- Air flow through ventilation system: 1000 ft^3/min
- All PCBs volatilize and are emitted within the first hour of processing
- Stack height11: 10 m

The results are as follows:

- PCBs emitted per hour: 154.8 g/hr
- Maximum concentration exiting the stack: 91.0 mg/m^3
- Maximum PCB concentration in ambient air at ground level in 200 Area near processing facility: 21.41 µg/m^3

Industrial risk. The risk to someone working in the 200 Area near a facility processing the K Basins sludge was calculated based on the following:

- Maximum concentration of PCBs in air at ground level in 200 Area: 21.41 µg/m^3

- Receptor on-site 8 hrs/day, 250 days/year, located at point of maximum exposure; exposed to PCB emissions from K Basins sludge for on hour per day12

- Exposure period: 20 years13

- Upper-bound cancer slope factor for inhalation of evaporated congeners from IRIS (www.epa.gov/iris): 0.4 per (mg/kg)/day

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9 It is assumed that the processing system is designed to accommodate both the K Basins sludge and other waste streams and that the system has a feed rate 4 times greater than for a K Basins only system

10 This is the maximum PCB concentration detected in the sludge, and the solids content of that sludge fraction, from Pearce, et al. (1998).

11 The maximum exposure concentration depends on the stack height. Stack height was varied from 5 to 30 m in the analysis to illustrate the impacts (Attachment C-2). The results are based on the lowest reasonable stack height, 10 m (30 feet).

12 Exposure is assumed to occur for one hour per day because all PCBs were assumed to be volatilized within the first hour of processing each day. If PCBs volatilize more slowly, the exposure period would be longer but the maximum concentration would be lower, and the net effect would be the same. Conversely, if PCBs volatilize more quickly, the exposure period would be shorter but the maximum concentration would be higher, again with the same net effect.

13See footnote number 6.

- Other risk calculation parameters are from Table A-2 of the *Hanford Site Risk Assessment Methodology* (HSRAM)

Under this exposure scenario, the incremental cancer risk to a 200 Area worker would be 4.98E-06. Calculations are provided in Attachment C-5.

Comparison to industrial standards. The maximum PCB concentration to which a worker would be exposed would be 21.41 $\mu g/m^3$. This would be well below the OSHA exposure limit for an 8-hour daily exposure is 0.5 mg/m^3 (500 $\mu g/ m^3$). The incremental cancer risk of 2.00E-05 would be within the EPA CERCLA generally acceptable risk range of 10^{-4} to 10^{-6}.

C1.7 CONCLUSIONS

The DOE is proposing to take a risk-based approach to managing the PCBs present in the K Basins sludge.

The concentration and mass of the PCBs in the sludge are low to begin with. The PCBs will undergo some degree of treatment in the sludge treatment system, including off-gas treatment to capture PCBs that volatilize, further reducing the concentration of PCBs in the sludge. PCBs remaining in the sludge after treatment will be managed in a protective manner because the treated sludge will be a highly radioactive waste. Finally, even if the PCBs were emitted to the environment, risks would be low. Two scenarios were evaluated for worst-case risks associated with the release of the K Basins PCBs to the environment. In one scenario, all of the PCBs were assumed to be released to the air in the 100-K Area, and in the other scenario, all of the PCBs were assumed to be released to the air in the 200 Area. Under both scenarios, the risk to workers and the public associated with the PCBs in the K Basins sludge is within the CERCLA generally acceptable risk range of 10^{-4} to 10^{-6}. In addition, concentrations to which workers would be exposed are well below limits established by OSHA for routine exposure to PCBs.

Based on this information, it can be concluded that the PCBs do not present an unreasonable risk to human health and the environment. Any of the sludge alternatives identified in this FFS would be protective of human health and the environment with respect to PCBs. As presented in this appendix, this protectiveness conclusion would also apply to the future management of the treated sludge. Therefore, the sludge treatment performed under this CERCLA action would satisfy the requirements of TSCA, and the residual PCBs in the treated sludge should not be regulated under TSCA.

Table C1-1. Total Mass of PCBs in K Basins Sludge Fractions.

Sludge Location	Sludge Volume (m^3 settled solids)	PCB Concentration (g/cm^3 settled solids)[1]	PCB Mass (kg)
KE Weasel Pit	10.1	0.000225	2.272
KE Tech View Pit, Dummy Elevator Pit[2]	1.8	0.000225	0.405
KE Main Basin Floor	21.5	0.000083	1.784
KE North Loadout Pit	6.3	0	0
KE Canister Sludge	3.4	0.0000018	0.006
KE Fuel Waste Sludge[3]	0.7	0.0000018	0.001
KW Main Floor and Pits[4]	4.7	0.000225	1.058
KW Canister Sludge	1.0	0.000015	0.015
KW Fuel Wash Sludge[5]	1.1	0.000015	0.016
Total/Weighted Mean	50.6	0.00011	5.557

1. Concentrations are the maximum detected at that basin location as reported in Pearce, et al. (1998) unless otherwise noted.
2. The KE Tech View Pit and Dummy Elevator Pit were not sampled. The sludge composition is assumed to be the same as the KE Weasel Pit in Pearce, et al. (1998).
3. The KE Fuel Wash Sludge has not been sampled and no PCB concentration was assumed in Pearce, et al. (1998). For this evaluation, the PCB concentration in the KE Fuel Wash Sludge was assumed to be the same as for KE Canister Sludge.
4. Sludge from the KW Main Floor and Pits has not been sampled. The PCB concentration was assumed to be zero in Pearce, et al. (1998). For this evaluation, the PCB concentration was assumed to be the same as the maximum detected in the KE Main Floor and Pits.
5. The KW Fuel Wash Sludge has not been sampled and no PCB concentration was assumed in Pearce, et al. (1998). For this evaluation, the PCB concentration in the KW Fuel Wash Sludge was assumed to be the same as for KW Canister Sludge.

ATTACHMENT C-1

Problem:
The sludge from K Basins contains PCBs that will be volatilized during treatment. For Scenario A, determine the concentrations of PCBs that may occur in the air stream exiting the treatment system and the maximum concentrations that would be observed in the 100-K Area and at the 100-K Area shoreline.

Given:
1) Feed rate = 160 kg solids/hr.
2) As-settled sludge solids content = 0.931 gm/cubic cm (Pearce 1998).
3) PCB concentration = 0.000225 gm/cubic cm settled solids (Pearce 1998).
4) Air flow through ventilation system = 100 cfm

Solution:
The maximum concentration of PCBs that may occur in the air stream exiting the treatment system is determined by arithmetic calculations using conversion factors. The maximum concentration in the 100-K Area and at the 100-K Area shoreline is determined using the EPA air dispersion model Screen3 available on the Internet.

Results:
Maximum Concentration of PCBs in Air Stream Exiting the Treatment System:

$$\left[\frac{160(kg)}{(hr)}\right]\left[\frac{1000(gm)}{(kg)}\right]\left[\frac{(cucm)}{0.931(gm)}\right]\left[\frac{(hr)}{60(\min)}\right]\left[\frac{0.000225(gmPCB)}{(cucm)}\right]\left[\frac{(\min)}{100(cuft)}\right]\left[\frac{35.311(cuft)}{(cum)}\right]\left[\frac{1000(mg)}{(gm)}\right]$$

Equals: 227.6 mg PCBs/cubic meter in the air stream leaving the treatment system

Maximum Concentration of Airborne PCBs in the 100-K Area and at the 100-K Area shoreline from the EPA Screen3 Air Dispersion Model:
Assumptions:
1) Point source of air emissions
2) Emission rate = 0.0108 g/s from the following equation:
$$\left[\frac{160(kg)}{(hr)}\right]\left[\frac{1000(gm)}{(kg)}\right]\left[\frac{(cucm)}{0.931(gm)}\right]\left[\frac{(hr)}{60(\min)}\right]\left[\frac{0.000225(gmPCB)}{(cucm)}\right]\left[\frac{(\min)}{60(\sec)}\right]$$
3) Stack height = 5, 10, 20, 30 m (for sensitivity analysis)
4) Stack inside diameter = 0.5 m
5) Stack exit velocity: (Input: "VF=100" for 100 ACFM)
6) Ambient temperature = 293 degrees Kelvin (20 degrees Centigrade)
7) Stack gas exit temperature = 400 degrees Kelvin (ambient 293 degrees Kelvin + 100 degrees Centigrade + rounding up)

ATTACHMENT C-1 (continued)

8) Receptor height above ground = 2 meters
9) Area considered 'Urban' (50% or more of area contains buildings separated by open space)
10) Do not consider building downwash in calculations (simple model)
11) No complex terrain; no terrain above stack base
12) Full meteorology (per Screen3 users guide recommendations)
13) Consider discrete distances for Screen3 modeling: Distance from stack to 100-K Area shoreline: 400 yards = 366 meters

EPA Screen3 Air Dispersion Model results:

- Maximum PCB concentration at ground level in 100-K Area from a 10 m stack (see Attachment C-2): 21.31 ug/m^3

- Maximum PCB concentration in ambient air at 100-K Area shoreline from a 10 m stack (see Attachment C-2): 2.963 ug/m^3

ATTACHMENT C-2

Screen3 Air Dispersion Modeling Results PCB Concentration in Ambient Air with Various Stack Heights

Distance from Stack, meters	Processing in 100-K Area				Processing in 200 Area			
	5 m Stack; PCBs in Air, ug/m3	10 m Stack; PCBs in Air, ug/m3	20 m Stack; PCBs in Air, ug/m3	30 m Stack; PCBs in Air, ug/m3	5 m Stack; PCBs in Air, ug/m3	10 m Stack; PCBs in Air, ug/m3	20 m Stack; PCBs in Air, ug/m3	30 m Stack; PCBs in Air, ug/m3
10	90.81	0.883	0	0	58.71	0.157	0	0
30	75.01	20.32	1.139	0.013	54.32	15.15	0.790	0.0084
50	44.16	21.31[b]	4.099	0.768	45.95	20.85	4.660	0.7271
70	26.67	17.64	4.945	1.682	39.23	21.41[b]	7.729	2.578
100	14.47	11.74	4.581	2.057	32.85	21.03	9.524	4.447
200	7.861	5.518	2.609	1.690	13.69	12.13	7.769	4.666
300	4.547	3.799	1.864	1.081	11.22	8.323	4.848	3.631
366[a]	3.374	2.963	1.672	0.864				
400	2.943	2.629	1.558	0.865	8.619	7.123	3.774	2.546
500	2.078	1.919	1.249	0.797	6.648	5.807	3.486	2.044
1000					2.603	2.478	1.804	1.375

[a] Distance to the Columbia River shoreline (400 yards)
[b] Shaded concentrations are maximum concentrations in reasonable worst-case exposure scenarios

ATTACHMENT C-3

Incremental cancer risk from exposure to PCB air emissions in an industrial scenario:		
Risk = (CPF*CONC*IH*EF*ED)/(BW*AT*UCF1*UCF2)		
Variable	Value	Description
CPF	0.4	cancer potency slope factor, kg-day/mg (from www.epa.gov/iris/)
CONC	21.31	max. conc. of PCBs in ambient air, micrograms/cubic meter, from 10 m stack (see Attachment C-2)
IH	20	inhalation rate, cubic meters per day
EF	10.42	exposure frequency, days (250 days per year, 1/24 hrs/day)
ED	20	exposure duration, years (specific to industrial exposure scenario)
BW	70	body weight, kg
AT	70	averaging time, years
UCF1	1000	units conversion factor, micrograms per milligram
UCF2	365	units conversion factor, days per year
Incremental Cancer Risk = 1.99E-05		

Incremental cancer risk from exposure to PCB air emissions in a recreational scenario:		
Risk = (CPF*CONC*IH*EF*ED)/(BW*AT*UCF1*UCF2)		
Variable	Value	Description
CPF	0.4	cancer potency slope factor, kg-day/mg (from www.epa.gov/iris/)
CONC	2.963	conc. of PCBs in ambient air, micrograms/cubic meter, at site boundary (see Attachment C-2)
IH	20	inhalation rate, cubic meters per day
EF	4.17	exposure frequency, days (100 days per year, 1/24 hrs/day)
ED	30	exposure duration, years (specific to exposure scenario)
BW	70	body weight, kg
AT	70	averaging time, years
UCF1	1000	units conversion factor, micrograms per milligram
UCF2	365	units conversion factor, days per year
Incremental Cancer Risk =1.66E-06		

ATTACHMENT C-4

Problem:
The sludge from K Basins contains PCBs that will be volatilized during treatment. For Scenario B, determine the concentrations of PCBs that may occur in the air stream exiting the 200 Area treatment system and the maximum concentrations that would be observed in air in an industrial scenario.

Given:
1) Feed rate = 640 kg solids/hr.
2) As-settled sludge solids content = 0.931 gm/cubic cm (Pearce 1998).
3) PCB concentration = 0.000225 gm/cubic cm settled solids (Pearce 1998).
4) Air flow through ventilation system = 1000 cfm (in 200 Area)

Solution:
The maximum concentration of PCBs that may occur in the air stream exiting the treatment system is determined by arithmetic calculations using conversion factors. The maximum ambient air concentration in an industrial scenario is determined using the EPA Screen3 air dispersion model available on the internet.

Results:
Maximum Concentration of PCBs in Air Stream Exiting the Treatment System:

$$\left[\frac{640(kg)}{(hr)}\right]\left[\frac{1000(gm)}{(kg)}\right]\left[\frac{(cucm)}{0.931(gm)}\right]\left[\frac{(hr)}{60(\min)}\right]\left[\frac{0.000225(gmPCB)}{(cucm)}\right]\left[\frac{(\min)}{1000(cuft)}\right]\left[\frac{35.311(cuft)}{(cum)}\right]\left[\frac{1000(mg)}{(gm)}\right]$$

Equals: 91.0 mg PCBs/cubic meter in the air stream leaving the treatment system

Maximum Concentration of PCBs in Ambient Air in an Industrial Scenario from EPA Screen3 Air Dispersion Model:
1) Point source
2) Emission rate = 0.04296 g/s from the following equation:
$$\left[\frac{640(kg)}{(hr)}\right]\left[\frac{1000(gm)}{(kg)}\right]\left[\frac{(cucm)}{0.931(gm)}\right]\left[\frac{(hr)}{60(\min)}\right]\left[\frac{0.000225(gmPCB)}{(cucm)}\right]\left[\frac{(\min)}{60(\sec)}\right]$$
3) Stack height = 5, 10, 20, 30 m (for sensitivity analysis)
4) Stack inside diameter = 0.5 m
5) Stack exit velocity: (Input: "VF=1000" for 1000 ACFM)
6) Ambient temperature = 293 degrees Kelvin (20 degrees Centigrade)
7) Stack gas exit temperature = 400 degrees Kelvin (ambient 293 degrees Kelvin + 100 degrees Centigrade + rounding up)

ATTACHMENT C-4 (continued)

8) Receptor height above ground = 2 meters
9) Area considered 'Urban' (50% or more of area contains buildings separated by open space)
10) Do not consider building downwash in calculations (simple model)
11) No complex terrain; no terrain above stack base
12) Full meteorology (per Screen3 users guide recommendations)
13) Consider discrete distances from the stack to determine maximum ambient air concentration in an industrial scenario.

EPA Screen3 Air Dispersion Model results:

- Maximum PCB concentration at ground level in the 200 Area from a 10 m stack (see Attachment C-2): 21.41 ug/m^3

ATTACHMENT C-5

Incremental Cancer Risk from Exposure to PCB Air Emissions in a 200 Area Industrial Scenario (EXCEL Spreadsheet)

Risk = (CPF*CONC*IH*EF*ED)/(BW*AT*UCF1*UCF2)		
Variable	Value	Description
CPF	0.4	cancer potency slope factor, kg-day/mg (from www.epa.gov/iris/)
CONC	21.41	max. conc. of PCBs in ambient air, micrograms/cubic meter, from 10 m stack (see Attachment C-2)
IH	20	inhalation rate, cubic meters per day
EF	10.42	exposure frequency, days (250 days per year, 1/24 hrs/day)
ED	20	exposure duration, years (specific to industrial exposure scenario)
BW	70	body weight, kg
AT	70	averaging time, years
UCF1	1000	units conversion factor, micrograms per milligram
UCF2	365	units conversion factor, days per year
Incremental Cancer Risk = 2.00E-05		

APPENDIX D

TREATABILITY VARIANCE FOR PCBs

D1.0 TREATABILITY VARIANCE FOR PCBS

The K Basins sludge contains certain heavy metals that are identified as characteristic metals under the federal *Resource Conservation and Recovery Act of 1976* (RCRA) and the Washington State *Hazardous Waste Management Act* (HWMA). Therefore, it is likely that the sludge and wastes derived from the sludge will be subject to the RCRA land disposal restrictions (LDR). The Department of Energy, Richland Operations Office (DOE) is requesting an LDR treatability variance for polychlorinated biphenyls (PCBs), an underlying hazardous constituent in the sludge, pursuant to Title 40 Code of Federal Regulations (CFR) 268.44(h)(2).

D1.1 BACKGROUND

Heavy metals that have been detected in the sludge include cadmium, chromium, and lead (Makenas 1996). The sludge has not been analyzed using the toxicity characteristic leaching procedure (TCLP) to determine whether extracts of the sludge contain these metals at concentrations equal to or greater than the toxicity characteristic concentrations specified in Washington Administrative Code (WAC) 173-303-090(8)(c). In the absence of TCLP data, it is assumed that the sludge designates as a mixed waste for TCLP metals.14

In general, the LDR prohibit land disposal of mixed waste unless it has been treated to meet certain standards, which are established in 40 CFR 268, Subpart D. The LDR for TCLP wastes require the wastes to be treated both for the characteristics and constituents that caused the waste to be a mixed waste (in this case, the heavy metals) and for underlying hazardous constituents (40 CFR 268.40[e]**)**. Treatment standards for underlying hazardous constituents are the universal treatment standards (UTS) established in 40 CFR 268.48. Compliance with the UTS is measured by an analysis of grab samples, unless otherwise specified. The requirement to treat underlying hazardous constituents applies even after the waste is treated so that it no longer exhibits the characteristic that caused it to be designated. PCBs have been identified as an underlying hazardous constituent in the K Basins sludge (Pearce et al. 1998). The UTS for non-wastewater PCBs is 10 mg/kg total constituent concentration. This value is based on combustion technologies.

Under certain circumstances, a generator may request a variance from an LDR treatment standard (40 CFR 268.44). The U.S. Environmental Protection Agency (EPA) has recognized two situations where a variance from a technology-based treatment standard may be approved:

- When it is not physically possible to treat the waste to the levels or by the methods established in the regulations
- When such treatment may be possible but is nevertheless inappropriate for the particular waste.

14 A mixed waste is a waste that designates as a dangerous waste under the HWMA and that is also subject to management under the *Atomic Energy Act of 1954* (AEA).

EPA has indicated several circumstances where treatment to the level or by the method set out in the LDR regulations would be inappropriate. Generally, these include circumstances where technology-based treatment standards are unsuitable or impracticable from a technical standpoint or where technology-based treatment standards could result in a net environmental detriment.

Any alternative treatment standard must result in substantial treatment of hazardous constituents in the waste so that threats posed by land disposal are minimized. In addition, EPA guidance contained in the January 8, 1997 memorandum "Use of Site-Specific Land Disposal Restriction Treatability Variances Under 40 CFR 268.44(h) During Cleanups" (EPA 1997) states that alternative treatment standards must satisfy the statutory requirement of RCRA 3004(m) by minimizing threats to human health and the environment.

D1.2 VARIANCE FOR TREATED SLUDGE

A treatability variance is requested for those remedial alternatives where the sludge undergoes thermal treatment. Treatment using the combustion technologies on which the UTS for PCBs is based would be inappropriate given the radioactive constituents in the sludge and would result in a potential worker exposure; more appropriate alternative thermal treatment technologies would still meet the statutory requirements for protectiveness. Based on this, DOE requests that EPA approve an LDR site-specific treatability variance for the thermally-treated sludge pursuant to 40 CFR 268.44(h)(2). Specifically, DOE requests that vitrification, calcination, and thermal pretreatment (as part of solidification) be allowed as a specified technologies and the alternative treatment standards for the sludge.

Thermal treatment occurs under two of the sludge treatment alternatives, Thermal Treatment and Solidification. In both of these alternatives, the sludge would be treated at high temperature either as part of the core technology (Thermal Treatment) or as a pretreatment step (Solidification).. Under Thermal Treatment -Vitrification, the sludge would be treated at 1150^{o}C and the product would be a solidified mass. Under Thermal Treatment-Calcination, the sludge would be treated at up to 500^{o}C and the product would be particulate matter. Under Solidification, the sludge would be pretreated in two fractions; the fraction containing large particles would be treated at up to 500^{o}C and the fraction containing small particles would be treated at 100^{o}C. Most of the PCBs would be volatilized or destroyed during thermal treatment/pretreatment.

Under the Thermal Treatment and Solidification Alternatives, the treated sludge would be disposed at either the national geologic repository or the WIPP. Wastes that are disposed at the WIPP are exempted from the LDR treatment standards. However, wastes that are disposed at the repository must meet the LDR treatment standards.. Therefore, any treated sludge that is disposed at the repository would be subject to treatment of PCBs as an underlying hazardous constituent. Because most of the PCBs in the sludge would either volatilize or be destroyed during thermal treatment/pretreatment, the concentration of PCBs in the treated sludge would be low. However, the concentration might be slightly above the PCB UTS of 10 mg/kg total

constituent concentration. Because of the highly radioactive nature of the treated sludge, workers would potentially incur an increased radiation dose in obtaining grab samples of the treated sludge to demonstrate that the treatment standard had been met.

The UTS for nonwastewater PCBs (10 mg/kg total constituent concentration) is based on combustion technologies such as incineration that would destroy PCBs. Combustion technologies were not designed to address wastes like the K Basins sludge in which radioactive contaminants, rather than organic contaminants, pose the primary hazard. Incineration does not treat radioactive contaminants to reduce the hazard associated with them. Instead, incineration would result in volatilizing some radioactive contaminants such as cesium and thus could have a net detrimental impact on the environment.

In contrast, the proposed vitrification, calcination, and thermal pretreatment processes were designed specifically with consideration of the radioactive nature of the sludge. The systems are designed to minimize volatilization of radioactive contaminants and to provide a high degree of worker protection. These thermal processes would not be likely to fully combust the PCBs. However, based on experience with thermal desorption as a PCB treatment technology, the PCBs in the sludge would likely be volatilized and captured in the off-gas treatment system or destroyed almost completely under thermal treatment.

The proposed thermal treatment processes would minimize threats to human health and the environment and would be consistent with the LDR criteria in that they would pose less total risk than land disposal of untreated sludge and less risk to workers, would provide substantial treatment of the PCBs, and would result in relatively low concentrations of PCBs,