Focused Feasibility Study for the K Basins Interim Remedial Action

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] Sludge[4] Total	NA NA NA	$689 M $126 M $815 M	$689 M $116 M $805 M	$689 M $ 98 M $787 M	$689 M $122 M $811M	$689 M $ 81 M $770 M	$689 M $ 94 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