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Life-Cycle Costs and Impacts: Alternatives for Managing KE Basin Sludge

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Abstract: This document presents the results of a life-cycle cost and impacts evaluation of alternatives for managing sludge that will be removed from the K Basins. The two basins are located in the 100-K Area of the Hanford Site. This evaluation was conducted by Fluor Daniel Hanford (FDH), Inc. and its subcontractors to support decisions regarding the ultimate disposition of the sludge.

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LIFE-CYCLE COSTS AND IMPACTS: ALTERNATIVES FOR MANAGING KE BASIN SLUDGE

June 27, 1997

Prepared for
Duke Engineering Services, Hanford Inc.
Richland, Washington

CH2M HILL, Inc.
Richland, Washington

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ACRONYMS

AEA	Atomic Energy Act of 1954
ALARA	as low as reasonably achievable
BHI	Bechtel Hanford, Inc.
CERCLA	*Comprehensive Environmental Response, Compensation, and Liability Act of 1980*
CFR	Code of Federal Regulations
Ci	curie(s)
CVD	Cold Vacuum Drying
CWC	Central Waste Complex
DESH	Duke Engineering & Services Hanford
DOE	U. S. Department of Energy
DST	double-shell tank
EA	Environmental Assessment
Ecology	Washington State Department of Ecology
EE/CA	engineering evaluation/cost analysis
EIS	environmental impact statement
EPA	U.S. Environmental Protection Agency
ERDF	Environmental Restoration Disposal Facility
FDH	Fluor Daniel Hanford, Inc.
KE	K East
KW	K West
LLBG	low-level burial grounds
LLW	low-level waste
NEPA	*National Environmental Policy Act of 1969*
NHC	Numatec Hanford Company
NRC	U.S. Nuclear Regulatory Commission
NOC	Notice of Construction
ORNL	Oak Ridge National Laboratory
OSHA	Occupational Safety and Health Administration
PCB	polychlorinated biphenyl
ppm	parts per million
ppb	parts per billion
PUREX	Plutonium-Uranium Extraction Plant
RCRA	*Resource Conservation and Recovery Act of 1976*
RL	Richland Operations Office
ROD	Record of Decision
SNF	spent nuclear fuel
TCLP	toxicity characteristic leaching procedure
TPA	*Hanford Federal Facility Agreement and Consent Order*
TRU	transuranic
TSCA	*Toxic Substances Control Act*
TWRS	Tank Waste Remediation System
WAC	*Washington Administrative Code*

WHC	Westinghouse Hanford Company
WIPP	Waste Isolation Pilot Plant
WRAP	Waste Receiving and Processing Facility

1.0 INTRODUCTION

This document presents the results of a life-cycle cost and impacts evaluation of alternatives for managing sludge that will be removed from the K Basins. The two basins are located in the 100-K Area of the Hanford Site. This evaluation was conducted by Fluor Daniel Hanford, Inc. (FDH) and its subcontractors to support decisions regarding the ultimate disposition of the sludge.

The long-range plan for the Hanford Site calls for spent nuclear fuel (SNF), sludge, debris, and water to be removed from the K East (KE) and K West (KW) Basins. This activity will be conducted as a removal action under the *Comprehensive Environmental Response, Compensation, and Liability Act of 1980* (CERCLA). The scope of the CERCLA action will be limited to removing the SNF, sludge, debris, and water from the basins and transferring them to authorized facilities for interim storage and/or treatment and disposal. The scope includes treating the sludge and water in the 100-K Area prior to the transfer. Alternatives for the removal action are evaluated in a CERCLA engineering evaluation/cost analysis (EE/CA) and include different methods for managing sludge from the KE Basins. The scope of the removal action does not include storing, treating, or disposing of the sludge once it is transferred to the receiving facility and the EE/CA does not evaluate those downstream activities. This life-cycle evaluation goes beyond the EE/CA and considers the full life-cycle costs and impacts of dispositioning sludge.

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2.0 BACKGROUND

2.1 SITE DESCRIPTION

The 100-K Area is one of six reactor areas in the 100 Area. It is situated on the southern shore of the Columbia River in the north-central part of the Hanford Site, and consists of two reactors, the KE Reactor and the KW Reactor, and their associated support facilities and waste sites (Figure 2-1). The reactors were constructed in the early 1950s and are located about 420 meters (1,400 feet) from the Columbia River (U.S. Department of Energy [DOE] 1996a). Each reactor has an attached basin that was originally used to store irradiated fuel after it was discharged from the reactor and before it was taken to the 200 Area to be reprocessed. The basins are uncovered, unlined, concrete water pools inside steel-framed buildings that are not air-tight. Each basin has a capacity of 4.9 million liter (1.3 million gallon). An asphaltic membrane is located beneath each pool. Prior to receiving N Reactor SNF, the concrete surfaces inside the KW Basin were refurbished by coating them with an epoxy to keep radioactive elements from being absorbed into the concrete. The KE Basin was not refurbished. Six pits are attached to each basin: the Sandfilter Backwash Pit, the South Loadout Pit, the Wash Pit (also known as the Dummy Elevator Pit), the Tech View Pit, the Weasel Pit, and the Discharge Chute. The configuration of the basins and pits is shown in Figure 2-2.

Operational History. The KE and KW Reactors operated from the mid-1950s until the early 1970s; during that time the basins were used to store fuel from the K Reactors. Water in the basins provided both radiation shielding and cooling to remove decay heat until the fuel was transferred. Much of this fuel was removed from the basins when the reactors were shut down. The basins have subsequently been used to store N Reactor SNF underwater, starting in 1975 for KE and 1981 for KW. In 1992, the decision was made to deactivate the Plutonium-Uranium Extraction (PUREX) Plant where the SNF was being reprocessed. This left approximately 2,100 metric tons (2,135 tons) of SNF in the K Basins with no means for near-term reprocessing. An estimated 1 percent of the original mass of this SNF has corroded and become radioactive sludge. The water and debris in the basins are also contaminated.

The KE Basin leaked up to 56.8 million liters (15 million gallons) of contaminated water to the soil in the 1970s and another 341,000 liters (90,000 gallons) 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 control the leakage and 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. Monitoring data and groundwater data indicate the basins are not currently leaking.

Regulatory Status. Nuclear fuel is regulated under the *Atomic Energy Act of 1954* (AEA) and historically the K Basins and their contents have been managed in accordance with the AEA. In the future, the SNF will continue to be regulated under the AEA; as the SNF is removed from the K Basins, the basins and materials in the basins will be subject to regulation under appropriate environmental laws and regulations as well as the AEA.

The *Hanford Federal Facility Agreement and Consent Order* (commonly known as the Tri-Party Agreement, or TPA) (Ecology et al. 1990) includes milestones for cleanup of the K Basins. Milestone M-34 currently requires that all SNF and sludge be removed from the basins by December 2002.

To support K Basins cleanup, DOE prepared an environmental impact statement (EIS) in accordance with the *National Environmental Policy Act of 1969* (NEPA) to address the potential environmental impacts of alternatives for the safe management and storage of the SNF currently stored in the K Basins (DOE 1996a). The EIS focused on removing the SNF from the basins, but included some discussion of the sludge, debris, and water in the basins. After public review, DOE issued a Record of Decision in March 1996 (DOE 1996b) to document the decision to remove the SNF from the basins and place it in dry-vault storage at the Hanford Site. The Record of Decision also stated that as a first option, the sludge would be transferred to a double-shell tank (DST), but that if this wasn't possible, the sludge would be managed as solid waste or with SNF.

In late 1996, DOE, The Washington State Department of Ecology (Ecology), and the U.S. Environmental Protection Agency (EPA) decided that it would be appropriate to conduct the K Basins cleanout under CERCLA. Actions taken at the K Basins under CERCLA will be consistent with the EIS and NEPA Record of Decision.

Affected Environment. Aspects of the affected environment around the K Basins that are important in this life-cycle evaluation include the following:

- Public access to the Hanford Site is generally restricted, however, members of the Yakama Indian Nation are currently authorized access to the 100-K Area for the purpose of raising fish in water basins located near the river. There is no public access to the K Basins themselves.

- The K Basins are within one-quarter mile of the Columbia River, which is under consideration for designation as a National Wild and Scenic River.

2.2 K BASINS SLUDGE DESCRIPTION

Both the KE and KW Basins contain contaminated sludge. Sludge on the floor and in the pits of the KE Basin is a mix of fuel corrosion products (including substantial quantities of reactive metallic uranium and uranium hydrides, fissile constituents, and fission and activation products), small fuel fragments, iron and aluminum oxide from the storage racks and canisters, concrete grit from the basin walls, sand and dirt from outside the basins, and biological debris. 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 canisters themselves consists predominantly of fuel corrosion product.

There is very little sludge on the floor of the KW Basin, and what is there appears to consist primarily of dust and sediment. The sludge has not been characterized yet. Although there are probably low levels of radioactivity in the KW floor sludge, it is not expected to contain significant amounts of fuel corrosion products because the canisters in the KW Basin have closed tops and bottoms. Because the canisters in the KW Basin are completely closed, any sludge in them is expected to derive solely from SNF and consist of fuel corrosion product.

Estimated volumes of sludge from the floors, pits, and canisters of the KE and KW Basin are shown in Appendix A. The volume of sludge that is expected to be created when the SNF elements are washed during retrieval is also shown. The total upper-bounding volume of sludge in the two basins combined is about 70 m^3 (2,500 ft^3). Although the characteristics of the sludge vary between the basins and between different sources in each basin, it is likely that most or all of the sludge will be managed as a single waste stream during retrieval, pretreatment, and interim storage, therefore, this total volume is used for evaluation purposes in this EE/CA.

The sludge as-is in the basins is commingled with SNF and not considered a waste; when the sludge is separated from the SNF and removed from the basins it will be designated and managed as a waste (Wagoner 1996). The sludge is not itself irradiated nuclear fuel nor is it derived from liquid waste from the solvent extraction of irradiated nuclear fuel, therefore, the sludge will not designate as SNF or high-level waste under the AEA.

Characterization data for the K Basins sludge are provided in Appendix A. Data for chemical and radionuclide constituents in the KE Basin floor and Weasel Pit were based on 18 samples collected in 1995 (Makenas 1995). 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 sludge in the KE Basin North Loadout Pit was characterized based on sand filter backwash samples (Lodwick 1997). Final characterization data are not available for KE canister sludge or for any sludge from the KW Basin. The sludge in the North Loadout Pit of the KW Basin is assumed to be similar to the sludge in the KE Basin North Loadout Pit. Canister sludge in both basins and sludge generated during fuel washing are assumed to consist exclusively of fuel corrosion product; this assumption was used to calculate the chemical and radiological characteristics (Lodwick 1997).

In summary, the following conclusions are drawn regarding the regulatory designation of the floor and pit sludge from the KE Basin:

- The floor and pit sludge contains approximately 15,000 nCi/g of transuranic[1] (TRU) isotopes with half-lives greater than 20 years and therefore designates as TRU waste[2] in accordance with the AEA.

- The sludge designates as a dangerous waste based on the toxicity characteristic for heavy metals. This is based on the total metals concentration rather than the toxicity characteristic leaching procedure (TCLP) prescribed by the dangerous waste regulations in Washington Administrative Code (WAC) 173-303. A designation based on total metal concentrations is conservative. Because the sludge is both a dangerous waste and a radioactive waste, it is regulated as a mixed (dangerous and radioactive) waste. A bioassay test for the state toxicity criteria has not been performed.

- The sludge is regulated under the *Toxic Substances Control Act* (TSCA) due to the presence of polychlorinated biphenyls (PCBs). Seven of the sludge samples were screened for organic compounds; PCBs were detected in two of the samples above 50 parts per million (ppm) by weight on a settled solids basis. The highest concentration detected was 140 ppm on a settled solids basis (Schmidt 1997). The source of the PCBs in the KE Basin is unknown. Based on TSCA's anti-dilution rule[3] and the fact that basin activities have caused the floor sludge to mix, it has been determined that since at least one of the samples exceeds 50 ppm, all of the sludge from the floor and pits of the KE Basin is TSCA-regulated. A Site-wide strategy for managing PCB waste is being developed by RL in consultation with EPA; separately, the PCB regulations implementing TSCA are currently under revision by EPA. The final TSCA designation of the sludge will be made at the time of removal in accordance with the strategy and current regulations.

Based on the assumption that canister sludge consists primarily of corroded SNF, the following conclusions are drawn regarding the regulatory designation of the canister and wash sludge from the KE and KW Basins:

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[1]Transuranic refers to those isotopes with an atomic number greater than 92.

[2]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.

[3]TSCA regulates materials that contain 50 ppm or greater of PCBs. TSCA's anti-dilution rule states that TSCA requirements that are based on a concentration cannot be avoided by dilution (40 CFR 761.1(b)). If a material that contains 50 ppm or greater of PCBs (and is thus regulated under TSCA) is mixed with a material that has less than 50 ppm PCBs, the entire mixture becomes regulated under TSCA. Most of the sludge on the floor and in the pits of the KE Basin appears to have less than 50 ppm of PCBs, but because the floor sludge has been disturbed and mixing of the material has occurred, it has been determined that all of the floor and pit sludge in KE Basin is regulated under TSCA.

- The canister and wash sludge contains about 350,000 nCi/g of TRU isotopes with half-lives greater than 20 years and therefore designates as TRU waste.

- The sludge designates as a dangerous waste based on the toxicity characteristic for heavy metals. This is based on a total metals concentration rather than the TCLP prescribed by the dangerous waste regulations, a conservative approach. The sludge is regulated as a mixed waste.

- There is no process knowledge to indicate that there have been spills of substances containing 50 ppm or greater PCBs in the canisters, so it is assumed that the canister sludge is not TSCA-regulated.

It is assumed that the sludge from the North Loadout Pit in the KW Basin will have the same regulatory designations as the pit sludge from the KE Basin, with the exception that no source of PCB contamination has been identified in the KW Basin and it is assumed that the pit sludge will not be regulated under TSCA.

It has been calculated that containers for combined sludge removed from the basin will have a surface dose rate of greater than 23 rem/hr and therefore must be managed as a remote-handled[4] TRU waste.

[4]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 (mrem/hr), the waste is defined as contact-handled TRU. If the contact dose rate is greater than 200 mrem/hr, the waste and its container are defined as remote-handled TRU. Remote-handled TRU has a higher radionuclide inventory than contact-handled TRU and requires special management.

Figure 2-1. 100-K Area Site Plan.

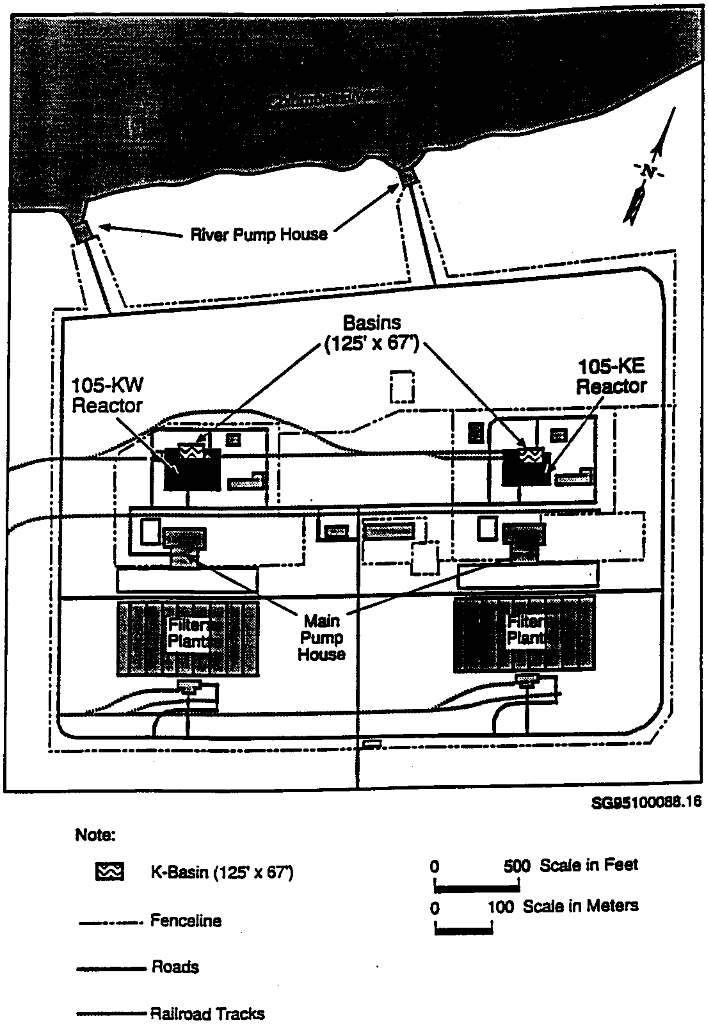
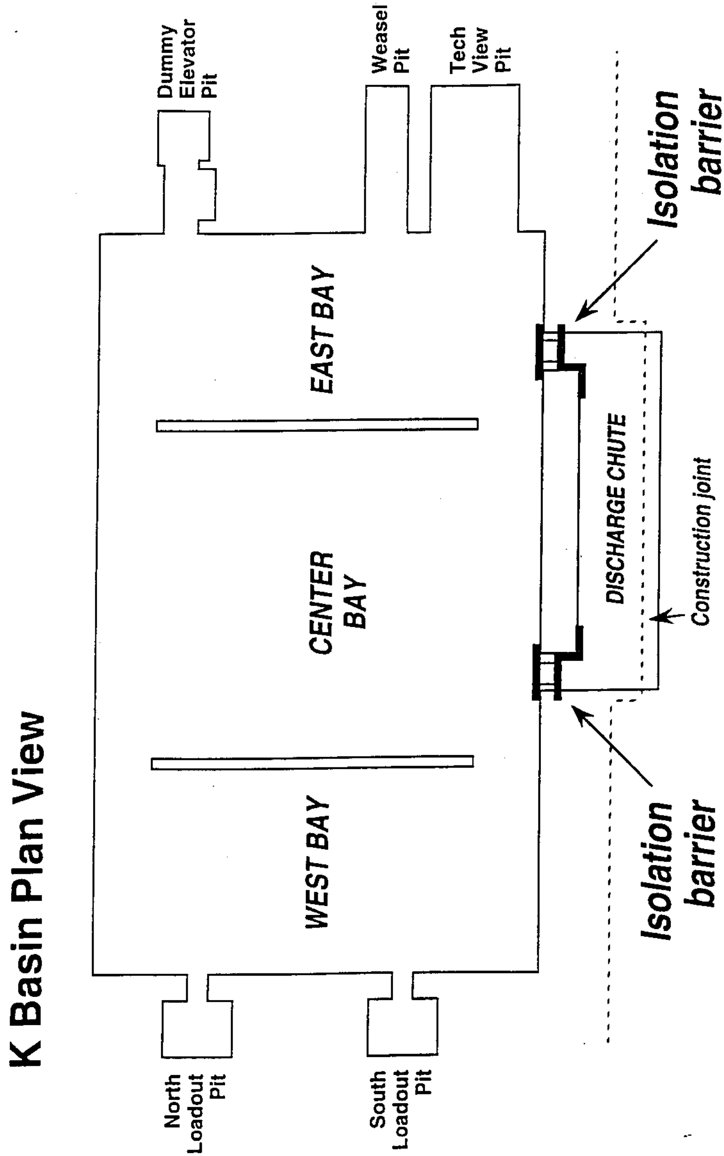


Figure 2-2. Configuration of the K Basins.



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3.0 DEVELOPMENT OF SLUDGE ALTERNATIVES

The preferred alternative for the K Basins sludge in the K Basins ROD (DOE 1996b) includes transferring the sludge from the basins to a Hanford DST for management; the ROD states that if it is not possible to place the sludge into the tanks, the sludge will be disposed as a solid waste or continue to be managed as SNF. DOE has determined that it will manage the sludge as a waste rather than as SNF when it is removed from the basins (Wagoner 1995), therefore, options for managing the sludge are reduced to management in a DST (more broadly, management in the Tank Waste Remediation System [TWRS]) and management as solid waste.

The following additional criteria and constraints were considered in identifying viable alternatives for managing the sludge removed from the KE Basin:

1. An alternative must ensure nuclear and operational safety. The K Basins sludge contains substantial quantities of plutonium, metallic uranium and uranium hydrides, and radioactive fission products. In addition, the sludge contains some organic resin. These properties will require addressing:

    - Criticality
    - Pyrophoricity
    - Gas generation and retention
    - Metal-water reactions
    - Reactive organic constituents

2. An alternative must address operational impacts and incorporate safe operating practices (e.g., impacts of particle size on the TWRS retrieval and treatment program).

3. The bulk sludge (KE and KW sludge together) contains about 60,000 nCi/g of long-lived TRU constituents and designates as a TRU waste. Newly-generated TRU waste must be disposed at the Waste Isolation Pilot Plant (WIPP) (DOE Order 5820.2A); near-surface disposal at the Hanford Site is prohibited.

4. The KE Basin sludge is regulated under TSCA due to the presence of PCBs; it is unknown whether the KW Basin sludge will be regulated under TSCA. Liquids containing between 50 and 500 ppm of PCBs (such as observed in the K Basins sludge) must either be treated to meet standards to exit TSCA or be disposed in a TSCA-approved chemical waste landfill.

5. If the sludge is TSCA-regulated when it is transferred to interim storage, the storage facility must meet TSCA storage requirements, and there must be a pathway (existing or potential) to treat/dispose of the sludge in accordance with TSCA.

6. The sludge designates as a dangerous waste for heavy metals. The facility that receives the sludge must comply with *Resource Conservation and Recovery Act of 1976* (RCRA)

storage criteria, and there must be a pathway (existing or potential) to treat/dispose of the sludge in accordance with RCRA.

7. The radioactivity of the sludge is such that the surface dose of the packaged sludge is about 23 rem/hr. This requires that the sludge be managed as a remote-handled waste.

8. The sludge must be pretreated in the 100-K Area sufficient to meet the waste acceptance criteria at the receiving interim storage facility, including criteria related to safety (e.g., criticality pyrophoricity).

9. The Hanford Site low-level burial grounds (LLBG) can only accept low-level waste (LLW). They cannot accept TRU waste, mixed waste, or TSCA-regulated waste.

10. The Hanford Site mixed waste trenches (Trenches 31/34) can accept mixed waste that has been treated to meet RCRA land disposal restrictions. They cannot receive TRU waste or TSCA-regulated waste.

11. The Environmental Restoration Disposal Facility (ERDF) can only accept waste generated as a result of CERCLA actions. It can accept mixed waste that has been treated to meet RCRA land disposal restrictions and TSCA-regulated waste up to 500 ppm of PCBs. It cannot accept TRU waste.

12. The Waste Isolation Pilot Plant (WIPP) in Carlsbad, New Mexico, is the designated location for disposal of TRU waste. It can accept some remote-handled TRU waste, with an activity limit of 23 Ci/L. It cannot accept TSCA-regulated waste (DOE 1996c). DOE personnel at the WIPP have expressed strong concerns that the sludge might not be acceptable for disposal at the WIPP because it derives in large part from the corrosion of SNF. This concern is not explicitly stated in the WIPP waste acceptance criteria, but introduces substantial uncertainty for disposal of the sludge at the WIPP.

13. The national geologic repository that is to be constructed will be the disposal site for SNF and high-level waste, including any glass logs generated by vitrification of Hanford TWRS waste. In special cases, the repository might accept waste that requires long-term isolation but that is not SNF or high-level waste. Waste acceptance criteria have not been established for the repository, including criteria for waste form; it is anticipated that the repository will not accept RCRA-regulated or TSCA-regulated waste.

14. An alternative must be consistent with the TPA milestone schedule to begin sludge removal, currently September 2000.

A key reason for performing this life-cycle evaluation is that none of the current waste management programs at the Hanford Site have an established process for disposing of mixed TRU waste that is regulated under TSCA. If the final waste form of the K Basins sludge designates as TRU waste, it must be disposed off-site, but the potential off-site facilities (the

WIPP and the repository) cannot accept TSCA-regulated waste. There are currently no onsite or off-site facilities designed to treat remote-handled mixed TRU waste to remove or destroy PCBs.

The following possible pathways were considered:

1. Interim storage: an existing DST tank. Treatment: modify the TWRS treatment process as necessary for TSCA treatment such that the final waste form exiting TSCA regulation. Disposal: geologic repository.

2. Interim storage: a new tank. Final treatment: modify the TWRS treatment process as necessary to obtain a TSCA treatment permit that results in the final waste form exiting TSCA regulation *or* pretreat the sludge for PCBs upon retrieval from the tank and before processing at the TWRS treatment system. Disposal: geologic repository.

3. Interim storage: modified tank at the T Plant. Treatment: in-tank treatment for PCBs at T Plant, followed by other mixed TRU waste treatment/packaging at T Plant. Disposal: WIPP.

4. Interim storage: wet or dry storage in containers at the Central Waste Complex (CWC). Treatment: construct a new remote-handled waste PCB treatment system onsite, treat/package resulting mixed TRU using existing facilities. Disposal: WIPP.

5. Interim storage: wet or dry storage in containers at the CWC. Treatment: solidify the sludge (e.g., in a grout or polymer matrix) such that the resulting waste form designates as non-TRU mixed LLW. Disposal: the ERDF *or* obtain a TSCA chemical landfill approval for Trenches 31/34.

6. Interim storage: new tank at the Grout Facility. Treatment: solidify the sludge (e.g., in a grout matrix) such that the resulting waste form designates as non-TRU mixed LLW. Disposal: a new RCRA- and TSCA-approved chemical waste landfill *or* obtain a TSCA chemical landfill approval for the existing Trenches 31/34.

7. PCB Pretreatment: treat the sludge at the 100-K Area such that the sludge exits TSCA regulation. Interim storage: an existing DST or new tanks. Treatment: TWRS treatment system as planned (no additional PCB treatment requirements). Disposal: national repository.

8. PCB Pretreatment: treat the sludge at the 100-K Area such that sludge exits TSCA regulation. Interim storage: CWC or T Plant. Treatment: mixed TRU waste treatment as planned (no additional PCB treatment requirements). Disposal: WIPP.

Pathways 5 and 6 were eliminated from further consideration. The Nuclear Regulatory Commission (NRC) position is that in determining waste classification, the activity may be averaged over the net mass of the waste if the waste form is essentially uniform (NRC 1995). The NRC specifically cites solidified liquid as an example of this position; where a liquid is solidified to achieve homogeneity or stability criteria, waste classification would depend on the total TRU activity divided by the weight of the solidified mass. Thus, solidification that results in reclassification is allowable. However, the addition of additives solely to achieve reclassification is a form of dilution and is contrary to waste minimization. One part K Basins sludge would have to be mixed with nearly 1,000 parts additive (such as grout) to ensure that the resulting solid was below the TRU waste designation standard of 100 nCi/g. There is no technical or regulatory reason to use such a high ratio of additive; solidification could be achieved at much lower ratios. Therefore, pathways requiring high additive ratios solely to achieve reclassification were eliminated.

Pathways 3, 4, and 8 rely on the Hanford Solid Waste Program and specify that the final disposal location would be the WIPP. One of the constraints identified is the possibility that the WIPP would not accept K Basins sludge. It is possible that the sludge could still be accepted at the national geologic repository as a special case, but since waste acceptance criteria for disposing of the sludge at the repository have not been established, it makes evaluating the use of the repository difficult. If disposal at the repository outside of the TWRS program is contemplated, it would not be prudent to solidify the sludge prior to establishing the waste acceptance criteria and pretreatment requirements, since solidification would make further pretreatment difficult.

Several technology types are available for treating PCB-contaminated wastes (EPA 1993). They include:

- Thermal treatment: the sludge is heated to remove or destroy PCBs. Destruction via combustion is achieved if the sludge is heated to temperatures typically greater than 1,000°C in the presence of oxygen. At lower temperatures (<1,000°C), the PCBs volatilize and separate from the sludge; they are then transferred to the off-gas where they can be collected or recovered for later destruction.

- Chemical treatment: the sludge is treated with chemicals that react with the PCBs to dechlorinate the PCBs to form other, less toxic, chemicals. Alternately, solvents can be used to extract the PCBs from the sludge. The PCB-containing solvent is then subjected to further treatment to destroy the PCBs.

- Biological treatment: microorganisms are introduced into the sludge that break down the PCBs.

- Solidification/stabilization: a binder, such as Portland cement, is added to the sludge to reduce the mobility of the PCBs. The PCBs are still present in the sludge and it must be managed in a chemical waste landfill that is TSCA-approved.

Biological treatment was eliminated as a viable treatment for the K Basins sludge because (1) the technology is still in the early stages of development and (2) it is assumed that the high radiation field of the sludge would inhibit the action of microorganisms. Solidification/stabilization was eliminated as a viable PCB treatment technology because the resulting product would still be

TSCA-regulated and could not be disposed at either the WIPP or the national repository; solidification in combination with a technology that removes or destroys PCBs would be viable.

Chemical treatment could be performed either at the 100-K Area or after interim storage. Chemical treatment would be compatible with any of the interim storage facilities and disposal options described above. Thermal treatment could be performed either at the 100-K Area or after interim storage, however, thermal treatment would produce a dry solid. If thermal treatment is performed at the 100-K Area, resuspending the solids to form a slurry that can be managed under the TWRS program is not technically practicable; interim storage options for dry solids would be limited to the CWC and T Plant (non-tank storage) and disposal would be limited to the WIPP.

The options retained for further evaluation are shown in Table 3-1.

Table 3-1. Summary of KE Basin Sludge Management Options.

Option	Pretreatment	Interim Storage	Treatment	Disposal
1(a)	Chemical treatment to meet TWRS criteria	Existing DST	Via TWRS Phase 2 treatment plant(s)	Geologic repository
1(b)	Chemical treatment to meet TWRS criteria	New DST	Via TWRS Phase 2 treatment plant(s)	Geologic repository
2	Chemical treatment to meet TWRS criteria	Modified tank in T Plant	In-tank treatment for PCBs, other T plant treatment for mixed TRU waste	WIPP
3	Chemical treatment to meet CWC criteria	Container storage at CWC	Remote-handled TRU treatment facility (not currently planned)	WIPP
4(a)	Chemical treatment to meet TWRS criteria (encompasses PCB treatment)	Existing DST	Via TWRS Phase 2 treatment plant(s)	Geologic repository
4(b)	Chemical treatment to meet TWRS criteria (encompasses PCB treatment)	New tanks	Via TWRS Phase 2 treatment plant(s)	Geologic repository
4©	Chemical treatment to meet TWRS criteria (encompasses PCB treatment)	Modified tank in T Plant	T plant treatment for mixed TRU waste	WIPP
4(d)	Chemical treatment to meet TWRS criteria (encompasses PCB treatment)	Container storage at CWC	Remote-handled TRU treatment facility (not currently planned)	WIPP
5(a)	Thermal treatment for PCBs	Modified tank at T Plant	T plant treatment for mixed TRU waste	WIPP
5(b)	Thermal treatment for PCBs	Container storage at CWC	Remote-handled TRU treatment facility (not currently planned)	WIPP

4.0 LIFE-CYCLE COSTS AND IMPACTS

The options for managing the K Basins sludge are evaluated in the following section. Evaluation criteria consist of:

- Technical feasibility. This evaluation criterion focuses on whether pretreatment is expected to be effective and the technical difficulties and unknowns associated with the pretreatment technology and with interim storage, final treatment, and disposal. It also considers the reliability of the technology, including whether it has been previously demonstrated, and whether implementation of the option would be expected to meet TPA milestone schedules for sludge removal.

- Regulatory feasibility. This criterion identifies issues associated with regulatory requirements and the coordination needed to obtain appropriate approvals from regulatory agencies both during pretreatment and during interim storage, treatment, and final disposal.

- Safety. This criterion identifies worker and public safety issues associated with each option and steps necessary to resolve these issues.

- Life-cycle cost. The life-cycle costs associated with each option are presented. Throughout this evaluation, it should be remembered that interim storage in an existing DST followed by treatment/disposal under the TWRS program (without consideration of PCBs) has been the baseline option for the Spent Fuel Program. As such, cost estimates for Option 1(a) have been more fully developed than for other options. Impacts of and treatment for PCBs, and interim storage, treatment, and disposal via new tanks or the Solid Waste Program have been developed more recently; as a result, costs for these options have a higher degree of uncertainty.

4.1 COMMON ASSUMPTIONS

To evaluate life-cycle costs and impacts for each option, several assumptions were made based on the best information available, applications of a similar technology, or engineering judgement. Assumptions common to several of the sludge options are identified in this section. Assumptions that are unique to a specific option are identified in the appropriate option description.

Key properties of the K Basins sludge based on best available data are:

- Total upper-bounding volume (KE and KW sludge): 70 m^3
- Solids fraction: 60 volume percent (on a settled solids basis)
- Maximum PCB concentration: 140 ppm
- Dangerous waste constituents: toxicity characteristic heavy metals

- Average TRU activity (KE and KW sludge): 60,000 nCi/g
- Total fissile activity (KE and KW sludge): 34,000 Ci
- The untreated sludge contains pyrophoric materials in the form of unreacted metallic uranium and uranium hydrides.

Key TWRS waste acceptance criteria specific to the K Basins sludge include:

- Particle size (for criticality control, operating requirements): less or equal to 50 microns
- No waste with the potential to become critically unsafe
- No pyrophoric materials (e.g., metallic uranium or uranium hydrides)
- Minimum hydroxide concentration: 0.01 M
- Minimum nitrite concentration: 0.011 M

Key TWRS cost assumptions include:

- Incremental cost to produce one additional canister of vitrified tank waste: $630,000. This includes the cost to operate the vitrification facility ($150 million per year, or $200 K per canister) and to provide interim storage and disposal of the canister ($430 K per canister) (Sloughter 1997)

General CWC waste acceptance criteria include (Westinghouse Hanford Company [WHC] 1996):

- No waste with the potential to be critically unsafe
- No pyrophoric materials
- Wet waste (liquid or slurry) received for interim storage at CWC must either be solidified or must be provided with absorbent capable of absorbing two times the liquid volume
- Surface contact dose less than 100 mrem/hour

General 221-T (T Plant) Canyon waste acceptance criteria include (WHC 1996):

- No prohibition against radioactive waste with a surface dose greater than 100 mrem/hour
- Containers must contain less than 190 grams of fissile material
- No waste with the potential to become critically unsafe (this is implicit in the requirements)

Key WIPP waste acceptance criteria applicable to the K Basins sludge include (DOE 1996c):

- Can accept TRU and mixed TRU waste only; TRU designation to be based on the total waste matrix excluding shielding and packaging; no waste that could be designated as SNF, high-level waste, or LLW
- No TSCA-regulated waste or waste containing greater than 50 ppm of PCBs
- No pyrophoric materials
- Maximum curie content: 23 curie/liter

- Free liquids: must be reduced to less than 6 liters per remote-handled container or 2 liters per 55-gallon drum

Environmental documentation cost assumptions:

- Preparation of a typical NEPA Environmental Assessment: $50,000
- Preparation of a typical NEPA supplemental analysis: $50,000
- Amendment of a typical dangerous waste Part A application for an interim status facility to include expansion of facility: $50,000
- Preparation of a full dangerous waste Part B application for a final status facility: $1 M
- Preparation of an air emissions Notice of Construction (NOC): $50,000

TSCA storage requirements:

- TSCA storage approval is not required except for commercial storage; Hanford is not a commercial storer.
- Radioactive TSCA-regulated sludge can be stored beyond one year per the DOE and EPA Federal Facility Compliance Agreement regarding storage of radioactive PCB items (DOE and EPA 1995).
- The facility must be marked with a PCB label.
- It must have a roof and walls adequate to prevent rain water from reaching the stored PCBs.
- It must have an impervious floor with a curb that contains at least 25% of the total internal volume of PCBs.
- If storage is in a tank, the tank must meet Occupational Safety and Health Administration (OSHA) standards for storing flammable/combustible liquids.
- A spill prevention, control, and countermeasure plan must be prepared for the facility in accordance with 40 CFR 112.

RCRA storage requirements:

- Containers must be in good condition and handled to avoid ruptures or leaks.
- Container and tank materials must be compatible with the waste.
- Containers must be marked to show when waste accumulation began.
- Containers and tanks must be marked as "Dangerous Waste."
- Tanks must have secondary containment and leak detection capabilities.

4.2 OPTION 1(a): CHEMICALLY PRETREAT FOR WASTE ACCEPTANCE CRITERIA; MANAGE IN AN EXISTING DST

Option 1(a) consists of the following activities:

- Removing the K Basins sludge from the floor, pits, and canisters, consolidating it at staging areas in the basins, and transferring it to a pretreatment system in the 100-K Area
- Chemically pretreating the sludge to meet TWRS waste acceptance criteria
- Transferring the sludge to an existing DST for interim storage
- Operating the DST in either an unrestricted or restricted mode, depending on potential TSCA impacts
- Retrieving the sludge with the rest of the DST contents to be treated at the Phase 2 TWRS treatment plants and disposed at the geologic repository.

Sludge Retrieval and Loadout. Canister, floor, and pit sludge would be collected using vacuum heads, pumps, hoses, and pipes and moved to safe 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 other systems such as the Fuel Removal System and the Debris Removal System and moved to the staging locations. From the staging locations, the sludge would be pumped into specially-designed containers on transport trailers. The transport packages would then transfer the sludge to the pretreatment system in the 100-K Area. The number of shipments would depend on the physical form of the sludge, shipping requirements, the transport container size, and the total volume of sludge collected in the basin.

Assumptions relative to retrieval and loadout are identified in Cost Elements 1 through 5, Appendix B.

Pretreatment. In this option, the goal of pretreatment would be to meet TWRS safety and operational requirements, including safe storage in an existing DST, retrieval, and eventual processing at the high-activity waste treatment plant. A *Preliminary Safety Assessment* (Daling, et al, 1997) has indicated that to achieve this, the pretreatment process must be capable of reducing particle size, oxidizing metallic uranium and uranium hydrides to reduce pyrophoricity, and ensuring that the sludge is critically safe under various potential storage configurations. Laboratory studies have indicated that dissolution of the sludge followed by coprecipitation with neutron absorbers can address both particle size and criticality control (Daling and Vail 1997). Oxidation with concentrated acid can eliminate the pyrophoricity associated with unreacted metallic uranium and uranium hydrides.

Pretreatment would be conducted in the 100-K Area in the Cold Vacuum Drying (CVD) facility. The CVD is a new facility being constructed near the K Basins for drying/passivation of the SNF removed from the K Basins. Sludge pretreatment would be performed after most of the SNF conditioning is completed. The CVD is being designed and constructed to achieve nuclear safety equivalence comparable to NRC-licensed facilities and will provide a substantial level of protection and control.

The waste streams that would be generated from pretreatment are likely to include the following:

- Treated sludge. It is likely that the treated sludge would designate as a mixed TRU waste. Under this alternative, it is also assumed that the sludge would be TSCA-regulated, since the chemical treatment process would not be optimized for PCB removal/destruction.

- Insoluble particulate. Acid dissolution would produce a waste stream containing the insoluble fraction of sludge (such as sand). Because most radionuclides are soluble in acid, any insoluble fraction would be unlikely to designate as TRU waste; it would be likely to designate as either LLW or mixed LLW. Under this alternative, it is also assumed that the particulate would be TSCA-regulated. This waste stream could be disposed offsite (such as at the LLW TSCA incinerator at the Oak Ridge National Laboratory) or at the ERDF, which can accept LLW with PCB concentrations of up to 500 ppm (Bechtel Hanford, Inc. [BHI] 1996).

- Contaminated off-gas. Acid dissolution would produce an off-gas that would likely include nitrous oxide and might potentially include other regulated or toxic gases and/or gaseous and particulate radionuclides.

- Aqueous waste. As a result of chemical treatment, an aqueous waste stream might be generated. To the extent possible, any aqueous streams would be recycled during pretreatment, but an aqueous waste stream could remain at the end of pretreatment. This stream would likely be returned to the K Basins to be managed with other basin water.

- Miscellaneous wastes. Other potential wastes include contaminated air filters, debris collected during initial sludge screening, contaminated equipment, etc. This debris would be designated and managed at existing solid waste management facilities.

After the sludge is pretreated, it would be sampled to ensure that it meets the TWRS waste acceptance criteria. The treated sludge would be pumped back into the transport packages in preparation for transfer to the DST.

Assumptions related to pretreatment include:

- Pretreatment would be conducted as part of the CERCLA removal action, therefore, permits would not be required.

- The pretreatment system would be located inside the CVD facility in the 100-K Area.

- The pretreatment process would consist of coarse screening (to remove debris), nitric acid dissolution/caustic precipitation (to reduce particle size and oxidize metallic uranium), and the addition of neutron absorbers (such as depleted uranium) to control criticality during storage. The sludge would then be chemically adjusted to comply with DST criteria.

Interim Storage. The pretreated sludge would be taken in the transport packages from the 100-K Area to the selected DST (most likely Tank 241-AW-105) in the 200 East Area. All transportation of the sludge would occur on the Hanford Site. A transportation safety analysis would be performed to establish the design, procedures, and controls necessary to ensure protection of workers and prevention of releases during transportation. The sludge would be off-loaded using a Sludge Receiving Station that would connect the transport package to the DST through an existing pump pit. The Sludge Receiving Station would provide double-containment from the transport package to the tank and leak detection sensors on the transfer line and any additional equipment. The piping would be shielded to meet as low as reasonably achievable (ALARA) goals.

Tank 105-AW currently contains solids and liquids (supernate), including waste generated when the outer cladding of irradiated fuel was dissolved during fuel reprocessing. The waste in the tank is designated as mixed TRU waste. The tank operates in accordance with RCRA interim status requirements under the DST interim status permit application. The current tank contents are not regulated under TSCA. If the K Basins sludge is added to the tank, the solids in the tank would become TSCA-regulated. In addition, the supernate in the tank might become TSCA-regulated, unless it is demonstrated that there is adequate physical separation of PCBs between the solids and the supernate. Under normal operations, the supernate would be transferred to an evaporator; the resulting condensate would be transferred to other onsite facilities (e.g., the Effluent Treatment Facility) and the concentrate would be returned to a DST (not necessarily Tank 105-AW). Evaporation is performed to optimize the use of DST storage space and represents an *unrestricted* use of Tank 105-AW. If the supernate becomes TSCA-regulated, or if there is the potential to detect PCBs at facilities that receive the supernate, unrestricted use could cause those other facilities to become TSCA-regulated. This could result in unacceptable impacts, particularly, delays in the Phase 1 tank treatment facilities. If there is the potential for TSCA impacts on other TWRS or Hanford facilities, Tank 105-AW must be operated in a *restricted* mode.

Assumptions related to interim storage in an existing DST include:

- The proposed pretreatment would produce a sludge that meets the TWRS waste acceptance criteria developed specifically for the sludge, including nuclear safety and operational criteria (Daling, et al, 1997, Daling and Vail 1997).

- The K Basins sludge would be compatible with existing tank waste.

- Placing the K Basins sludge in Tank 105-AW would require modification of safety documentation and modification of the TWRS EIS.

- No tank structural or operational modifications would be required to meet RCRA requirements for storing K Basins sludge (i.e., the tank is already considered RCRA-compliant)

- No tank structural modifications would be required to meet TSCA requirements. TSCA large containers (e.g., tanks) storing PCBs to be designed and operated in accordance with standards in 29 CFR 1910.106, Flammable and Combustible Liquids. The 29 CFR 1910.106 defines four categories of combustible liquids; liquids with a flashpoint above 93.6°C (200°F) are defined as Class IIIB. Per 29 CFR 1910.106(a)(18), Class IIIB liquids are not subject to the requirements of the section. It is expected that the K Basins sludge, alone or mixed with the contents of Tank 105-AW, will have a flashpoint greater than 93.6°C, therefore, tank storage would not be subject to the 1910.106 requirements.

- New tank operational requirements under TSCA would consist of (1) placing PCB labels on the tank risers and (2) modification of existing tank contingency plans to meet the requirements of 40 CFR 112, Oil Spill Prevention, Control, and Countermeasure

- TWRS tank space requirements can be managed without construction of a new DST, even with restricted use of Tank 105-AW.

Sludge Treatment/Disposal. Treatment and disposal of K Basins sludge would use the infrastructure already planned as part of the TWRS program. As currently planned, solids from Tank 105-AW will be retrieved using mixers and in-tank pumps, transferred to another DST for staging and blending, and treated in the Phase 2 high-activity waste treatment plant. Tank supernate and some aqueous waste streams from the high-activity plant will be treated at the Phase 2 low-activity waste treatment plant. The plants will be dangerous waste-permitted facilities and required to meet standards for dangerous waste treatment including double-containment, air emissions controls, monitoring, and inspections. Current planning does not consider TSCA treatment or permitting for the plants. The destruction efficiency of the vitrification plant as planned (including off-gas systems) relative to PCBs is not known.

The high-activity waste treatment plant is expected to use vitrification, a technology in which a mixture of waste and glass formers (e.g., silica) is heated to the molten state. When the melt cools, it forms a rigid, glassy product. The ratio of waste to glass formers depends on the chemistry of the waste. The solids in Tank 105-AW contain high concentrations of constituents that require blending with other DST wastes to optimize the ratio of waste to glass formers and produce the minimum number of glass logs. If Tank 105-AW requires isolated storage because of the K Basins sludge, it could limit blending opportunities. This is reflected in the costs as a range. There would be no incremental vitrification cost if Tank 105-AW is blended as planned and up to $400 million in incremental cost if the tank is not blended at all.

The main residual produced by the vitrification plant will be the glass product, which will be placed into interim storage at the Hanford Site until the offsite national geologic repository is available. Secondary wastes might include contaminated water, solid wastes (e.g., contaminated equipment), and air emissions. Gases generated during the vitrification will be treated before being released to the environment. Liquid wastes generated during vitrification will be treated at onsite facilities. Solid wastes will be disposed at onsite facilities.

Assumptions related to final treatment and disposal of the K Basins sludge include:

- The incremental cost to retrieve the K Basins sludge along with the rest of the contents of Tank 105-AW is $50 K.

- Both Phase 2 plants would require a TSCA permit. The cost for a stand-alone TSCA permit was estimated at $1 M (TWRS presentation to EPA, December 13, 1996). Per discussion with EPA, the TSCA permit application could be prepared in conjunction with the dangerous waste permit application and information common to both would not be duplicated (December 13, 1996, meeting with EPA). Therefore, the initial estimate for a stand-alone TSCA permit was reduced by 50 percent.

- Both Phase 2 plants would require a TSCA demonstration test. The cost for a stand-alone demonstration test was estimated at $1 M (TWRS presentation to EPA, December 13, 1996). Per discussion with EPA, the test could be conducted in conjunction with the dangerous waste demonstration test (December 13, 1996, meeting with EPA), therefore, the initial estimate for a stand-alone test was reduced by 50 percent.

- Both Phase 2 plants could require modification to enhance PCB treatment capabilities. The cost to modify the plants was estimated at $50 M per plant (TWRS presentation to EPA, December 13, 1996). Because the need for modification is unknown, the cost for modification is shown as a range in the cost table.

- If Tank 105-AW solids (including the K Basins sludge) are blended with other tank wastes before vitrification, the presence of K Basins sludge would result in no additional canisters of glass produced over the current baseline (Higley 1997).

- If Tank 105-AW solids (including the K Basins sludge) are not blended with other tank wastes before vitrification, an additional 630 canisters of glass would be produced over the current baseline (Higley 1997).

- EPA Region 10 would issue a PCB Certificate of Destruction following vitrification of the K Basins sludge.

Technical Feasibility. The pretreatment process and interim storage proposed in this option appear to be technically feasible, but there are significant technical uncertainties associated with further treatment and disposal.

Pretreatment must result in the sludge meeting TWRS waste acceptance criteria, including safety requirements. The *Preliminary Safety Assessment* (Daling, et al, 1997) identified three key sludge properties that must be addressed to meet these criteria: (1) the presence of large particles, (2) higher fissile concentrations than typical DST solids, and (3) the presence of potentially pyrophoric materials. These issues were addressed in the *Preliminary Safety Assessment* and the *Criticality Feasibility Study* (Daling and Vail 1997). These studies concluded that (1) chemical dissolution/re-precipitation can reduce particle size to below the 50 micron particle size required, (2) criticality can be controlled through dissolution and coprecipitation with an added neutron absorber, and (3) the risks associated with pyrophoricity should be low as long as the pyrophoric materials are kept wet. The pretreatment proposed under Option 1(a) includes dissolution, the addition of neutron absorbers, and precipitation. Dissolution would be accomplished using concentrated nitric acid, which would be expected to oxidize the metallic uranium to a non-pyrophoric state, thus eliminating the risk associated with interim storage of pyrophoric materials. The chemistry of acid dissolution/caustic precipitation relative to uranium and other fuel corrosion product is well-understood as a result of fuel reprocessing activities formerly conducted at the Hanford Site; although the sludge contains many constituents in addition to fuel corrosion product, the general chemistry would be expected to apply.

Chemical pretreatment would generate an off-gas that potentially contains radioactive particulate and gases (e.g., radioactive iodine) and toxic and/or regulated constituents (e.g., nitrous oxide). The system would be designed with appropriate controls and monitoring to ensure that air emissions from the system are well within regulatory standards. Emissions control would not be expected to significantly affect the technical feasibility of the pretreatment system.

Interim storage as proposed under Option 1(a) appears to be technically feasible based on the following:

- Interim storage would rely on existing facilities.
- Initial engineering evaluations and laboratory testing of the proposed pretreatment process indicate it would be sufficient to meet TWRS safety and operational criteria for existing DST
- A waste compatibility study has concluded that the sludge would be compatible with waste in Tank 105-AW.
- Restricted use of Tank 105-AW, if necessary, would reduce operational flexibility in the DST tank system, however, waste volume projections indicate that the restricted use scenario would not require construction of new storage tanks.
- The few TSCA requirements for storage can be addressed relatively easily.

There are potentially serious technical difficulties associated with treatment and disposal under Option 1(a) because of TSCA requirements. Under this option, the K Basins sludge would be treated in the TWRS Phase 2 high-activity waste treatment plant. The treatment process (most likely vitrification or a similar technology) would provide reliable and permanent stabilization of radioactive and heavy metal contaminants in the sludge, however, there is substantial uncertainty as to whether the treatment would adequately destroy PCBs. Under certain operating conditions, vitrification meets the 99.9999 percent destruction efficiency for PCBs required of thermal treatment processes under TSCA (GeoSafe 1997), however, the vitrification method that is likely to be used to meet the requirements of the TWRS program is cold-capping, a method that would potentially result in volatilizing rather than destroying PCBs. Tests would be required to determine whether the planned vitrification would be adequate for treating PCBs; testing would have to be performed in conjunction with regulator input on the test parameters. If testing shows that PCBs are not adequately treated, the vitrification plant could be modified (e.g., by adding additional off-gas treatment equipment) to enhance PCB treatment. It is assumed that the Phase 2 low-activity waste treatment plant would also receive TSCA-regulated waste and would also have to be modified. An alternative would be to develop a separate PCB treatment process and treat the contents of Tank 105-AW prior to vitrification; costs for this alternative have not been developed but would be expected to be prohibitive because they would involve the entire volume of Tank 105-AW.

A further technical complication is uncertainty regarding interconnections between the Phase 1 and Phase 2 treatment plants. Secondary waste from the Phase 2 plants might be processed at the Phase 1 plant. If the waste is regulated under TSCA, this would require that the Phase 1 plant meet TSCA treatment and permitting requirements. However, the procurement agreements for the Phase 1 plants are already in place and do not include consideration of TSCA-regulated waste. Retrofit of the Phase 1 plants to meet TSCA requirements, especially after they become operational and are contaminated, would not be technically feasible.

Regulatory Feasibility. Consistent with the K Basins EE/CA and discussions with EPA, it is assumed that pretreatment would be conducted as part of the CERCLA removal action and would not require environmental permits. If this assumption changes, permits (such as air emissions permits) would be required for the pretreatment system. The time required to obtain permits could potentially delay this option.

There are likely to be regulatory concerns regarding operation of a chemical pretreatment system in the 100-K Area because of the potential for radioactive, toxic, and regulated air emissions and impacts to human health and the environment. The identification of appropriate controls and monitoring would require consultation with the Department of Health (for potential radioactive emissions) and Ecology (for potential regulated and toxic emissions). Initial evaluations have already been performed for the proposed pretreatment system to identify potential off-gas constituents and appropriate control devices. A mitigating factor in obtaining regulatory acceptance is the fact that the pretreatment system would be located inside the CVD, which will be designed and constructed to NRC-like standards and which will provide a substantial degree of confinement. Another regulatory issue related to pretreatment is that the system would be located within one-quarter mile of the Columbia River which has been nominated for Wild and Scenic status; the National Park Service would be consulted to ensure that the river is not adversely affected by the pretreatment.

Interim storage would require amendment of the DST RCRA interim status permit application (or amendment of the final status permit, if that has been obtained), a NEPA supplemental analysis for the TWRS EIS, and an air emissions Notice of Construction. Based on the assumption that pretreatment has successfully met TWRS waste acceptance criteria and addressed safety issues, neither permitting nor preparation of the supplemental analysis are expected to delay implementation of this option.

Several issues associated with treatment and disposal are expected to affect the regulatory feasibility of Option 1(a):

- The requirements for PCB treatment have not been established. The normal standard would be a 99.9999 percent destruction efficiency, however, the regulators have indicated that they might allow some flexibility in this because the initial concentrations of PCBs in the sludge are low; no specifics have been discussed.

- The requirements for the TSCA demonstration test have not been established. A demonstration test would normally require spiking the test feed with PCBs, however, the amount required for a spike could be more than the total amount PCBs in the K Basins sludge. Again, the regulators have indicated that there might be some flexibility in establishing the parameters of the demonstration test, but specifics have not been discussed.

- EPA has indicated that both the TSCA permitting and the TSCA demonstration test for the TWRS treatment plants could be conducted in conjunction with RCRA permitting and testing. The specific level of effort required for TSCA permitting/testing is undetermined.

- For the treated K Basins sludge to exit TSCA regulation, EPA Region 10 would need to issue a PCB Certificate of Destruction. There have been no discussions with EPA Region 6 or the State of Nevada to confirm that they will accept EPA Region 10's determination.

Safety. The two major safety concerns associated with this option are (1) the safety of the pretreatment system itself and (2) the nuclear and operational safety of interim storage in an existing DST. Safety concerns related to pretreatment include:

- The potential for exposure to sludge with high radiation doses. This would primarily represent a risk to workers at the pretreatment system. Exposure would be minimized by designing the pretreatment system to include substantial shielding and redundancy and to accommodate remote operations.

- The use of concentrated hazardous chemicals. This would primarily represent a risk to workers. The proposed pretreatment process would use concentrated nitric acid, which is very corrosive and reacts with water to produce heat. The process would also use a caustic agent which is also corrosive. Risks would be controlled through secondary containment as appropriate and procedures to ensure that chemicals are properly handled.

- The potential for chemical reaction. If done improperly, the mixing of acid and water or acid and caustic can result in a violent chemical reaction. This risk would be controlled by designing to minimize inadvertent mixing and procedures to ensure that chemicals are properly handled and that incompatible chemicals do not mix.

- Off-gas emissions. Emissions represent a risk to both workers and the public. The pretreatment system has the potential to generate radioactive and non-radioactive particulate and radioactive, regulated, and toxic gases (e.g., radioactive iodine gas, nitrous oxide). Emissions would be controlled through the use of an off-gas system designed to address the specific constituents and limit releases. In the event of a release from the treatment system, the CVD would add an additional level of confinement. The sludge would be processed in small batch sizes, thus limiting risks to workers and the public in the event of an upset condition.

Safety during storage is addressed by pretreating to meet the TWRS waste acceptance criteria. Many of the TWRS criteria for the K Basins sludge were developed specifically to ensure safe storage of the sludge in an existing DST. Based on recent engineering evaluations and laboratory tests, the proposed chemical pretreatment would meet the TWRS criteria (e.g., provide criticality control, eliminate pyrophoricity). Studies have indicated that gas generation and retention are not significant concerns (Daling, et al 1997). Based on this, it is expected that the pretreated K Basins sludge could be safely stored in a DST and treated and disposed with other tank waste.

Cost. The costs for Option 1(a) are provided in Table 4-1.

Table 4-1. Cost Estimates: Pretreat for Waste Acceptance Criteria, Manage Sludge in an Existing DST

Cost Element	No Additional Off-Gas Treatment ($000)	Additional Off-Gas Treatment ($000)
Sludge retrieval and consolidation (Cost Elements 1+2, App. B)	9,300	9,300
Sludge loadout and transport (Cost Elements 3+4+5, App. B)	10,900	10,900
Pretreatment to meet TWRS criteria (Cost Elements 6+8, App. B)	37,300	37,300
Sludge off-load (Cost Element 9, App. B)	1,000	1,000
Prepare environmental and safety documentation for DST storage	150	150
Store in DST	0	0
TSCA permits for two Phase 2 treatment plants	1,000	1,000
PCB demonstration tests at treatment plants	1,000	1,000
Retrieve to treatment[a]	50	50
Additional off-gas equipment for two treatment plants		100,000
Incremental costs for vitrification and storage of glass canisters[b]	0-400,000	0-400,000
Total	**$60-460 M**	**$160-560 M**

[a] Upper-bound reflects potential restricted use of Tank 105-AW; additional cost associated with restricted use depends on ability to blend some or all of the Tank 105-AW contents after isolated storage and before vitrification; if none of the tank contents can be blended before vitrification, an additional 630 canisters of glass will be generated at $630K per canister.

[B] Incremental cost only for retrieval of K Basins sludge with other waste in Tank 105-AW.

4.3 OPTION 1(b): CHEMICALLY PRETREAT FOR WASTE ACCEPTANCE CRITERIA; MANAGE IN NEW TANKS

Option 1(b) is a variation on Option 1(a) in which interim storage occurs in separate new tanks rather than an existing DST. This option consists of the following activities:

- Constructing new tanks in the 200 East Area for segregated storage of the K Basins sludge
- Removing the K Basins sludge from the floor, pits, and canisters, consolidating it at staging areas in the basins, and transferring it to a pretreatment system in the 100-K Area
- Chemically pretreating the sludge to meet TWRS waste acceptance criteria
- Transferring the sludge to the new tanks for interim storage
- Retrieving the sludge from the tanks and treating it with other tank waste at the Phase 2 TWRS treatment plants and disposed at the geologic repository.

Sludge Removal and Loadout. Canister, floor, and pit sludge from the K Basins would be collected, consolidated, and transferred to the pretreatment system as described for Option 1(a).

Pretreatment. The goal of pretreatment in this option is to meet waste acceptance criteria for interim storage in new tanks. Waste acceptance criteria for new tanks have not been established, however, the tanks are likely to require that the sludge be critically safe and that it not contain pyrophoric materials, therefore, waste acceptance criteria would require pretreatment to address criticality control and pyrophoricity. Furthermore, sludge would ultimately be treated and disposed under the TWRS program and would thus be subject to TWRS criteria related to tank retrieval and treatment. Therefore, it is assumed that the pretreatment process required to safely store sludge in new tanks would be the same as or very similar to the pretreatment process required to meet TWRS waste acceptance criteria. Based on that assumption, under this option the sludge would be pretreated as described in Option 1 (a), then sampled to ensure it meets the criteria. Pretreatment assumptions are listed in Option 1 (a).

New Tank Receipt and Interim Storage. The treated sludge would be pumped into the transport packages and taken from the 100-K Area to the new tanks in the 200 East Area. All transportation of the sludge would occur on the Hanford Site. A transportation safety analysis would be performed to establish the design, procedures, and controls necessary to ensure protection of workers and prevention of releases during transportation. The new tanks would be designed with off-load capabilities that would provide double-containment from the transport package to the new tank system and leak detection sensors on the transfer line and any additional equipment. The piping would be shielded to meet ALARA goals.

The new tanks would be designed and constructed exclusively to store K Basins sludge; no other wastes would be added to the tanks. The design would allow the tanks to operate completely independent of the existing DST infrastructure. Appropriate surveillance and monitoring of the tanks would be performed until such time as the sludge is removed for treatment.

Assumptions related to interim storage in new tanks include:

- Acceptance criteria for the new tanks would be essentially the same as the TWRS acceptance criteria, and the proposed pretreatment would be sufficient to ensure that managing the K Basins sludge in the tanks is acceptable from the standpoints of nuclear and operational safety (e.g., criticality safety, pyrophoricity, and gas generation and retention).

- The tanks would be designed, constructed, and operated to be compliant with RCRA and TSCA storage requirements.

- The tanks would be constructed in the 200 Area. The number and specific location of the tanks would be based on balancing cost, safety requirements, and future flexibility.

- For costing purposes, it is assumed that the new tanks would be constructed of stainless steel, that they would be double-contained, and that they would be placed in a subgrade concrete vault that would itself be constructed with a stainless steel liner.

- For RCRA permitting purposes, the tanks would be constructed and operated as an interim status expansion under the existing DST RCRA interim status permit application.

- Operation of the new tanks would require preparation of full safety documentation, submittal of a radioactive air emissions Notice of Construction, and preparation of a NEPA Environmental Assessment (at a minimum).

- The tanks would be operated for 11 years prior to retrieval.

Sludge Treatment/Disposal. The K Basins sludge would be retrieved using a system similar to the retrieval system planned for DST waste and transferred to either the DST system for staging or directly to the Phase 2 high-activity treatment plant. Further treatment and disposal would be conducted as described for Option 1(a).

Assumptions related to treatment and disposal after interim storage in new tanks would be the same as for Option 1 (a), with the following additions:

- The cost to design and construct the new tanks includes equipping the tanks with load-out capabilities for later retrieval; an additional $250 K is assumed to transfer the sludge from the new tanks to the TWRS system following retrieval.

- No further treatment of the sludge (including treatment for PCBs) is performed after retrieval from the new tanks and prior to treatment with DST waste.

- If the K Basins sludge is blended with other tank wastes before being vitrified, no additional glass logs are produced; if the K Basins sludge is not blended, an additional 37 canisters of glass are produced over the current baseline (Higley 1997).

Technical Feasibility. The pretreatment process included in Option 1(b) is the same as that proposed in Option 1(a). As discussed in Option 1(a), the proposed pretreatment process is expected to be technically feasible and to address the key safety and technical requirements associated with storing the sludge in tanks.

Interim storage as proposed under Option 1(b) appears to be technically feasible, but there is uncertainty regarding the availability of funding that could affect the schedule. There is substantial experience at the Hanford Site in designing and constructing standard double-contained tanks. The design and construction of new tanks are not expected to present new technical difficulties since the proposed pretreatment would substantially reduce safety concerns associated with criticality control and pyrophoricity. The estimated time required to design, construct, and test the tanks and prepare regulatory and safety documentation would be about 2-½ years from the time the project is authorized. However, the potential cost of $27 million to construct the tanks is not currently in the Hanford budget; if budget could not be provided by the beginning of calendar year 1998, the September 2000 sludge removal milestone would not be met.

As with Option 1(a), the most significant technical uncertainties are associated with final treatment and disposal. Under Option 1(b), the K Basins sludge would eventually be retrieved and treated at the Phase 2 high-activity waste treatment plant. The same technical uncertainties regarding the capabilities of the plant with respect to PCB treatment would exist as discussed for Option 1(a). The key technical difference in Option 1(b) is that separate storage of the sludge in new tanks would allow for separate processing of the sludge, including additional pretreatment to meet TSCA requirements, in the event that the planned Phase 2 plant does not meet those requirements. Separate storage would allow decisions regarding additional pretreatment needs to be deferred until the Phase 2 treatment plant is operational and processing requirements are better defined. Costs for additional pretreatment (between the time the sludge is retrieved from the new tanks and the time it is processed at the Phase 2 high-activity plant) have not been developed.

Regulatory Feasibility. The primary difference between this option and Option 1(a) is that interim storage would occur in new tanks rather than an existing DST. It is assumed that Ecology approves construction and operation of the new tanks as an interim status expansion of the Hanford RCRA permit. If this approval is not received, the new tanks would have to be authorized as a final status RCRA unit, a process that could take several years. Obtaining final status authorization could potentially delay implementation of this option. This option would also require preparing NEPA documentation, which is assumed to be an Environmental Assessment with a Finding of No Significant Impact. If an EIS is required, it could delay implementation of this option. The new tanks would also require submittal of an air emissions Notice of Construction; this is not expected to delay implementation.

Other regulatory issues are the same as in Option 1(a) and include:

- It is assumed that pretreatment would be conducted under CERCLA and would not require environmental permits; a change to this assumption could potentially delay this option.

- There are likely to be regulatory concerns regarding operation of a chemical pretreatment system in the 100-K Area because of the potential for radioactive, toxic, and regulated air emissions and proximity to the river.

- The requirements for PCB treatment at the Phase 2 plants have not been established.

- The requirements for TSCA demonstration tests at the plants have not been established.

- The specific level of effort required for TSCA permitting/testing is undetermined.

- There have been no discussions with EPA Region 6 or the State of Nevada to confirm that they will accept EPA Region 10's determination that the sludge is no longer regulated under TSCA following treatment.

Safety. The two major safety concerns associated with this option are (1) the safety of the pretreatment system itself and (2) the nuclear and operational safety of interim storage in new tanks. Both issues were discussed in Option 1(a). In summary, the chemical pretreatment system would present potential risks to workers because of the use of concentrated hazardous chemicals, the potential for violent chemical reaction, and the potential for exposure to sludge with high radiation doses. The primary risk to the public would be the potential for air emissions. Measures to ensure safety would include designing the pretreatment system to include shielding, redundancy, and remote operations; establishing procedures to ensure that chemicals are properly handled and that incompatible chemicals do not mix; designing the off-gas treatment system to limit routine atmospheric releases; processing small batch sizes to limit releases in the event of an upset condition.

Based on recent engineering evaluations and laboratory tests, the proposed chemical pretreatment would ensure safe storage in new tanks (e.g., provide criticality control, eliminate pyrophoricity). Studies have indicated that gas generation and retention are not significant concerns (Daling, et al 1997). Based on this, it is expected that the pretreated K Basins sludge could be safely stored in new tanks and treated and disposed with other tank waste.

Cost. The costs for Option 1(b) are provided in Table 4-2.

Table 4-2. Cost Estimates: Pretreat for Waste Acceptance Criteria, Manage Sludge in New Tanks

Cost Element	No Additional Off-Gas Treatment ($000)	Additional Off-Gas Treatment ($000)
Sludge retrieval and consolidation (Cost Elements 1+2, App. B)	9,300	9,300
Sludge loadout and transport (Cost Elements 3+4+5, App. B)	10,900	10,900
Pretreatment to meet TWRS criteria (Cost Elements 6+8, App. B)	37,300	37,300
Construct new tanks (Cost Element 10, Appendix B)	27,000	27,000
Store in new tanks[a]	1,100	1,100
TSCA permits for two Phase 2 treatment plants	1,000	1,000
PCB demonstration tests at treatment plants	1,000	1,000
Retrieve to treatment[b]	500	500
Additional off-gas equipment for two treatment plants		100,000
Incremental costs for vitrification and storage of glass canisters[c]	0-23,000	0-23,000
Total	**$88-111 M**	**$188-211 M**

[a] Storage at an incremental $100 K per year for 11 years.

[b] Estimated incremental cost to retrieve K Basins sludge from new tanks.

[c] Additional vitrification cost depends on ability to blend some or all of the K Basins sludge with other tank waste before vitrification; if none of the sludge can be blended with other wastes, an additional 37 canisters will be generated at $630K per canister.

4.4 OPTION 2: CHEMICALLY PRETREAT FOR WASTE ACCEPTANCE CRITERIA; MANAGE AT T PLANT

Option 2 consists of the following activities:

- Modifying an existing tank in T Plant to store the K Basins sludge
- Removing the K Basins sludge from the floor, pits, and canisters, consolidating it at staging areas in the basins, and transferring it to a pretreatment system in the 100-K Area
- Chemically pretreating the sludge to meet T Plant waste acceptance criteria for tank storage
- Transferring the sludge to T plant interim storage
- Treating the sludge in-tank to destroy PCBs
- Retrieving the sludge to be treated, packaged, assayed, and certified at T Plant and disposed at the Waste Isolation Pilot Plant (WIPP).

Sludge Removal and Loadout. Canister, floor, and pit sludge from the K Basins would be collected, consolidated, and transferred to the pretreatment system as described for Option 1(a).

Pretreatment. The goal of pretreatment in this option is to meet waste acceptance criteria for interim storage at the T Plant. General waste acceptance criteria for T Plant are found in *Hanford Site Solid Waste Acceptance Criteria* (WHC 1996), but criteria specific to interim storage of the K Basins sludge in a modified tank in T Plant have not been established. It is likely that the modified tank would be a non-critically safe design, therefore, waste acceptance criteria at a minimum would require pretreatment for criticality control. In addition, tank storage of TRU waste containing pyrophoric radionuclides would likely be prohibited for safety reasons. The pretreatment process described in Option 1(a) would address criticality control by reducing particle size and adding neutron absorbers and would address the pyrophoricity associated with unreacted metallic uranium and uranium hydrides through nitric acid oxidation. For purposes of evaluating Option 2, it is assumed that before transferring to T Plant, the sludge is pretreated in a process similar to that in Option 1(a), then sampled to ensure it meets T Plant waste acceptance criteria.

T Plant Interim Storage. The pretreated sludge would be taken in the transport packages from the 100-K Area to the T Plant in the 200 West Area. All transportation of the sludge would occur on the Hanford Site. A transportation safety analysis would be performed to establish the design, procedures, and controls necessary to ensure protection of workers and prevention of releases during transportation. A combination of existing handling systems in T Plant and new systems included as part of the tank modification would be used to off-load the sludge into the T Plant tank. The off-load system would provide double-containment from the transport package to the tank and leak detection sensors on the transfer line and any additional equipment. The piping would be shielded to meet ALARA goals.

An existing tank in T Plant would be modified to provide exclusive storage for K Basins sludge; no other wastes would be added to the tank. Appropriate surveillance and monitoring of the tank would be performed until such time as the sludge is removed.

Assumptions related to interim storage in a T Plant tank include:

- Acceptance criteria for the T Plant tank are similar to many of the TWRS waste acceptance criteria, and the proposed pretreatment to meet TWRS criteria is sufficient to ensure that managing the K Basins sludge at T Plant is acceptable from the standpoints of nuclear and operational safety and operational requirements.

- The tank is designed, constructed, and operated to be compliant with RCRA and TSCA storage requirements.

- The size, type, and specific configuration of the tank would be based on balancing cost, safety requirements, and future flexibility. For costing purposes, it is assumed that a new inner tank constructed of stainless steel would be installed inside an existing tank to provide double-containment.

- The tanks would be managed in accordance with a modification to the existing T Plant RCRA interim status permit application.

- Operation of the tank would require preparation of full safety documentation, submittal of a radioactive air emissions Notice of Construction, and preparation of a NEPA Environmental Assessment.

- The interim storage period would be about four years (from the end of sludge removal in 2001 until 2005 when remote-handled waste treatment capabilities are available).

Sludge Treatment/Disposal. Treatment at T Plant would consist of two phases. In the first phase, the sludge would be chemically treated within the storage tank to destroy PCBs. The sludge would then be homogenized and analyzed to verify that the chemical destruction treatment was successful in reducing the PCB concentration to less than 2 ppm. If the sludge meets this standard it would no longer be regulated under TSCA and would be managed solely as a remote-handled mixed TRU waste.

The sludge would also need to be treated to meet acceptance criteria at the WIPP. The Waste Receiving and Packaging (WRAP) facility that opened in 1997 was developed specifically to treat, assay, and package wastes to meet WIPP criteria, but the WRAP facility does not include a PCB treatment process nor is it equipped to process remote-handled TRU waste. Milestone M-91 of the TPA requires RL to develop remote-handled waste treatment capability by fiscal year 2005; such capability will be required in the future, not only for the K Basins sludge but for other Hanford wastes. The full evaluation and selection of a facility to provide this capability has not been completed; modification of T Plant is one option that would make use of an existing facility.

For the K Basins sludge, key WIPP criteria include (1) no pyrophoric material, (2) no TSCA-regulated material, and 3) unreacted water or other liquid within the containers must be reduced to less than 6 liters per remote-handled container or 2 liters per 55-gallon drum (DOE 1996c). The proposed pretreatment in the 100-K Area would eliminate pyrophoricity and in-tank treatment at T Plant would destroy PCBs. The liquid present in the K Basins sludge could be immobilized in grout. A variety of grouting systems including in-drum systems that mix the wastes with cement have been developed for the nuclear industry. Assuming an in-drum system is used, the sludge would be grouted, then the drums would be certified and loaded into a Remote-Handled TRU Canister for shipment to WIPP.

Assumptions related to treatment and disposal following interim storage at T Plant include:

- A modified T Plant is selected as the facility for treating all Hanford Site remote-handled TRU waste. The treatment system would be RCRA permitted and would comply with all nuclear safety standards; costs to meet RCRA and nuclear safety standards would be required for a broad range of wastes handled at the facility and would not be specific to the K Basins sludge.

- The WIPP cannot receive TSCA-regulated waste, therefore, PCBs would be treated to reduce the PCB concentrations to less than 2 ppm and the sludge would exit TSCA regulation. Treatment would be achieved by chemically destroying the PCBs in an in-tank treatment process. Potential chemical treatment technologies have not been evaluated but could include decomposition with peroxide or nitric acid.

- PCB treatment would require a TSCA permit. The cost for a stand-alone TSCA permit was estimated at $1 M.

- PCB treatment would require a TSCA demonstration test. The cost for a test for thermal destruction was estimated at $1 M, however, it is assumed that a test for chemical destruction is less complex because of the absence of an extensive off-gas treatment system for PCBs. Therefore, the cost for a TSCA demonstration test at T Plant was estimated at $500 K.

- The tank design would allow the sludge to be mixed within the tank so that the sludge is a homogenous material for sampling and certification purposes.

- The K Basins sludge would be treated along with approximately 1,670 m^3 of other remote-handled TRU waste and most of the remote-handled mixed low level waste that will be generated at the site over the next 35 years; therefore, the K Basins sludge would not bear the total costs of establishing this treatment capability. About 5% of the facility modification cost would be expected to be shared by the K Basins sludge waste stream (McKenney 1997).

- Fifty five-gallon drums would be used to grout the sludges, producing about 900 drums of waste.

- Each Remote-Handled TRU Canister can accommodate 3 drums, thus, 300 canisters would be required for the K Basins sludge.

- The T Plant tank and storage areas will have sufficient ventilation so that hydrogen from radiolysis within the storage tanks, drums, or canisters would not create any additional requirements.

- The grouted K Basins sludge would be shipped to WIPP as soon as the grout has been certified. The shipping containers would be made available to Hanford by the WIPP as they are needed so as to avoid a large interim storage capacity.

- The WIPP can receive about 400 Remote-Handled TRU Canisters a year.

- The WIPP Project bears the cost of transporting TRU wastes to the WIPP and disposing of them at the WIPP.

Technical Feasibility. The pretreatment process included in Option 2 is the same as that proposed in Option 1(a). As discussed in Option 1(a), the proposed pretreatment process is expected to be technically feasible and to address the key safety and technical requirements associated with storing the sludge in a tank.

Hanford experience with tank storage indicates that modification of a tank in T Plant to provide interim storage would be technically feasible (given sufficient time and budget), and grouting is a relatively simple and well-developed treatment technology. In addition, interim storage and treatment at T Plant eliminate concerns regarding impacts on the TWRS program. Despite these advantages, there is substantial uncertainty regarding the technical feasibility of interim storage and treatment at T Plant and disposal at the WIPP. These uncertainties include:

- The WIPP program has indicated that it might not accept the K Basins sludge, regardless of treatment, because of concerns that the sludge derives in part from SNF and thus does not meet the definition of TRU waste. It is unknown whether the repository would accept the sludge and whether there would be additional treatment requirements.

- The location for treating, packaging, assaying, and certifying remote-handled TRU waste has not yet been selected; T Plant is only one alternative. Although T Plant has the advantage of being an existing facility, it is also an older facility designed for other purposes. If T Plant is not selected, significant effort would be required to remove the sludge from the T Plant tank and transfer it to another processing location.

- While tank modification would be technically feasible given sufficient time and budget, the requirements to modify the tank to meet TSCA, RCRA, and safety storage requirements have not been well-developed. It is unknown whether the schedule required for modification could meet the TPA milestone for removing the sludge from the K Basins, and the source of funding to perform the modification has not been identified.

- Although it is likely that the addition of peroxide or nitric acid to the T Plant tank would destroy PCBs, this treatment process would require further development and testing, especially because in-tank treatment of the bulk sludge provides fewer opportunities for process control than batch treatment in a separate treatment system.

- Costs for developing remote-handled TRU waste treatment capability at T Plant are prorated based on the assumption that approximately 1,670 m^3 of remote-handled TRU waste will be generated at the Hanford Site. The projected volume of remote-handled TRU waste can vary greatly depending on programmatic assumptions; if the actual volume of remote-handled wastes is lower than currently projected, the fraction of the costs shared by the K Basins sludge may be higher than estimated.

Regulatory Feasibility. Interim storage at T Plant would require amending the T Plant RCRA interim status permit application, preparing NEPA documentation (assumed to be an EA), and obtaining air emissions approvals. No significant regulatory issues were identified with respect to interim storage that would delay implementation of this option.

Other regulatory issues are the same as or similar to Option 1(a) and include:

- It is assumed that pretreatment would be conducted under CERCLA and would not require environmental permits; a change to this assumption could potentially delay this option.

- There are likely to be regulatory concerns regarding operation of a chemical pretreatment system in the 100-K Area because of the potential for radioactive, toxic, and regulated air emissions and proximity to the river.

- The requirements for PCB treatment at T Plant have not been established.

- The requirements for a TSCA demonstration test at T Plant have not been established.

- The specific level of effort required for TSCA permitting/testing is undetermined.

- There have been no discussions with EPA Region 8 or the State of New Mexico to confirm that they will accept EPA Region 10's determination that the sludge is no longer regulated under TSCA following treatment.

Safety. The two major safety concerns associated with this option are (1) the safety of the pretreatment system itself and (2) the nuclear and operational safety of interim storage and treatment at T Plant. Safety issues related to the pretreatment system were discussed in Option 1(a). In summary, the chemical pretreatment system would present potential risks to workers because of the use of concentrated hazardous chemicals, the potential for violent chemical reaction, and the potential for exposure to sludge with high radiation doses. The primary risk to the public would be the potential for air emissions. Measures to ensure safety would include designing the pretreatment system to include shielding, redundancy, and remote operations; establishing procedures to ensure that chemicals are properly handled and that incompatible chemicals do not mix; designing the off-gas treatment system to limit routine atmospheric releases; and processing small batch sizes to limit releases in the event of an upset condition.

Based on recent engineering evaluations and laboratory tests, the proposed chemical pretreatment would be expected to ensure that the sludge can be safely stored in a tank (e.g., provide criticality control, eliminate pyrophoricity). Studies have indicated that gas generation and retention are not significant concerns (Daling, et al 1997). Based on this, it is expected that the pretreated K Basins sludge could be safely stored in a tank in T Plant and treated and disposed with other tank waste.

Safety evaluations relative to PCB treatment and grouting in T Plant have not been performed. The in-tank chemical treatment would require substantial safety systems to ensure control of the chemical reaction and resulting air emissions. The grouting system would be designed for all remote-handled TRU waste generated at Hanford and would be expected to provide adequate safety controls for grouting the K Basins sludge.

Costs. The costs for Option 2 are provided in Table 4-3.

Table 4-3. Cost Estimates: Pretreat for Waste Acceptance Criteria, Manage Sludge at T Plant.

Cost Element	**Cost ($000)**
Sludge retrieval and consolidation (Cost Elements 1+2, Appendix B)	9,400
Sludge loadout and transport (Cost Elements 3+4+5, Appendix B)	10,900
Pretreatment to meet T Plant criteria (Cost Elements 6+8, Appendix B)	37,300
Modify T Plant tank, including safety and regulatory documentation (Cost Element 11, Appendix B)	5,400
Storage at T plant (McKenney 1997)	7,300
TSCA permit and demonstration test	1,500
PCB treatment at T Plant (Cost Element 12, Appendix B)	3,000
Treat, package, assay, and certify to meet WIPP criteria (Cost Element 13, Appendix B)	22,900
Dispose at WIPP	0[a]
Total	**$98 M**

[a] Assumes that WIPP funding pays for transportation to and disposal at WIPP, no incremental cost to Hanford program.

4.5 OPTION 3: CHEMICALLY PRETREAT FOR WASTE ACCEPTANCE CRITERIA; MANAGE AT CWC

Option 3 consists of the following activities:

- Removing the K Basins sludge from the floor, pits, and canisters, consolidating it at staging areas in the basins, and transferring it to a pretreatment system in the 100-K Area
- Chemically pretreating and packaging the sludge to meet CWC waste acceptance criteria
- Transferring the sludge to the CWC for interim storage
- Transferring the sludge to a new facility to be treated (for PCBs and to meet WIPP requirements), packaged, assayed, and certified and disposed at the WIPP.

Sludge Removal and Loadout. Canister, floor, and pit sludge from the K Basins would be collected, consolidated, and transferred to the pretreatment system as described for Option 1(a).

Pretreatment. The goal of pretreatment in this option is to meet waste acceptance criteria for interim storage at the CWC. Specific criteria for storing K Basins sludge at the CWC have not been developed. General waste acceptance criteria for CWC storage of TRU waste include (WHC 1996):

- No free liquids. This could be accomplished by drying the sludge or adding a solidification agent (e.g., portland cement). In this option, immobilization of the sludge would not be feasible, because the sludge must later be treated for PCBs and immobilization would preclude many treatment methods.
- Not more than one percent by weight of the waste can be pyrophoric forms of radionuclides. This would require oxidizing the metallic uranium and uranium hydrides in the sludge to eliminate the characteristic of pyrophoricity. Potential oxidation methods include the addition of peroxide or acid, heating, or a hot water wash. the hot water wash was eliminated from consideration because it would produce a large volume of cesium- and strontium-contaminated water that would require treatment.
- Particulate waste must be immobilized if more than 1 weight percent is in the form of particulate less than 10 microns in diameter or if more than 15 weight percent of the waste is in the form of particulate less than 200 microns in diameter. Because immobilization is not viable for this option, this would require ensuring that the pretreated, dried sludge contains larger particle sizes.

- Fissile content is limited to 200 fissile gram equivalents of Pu-239. Fissile content could be controlled either through the addition of neutron absorbers or by limiting the amount of sludge in each container.

An acid dissolution/reprecipitation process similar to the pretreatment described in Option 1(a), followed by a drying process, would meet the CWC waste acceptance criteria. The addition of neutron absorbers as part of pretreatment might or might not be necessary, depending on the results of a criticality evaluation. Another difference from Option 1(a) is that the reprecipitation step would need to be modified to achieve larger, rather than smaller, particle sizes. This could be accomplished through the addition of flocculating agents as part of precipitation.

Following chemical pretreatment and drying, the solids would be transferred into containers that are part of the transport packages. The CWC can only accept TRU waste that has a surface contact dose of 100 mrem/hour or less (WHC 1996). Containers would be designed with substantial shielding or over-packed as necessary to meet this criterion.

Assumptions related to pretreatment include:

- In the absence of a specific evaluation of K Basins sludge pretreatment requirements to meet CWC waste acceptance criteria, it is assumed that the necessary pretreatment system would be comparable in cost to the one required to meet TWRS waste acceptance criteria. The specific processing steps are likely to differ (e.g., drying, addition of neutron absorbers) but the throughput requirements for the pretreatment system would be about the same as would requirements for shielding, remote operation capabilities, nuclear safety control, etc.

- Pretreatment would not include grouting or other immobilization, since this would preclude later PCB treatment options.

- The pretreatment system would be located inside the CVD.

- The sludge containers that are used as part of the transport package would also be used for interim storage. For interim storage, the containers would be packaged such that the outer packages meet CWC contact dose standards of 100 mrem/hr.

- Approximately 60 containers would be required to store the sludge, at a cost of about $25 K per container including outer packaging. The container cost is based on the shielded container used to package K Basins sludge-bearing filter cartridges for storage at the CWC. These containers are designed with an inner shell of 2-inch steel and an 11-inch thick concrete over-pack.

Interim Storage. The pretreated sludge would be taken in the transport packages from the 100-K Area to the CWC in the 200 West Area. All transportation of the sludge would occur on the Hanford Site. A transportation safety analysis would be performed to establish the design, procedures, and controls necessary to ensure protection of workers and prevention of releases during transportation. The transport containers would be off-loaded at the CWC and placed into existing storage buildings. Appropriate surveillance and monitoring would be performed until such time as the sludge is removed.

Assumptions related to interim storage at the CWC include:

- The proposed pretreatment would be sufficient to ensure that managing the K Basins sludge at the CWC is acceptable from the standpoints of nuclear and operational safety.

- Existing storage areas at the CWC could accommodate the K Basins sludge containers without impacting space requirements.

- There would be no incremental cost for surveillance and monitoring of the K Basins sludge at the CWC.

- Placing the K Basins sludge at the CWC would require modification of safety documentation and the RCRA permit for the CWC and preparation of NEPA documentation (assumed to be an Environmental Assessment).

- No structural or operational modifications would be required at the CWC to meet RCRA requirements for storing K Basins sludge (i.e., the CWC is already RCRA-compliant).

- No structural modifications would be required to meet TSCA requirements.

- New CWC operational requirements under TSCA would consist of placing PCB label on the K Basins sludge containers and at the sludge storage area.

- The interim storage period would be at least four years.

Sludge Treatment/Disposal. This option assumes that Hanford Site remote-handled TRU waste is treated, packaged, assayed, and certified at a new facility (rather than T Plant) that would be constructed to satisfy Milestone M-91 of the TPA. For the K Basins sludge, treatment capabilities at the new facility would have to include treatment for PCBs and treatment to meet WIPP waste acceptance criteria. The PCB treatment capability is likely to be needed by only a very few remote-handled waste streams, so a large fraction of the cost of that capability would be associated with the K Basins sludge. The PCB treatment technology that might be used at the new facility has not been identified.

Additional treatment of the K Basins sludge to meet WIPP criteria would consist primarily of immobilizing the waste after PCB treatment (criteria related to pyrophoricity and free liquids would be met earlier through pretreatment).

Assumptions related to treatment and disposal following interim storage at CWC include:

- A new facility would be constructed to serve as the facility for treating all Hanford Site remote-handled waste, including remote-handled TRU waste. The facility would be RCRA permitted and would comply with all nuclear safety standards; costs to meet RCRA and nuclear safety standards would be required for a broad range of wastes handled at the facility and would not be specific to the K Basins sludge.

- The WIPP cannot receive TSCA-regulated waste, therefore, PCBs would be sufficiently treated at the facility to reduce PCB levels to less than 2 ppm and EPA would issue a PCB Certificate of Destruction. PCBs would be treated either thermally or chemically; the cost to develop, design, and construct the PCB treatment system is assumed to be on the order of only $10 M, since most of the support systems would already be available in the plant. This cost is assumed to be associated solely with the K Basins sludge.

- A TSCA permit and demonstration test would be required for PCB treatment; costs for the permit are assumed to be the same as the stand-alone costs estimated for a permit at a single TWRS Phase 2 plant ($1 M). The cost for the demonstration test would depend on the type of PCB treatment (e.g., whether the pretreatment system relies on extensive off-gas treatment of PCBs). In the absence of information regarding the type of PCB treatment, it is assumed that the demonstration test costs $1 M, the cost estimated for a demonstration test at a single TWRS Phase 2 plant.

- The K Basins sludge would be treated at the new facility along with the other remote-handled TRU wastes and most of the remote-handled mixed low level waste that will be generated at the site over the next 35 years; therefore, the K Basins sludge would not bear the total costs of establishing this treatment capability. About 5% of the new facility cost is expected to be shared by the K Basins sludge waste stream (McKenney 1997).

- A new facility for remote-handled waste treatment would cost $150 M (rough order of magnitude).

- Costs for treatment to meet WIPP criteria would be the same as at T Plant.

- The new treatment facility would have sufficient ventilation so that hydrogen from radiolysis within the storage areas, drums, or canisters will not create any additional requirements.

- The treated K Basins sludge would be shipped to WIPP as soon as it has been certified. The shipping containers would be made available to Hanford by the WIPP as they are needed so as to avoid a large interim storage capacity.

- The WIPP can receive about 400 remote-handled waste canisters per year.

- The WIPP Project bears the cost of transporting TRU wastes to the WIPP and disposing of them at the WIPP.

Technical Feasibility. The pretreatment process included in Option 3 is the same as that proposed in Option 1(a). As discussed in Option 1(a), the proposed pretreatment process is expected to be technically feasible and to address the key safety and technical requirements associated with the sludge (e.g., criticality control, pyrophoricity).

Overall, storage at the CWC appears to be technically feasible. Filters containing high loadings of K Basins sludge are currently packaged in containers that are specially designed with extensive steel and concrete shielding and stored at the CWC. However, there are several uncertainties related to interim storage at the CWC and treatment at a new remote-handled TRU waste treatment facility. These include:

- Specific criteria for storing K Basins sludge have not been developed. At a minimum, it is anticipated that storage would require additional treatment to dry the sludge and that additional packaging would be required to reduce dose rates. The requirement to design and construct a drying and packaging system at the 100-K Area has not been evaluated but could potentially delay implementation of this option.

- The WIPP program has indicated that it might not accept the K Basins sludge, regardless of treatment, because of concerns that the sludge derives in part from SNF and thus does not meet the definition of TRU waste. It is unknown whether the repository would accept the sludge and whether there would be additional treatment requirements.

- The location for treating, packaging, assaying, and certifying remote-handled TRU waste has not yet been selected; a new facility is one alternative. A new facility has the advantage of being tailored for its purpose and built to current standards. If a new facility is not selected, it would not require significant effort to move the containerized sludge to the selected processing location.

- There is little information available to assess the capabilities and feasibility of a potential new remote-handled waste plant, including PCB treatment capabilities.
- Costs for developing remote-handled TRU waste treatment capability at a new facility are prorated based on the assumption that approximately 1,670 m^3 of remote-handled TRU waste will be generated at the Hanford Site. The projected volume of remote-handled TRU waste can vary greatly depending on programmatic assumptions; if the actual volume of remote-handled wastes is lower than currently projected, the fraction of the costs shared by the K Basins sludge may be higher than estimated.

Regulatory Feasibility. Interim storage at the CWC would require amending the CWC RCRA permit, potentially preparing NEPA documentation (assumed to be an EA), and obtaining air emissions approvals. No significant regulatory issues were identified with respect to interim storage that would delay implementation of this option.

Other regulatory issues are the same as or similar to Option 1(a) and include:

- It is assumed that pretreatment would be conducted under CERCLA and would not require environmental permits; a change to this assumption could potentially delay this option.
- There are likely to be regulatory concerns regarding operation of a chemical pretreatment system in the 100-K Area because of the potential for radioactive, toxic, and regulated air emissions and proximity to the river.
- The requirements for PCB treatment at a new facility have not been established.
- The requirements for a TSCA demonstration test at a new facility have not been established.
- The specific level of effort required for TSCA permitting/testing is undetermined.
- There have been no discussions with EPA Region 8 or the State of New Mexico to confirm that they will accept EPA Region 10's determination that the sludge is no longer regulated under TSCA following treatment.

Safety. The two major safety concerns associated with this option are (1) the safety of the pretreatment system itself and (2) the safety of interim storage in containers at the CWC. Safety issues related to the pretreatment system were discussed in Option 1(a). In summary, the chemical pretreatment system would present potential risks to workers because of the use of concentrated hazardous chemicals, the potential for violent chemical reaction, and the potential for exposure to sludge with high radiation doses. The primary risk to the public would be the potential for air emissions. Measures to ensure safety would include designing the pretreatment system to include shielding, redundancy, and remote operations; establishing procedures to ensure that chemicals are properly handled and that incompatible chemicals do not mix; designing the off-gas treatment system to limit routine atmospheric releases; and processing small batch sizes to limit releases in the event of an upset condition.

The proposed chemical pretreatment would be expected to provide criticality control and eliminate pyrophoricity, two safety concerns for interim storage at the CWC. The potential for gas generation would be minimized by drying the waste prior to storage.

Safety evaluations relative to PCB treatment and processing at a new remote-handled waste facility have not been performed. The PCB treatment system would require appropriate safety systems to ensure safe operations. The processing system to prepare the waste for the WIPP would be designed for all remote-handled TRU waste generated at Hanford and would be expected to provide adequate safety controls for grouting the K Basins sludge.

Costs. The costs for Option 3 are shown in Table 4-4.

Table 4-4. Cost Estimates: Pretreat for Waste Acceptance Criteria, Manage Sludge at CWC.

Cost Element	Cost ($000)
Sludge retrieval and consolidation (Cost Elements 1 and 2, Appendix B)	9,300
Sludge loadout and transport (Cost Elements 3, 4, and 5, Appendix B)	10,900
Pretreatment to meet CWC criteria (Cost Elements 6 and 8, Appendix B)	37,300
Storage containers (60 @ $25 per container)	1,500
Storage at CWC for 4 years	0
TSCA permit and demonstration test	2,000
PCB treatment at CWC	10,000
Treatment to meet WIPP criteria (Cost Element 13, Appendix B)	22,900
Dispose at WIPP	0[a]
Total	**$94 M**

[a] Assumes that WIPP funding pays for transportation to and disposal at WIPP, no incremental cost to Hanford program.

4.6 OPTION 4(a): CHEMICALLY PRETREAT FOR WASTE ACCEPTANCE CRITERIA AND PCBS; MANAGE IN AN EXISTING DST

Option 4(a) consists of the following activities:

- Removing the K Basins sludge from the floor, pits, and canisters, consolidating it at staging areas in the basins, and transferring it to a pretreatment system in the 100-K Area
- Chemically pretreating the sludge to meet TWRS waste acceptance criteria and for PCBs
- Transferring the sludge to an existing DST for interim storage for unrestricted operation
- Retrieving the sludge with the rest of the DST contents to be treated at the Phase 2 TWRS treatment plants and disposed at the geologic repository.

The key difference between this and Option 1(a) is that there would be no TSCA impacts on the TWRS program.

Sludge Removal and Loadout. Canister, floor, and pit sludge from the K Basins would be collected, consolidated, and transferred to the pretreatment system as described for Option 1(a).

Pretreatment. The goal of pretreatment in this option is two-fold: (1) to meet TWRS waste acceptance criteria (including criteria for safe interim storage at an existing DST) and (2) to remove/destroy PCBs prior to transferring waste to the DST. A chemical pretreatment process was proposed in Option 1(a) to meet the TWRS waste acceptance criteria developed for K Basins sludge. The proposed pretreatment would include dissolution with concentrated acid, addition of neutron absorbers, and reprecipitation with caustic.

Several chemical technologies have been demonstrated to remove or destroy PCBs from wastes. Among these are base-catalyzed decomposition (EPA 1993) and oxidation via the addition of peroxide or strong acid. Laboratory tests using the chemical treatment process proposed to meet TWRS criteria indicate that the process also successfully treats PCBs such that PCB concentrations in the pretreated sludge are less than 2 ppm, the EPA standard for non-thermal treatment (EPA 1988). Option 4(a) assumes that as the pretreatment process is further developed to meet TWRS criteria, it is also optimized to treat the sludge for PCBs. Optimization might consist of such things as evaluating the use of alternate or additional chemicals, increasing acid contact times, adjusting processing rates, heating the pretreatment process, etc.

Assumptions relative to the chemical pretreatment process include the following:

- Pretreatment would be conducted as part of the CERCLA removal action, therefore, permits would not be required.
- The pretreatment system would be located inside the CVD facility in the 100-K Area.
- The pretreatment process would consist of coarse screening (to remove debris), nitric acid dissolution/caustic precipitation (to reduce particle size and oxidize metallic uranium), and the addition of neutron absorbers (such as depleted uranium) to control criticality during storage. The sludge would then be chemically adjusted to comply with DST criteria.
- Additional development and testing (at a cost of $500 K) would be performed during pretreatment design to optimize and demonstrate treatment for PCBs. It is assumed that any additional PCB testing would be conducted as part of initial operations. The test parameters would be established during remedial design.
- The pretreated sludge would contain less than 2 ppm of PCBs and EPA would issue a PCB Certificate of Destruction for the sludge.

Interim Storage, Treatment, and Disposal. Interim storage at an existing DST and treatment and disposal with high-activity waste were discussed in Option 1(a). That discussion including assumptions is applicable to Option 4(a), with the notable exception that the K Basins sludge would not be TSCA-regulated when transferred to the DST, therefore, there should be no TSCA impacts on TWRS resulting from management of the K Basins sludge.

Technical Feasibility. The technical feasibility of pretreatment relative to meeting the TWRS waste acceptance criteria established for K Basins sludge was discussed in Option 1(a). In that discussion, it was concluded that the proposed pretreatment system appears to be capable of meeting the TWRS criteria, including nuclear safety and operational criteria.

Information available on PCB treatment technologies indicates that the proposed combination of nitric acid dissolution and caustic (e.g., sodium hydroxide) precipitation would be effective at pretreating PCBs. Base-catalyzed decomposition has been successfully performed at other sites by mixing PCB-contaminated waste with a variety of hydrogen donors such as sodium hydroxide and heating in a mixing vessel for a short period of time (one to two hours) (EPA 1993). PCBs are also known to decompose in the presence of strong oxidizers such as peroxide or strong acids. It would be expected that the nitric acid dissolution step would result in decomposition of the PCBs. In the absence of heating, the caustic precipitation step alone might not adequately achieve PCB treatment, however, initial laboratory tests specific to K Basins sludge indicate that in combination with the nitric acid dissolution step, the proposed pretreatment process successfully reduces the PCB concentration in the pretreated sludge to less than 2 ppm. Chemical treatment to remove or destroy PCBs has become an established technology that has been used at numerous sites (at least four PCB chemical dechlorination systems are permitted under TSCA nationwide [EPA 1997]), therefore, it is anticipated that it would be technically feasible to optimize the chemical treatment to meet PCB treatment requirements concurrent with pretreating to meet TWRS waste acceptance criteria.

Assuming that pretreatment meets TWRS criteria and treats PCBs sufficiently for the sludge to exit TSCA regulation, interim storage, treatment, and disposal are expected to be technically feasible. An advantage of this option over Option 1(a) is that potential impacts of TSCA regulation in the TWRS system resulting from storage and treatment of K Basins sludge would be virtually eliminated. There would continue to be some technical uncertainty regarding potential safety and operational risks of storing the K Basins sludge in an existing DST, in part because characterization data show wide concentration ranges for sludge constituents. Additional bench-scale testing and potentially pilot-scale testing would be required during design to fully address issues associated with interim storage, treatment, and disposal.

Regulatory Feasibility. Two regulatory issues associated with this option are the same as in Option 1(a). They are:

- It is assumed that pretreatment would be conducted under CERCLA and would not require environmental permits; a change to this assumption could potentially delay this option.

- There are likely to be regulatory concerns regarding operation of a chemical pretreatment system in the 100-K Area because of the potential for radioactive, toxic, and regulated air emissions and proximity to the river.

The obvious regulatory issues associated with TSCA regulation of the TWRS system (discussed in Option 1[a]) would be eliminated by pretreating the sludge for PCBs. It would be expected that once EPA determines (via a Certificate of Destruction) that pretreatment has met the TSCA requirements, the sludge no longer would be TSCA-regulated and downstream waste streams that mix with or that are derived from the sludge would not be TSCA-regulated. However, there is some risk that if PCBs are detected in any waste stream in the TWRS system after receiving K Basins sludge, EPA might conclude that the waste stream should be TSCA-regulated. The basis for this conclusion would be two assumptions: (1) that the PCBs are derived from residuals in the sludge and (2) that the sludge was still a TSCA-regulated material and subject to the anti-dilution rule. To minimize this risk, this issue should be specifically addressed when negotiating the removal action and agreement documented in the CERCLA Action Memorandum that downstream waste streams would not be TSCA-regulated.

Safety. The two major safety concerns associated with this option are (1) the safety of the pretreatment system itself and (2) the nuclear and operational safety of interim storage in an existing DST. Both issues were discussed in Option 1(a). In summary, the chemical pretreatment system would present potential risks to workers because of the use of concentrated hazardous chemicals, the potential for violent chemical reaction, and the potential for exposure to sludge with high radiation doses. The primary risk to the public would be the potential for air emissions. Measures to ensure safety would include designing the pretreatment system to include shielding, redundancy, and remote operations; establishing procedures to ensure that chemicals are properly handled and that incompatible chemicals do not mix; designing the off-gas treatment system to limit routine atmospheric releases; processing small batch sizes to limit releases in the event of an upset condition.

Based on recent engineering evaluations and laboratory tests, the proposed chemical pretreatment would meet the TWRS criteria which address safe storage in DST (e.g., provide criticality control, eliminate pyrophoricity). Studies have indicated that gas generation and retention are not significant concerns (Daling, et al 1997). Based on this, it is expected that the pretreated K Basins sludge could be safely stored in a DST and treated and disposed with other tank waste.

Cost. The costs for Option 4(a) are provided in Table 4-5.

Table 4-5. Cost Estimates: Chemically Pretreat for Waste Acceptance Criteria and PCBs, Manage in an Existing DST

Cost Element	**Cost ($000)**
Sludge retrieval and consolidation (Cost Elements1+2, Appendix B)	9,300
Sludge loadout and transport (Cost Elements 3+4+5, Appendix B)	10,900
Refine PCB treatment	500
Pretreatment to meet TWRS criteria and for PCBs (Cost Elements 6+8, Appendix B)	37,300
Sludge off-load (Cost Element 9, Appendix B)	1,000
Prepare environmental and safety documentation for DST storage	150
Store in DST	0
Retrieve to vitrification plant	50
Vitrification and interim storage	0
Total	**$59 M**

4.7 OPTION 4(b): CHEMICALLY PRETREAT FOR WASTE ACCEPTANCE CRITERIA AND PCBS; MANAGE IN NEW TANKS

Option 4(b) consists of the following activities:

- Constructing new tanks in the 200 East Area for segregated storage of the K Basins sludge
- Removing the K Basins sludge from the floor, pits, and canisters, consolidating it at staging areas in the basins, and transferring it to a pretreatment system in the 100-K Area
- Chemically pretreating the sludge to meet TWRS waste acceptance criteria and for PCBs
- Transferring the sludge to the new tanks for interim storage
- Retrieving the sludge from the tanks and to be treated with other tank waste at the Phase 2 TWRS treatment plants and disposed at the geologic repository.

The key difference between this and Option 1(b) is that there would be no TSCA impacts on the TWRS program.

Sludge Removal and Loadout. Canister, floor, and pit sludge from the K Basins would be collected, consolidated, and transferred to the pretreatment system as described for Option

Pretreatment. The goal of pretreatment in this option is two-fold: (1) to meet TWRS waste acceptance criteria (including criteria to be established for safe interim storage at new tanks) and (2) to remove/destroy PCBs prior to transferring waste to the new tanks.

To meet the pretreatment goals of this option, the sludge would be chemically treated as described in Option 1(a); in addition, the pretreatment process would be optimized as described in Option 4(a) to concurrently remove/destroy PCBs. The proposed chemical treatment would be expected to adequately address TWRS waste acceptance criteria, including addressing particle size, criticality control, and pyrophoricity. In addition, the proposed pretreatment would be expected to reduce PCB concentrations to the TSCA standard of less than 2 ppm.

Assumptions relative to the chemical pretreatment process are the same as those in Option 4(a).

Interim Storage, Treatment, and Disposal. New tanks would be constructed as described in Option 1(b) to provide segregated storage of the K Basins sludge. The purpose of segregated storage would be to reduce safety and operational risks associated with storage in an existing

DST. Because the sludge would no longer be TSCA-regulated, there would no longer be a risk associated with potential TSCA impacts on the TWRS program.

Technical Feasibility. It is assumed that the waste acceptance criteria for new tanks are similar to the TWRS waste acceptance criteria. The technical feasibility of pretreatment relative to meeting the TWRS waste acceptance criteria established for K Basins sludge is discussed in Option 1(a). In that discussion, it was concluded that the proposed pretreatment system appears to be capable of meeting the TWRS criteria, including nuclear safety and operational criteria.

The technical feasibility of enhancing the proposed pretreatment system to address PCBs is discussed in Option 4(a). In that discussion, it was concluded that it should be technically feasible to optimize the proposed system to achieve PCB treatment standards and that this would eliminate potential impacts of TSCA regulation in the TWRS system resulting from storage and treatment of K Basins sludge.

As discussed in Option 1(b), there is some technical uncertainty associated with constructing new tanks in time to meet the TPA milestone for sludge removal.

Safety. The two major safety concerns associated with this option are (1) the safety of the pretreatment system itself and (2) the nuclear and operational safety of interim storage in new tanks. These issues were discussed in Option 1(a) and 1(b). In summary, the chemical pretreatment system would present potential risks to workers because of the use of concentrated hazardous chemicals, the potential for violent chemical reaction, and the potential for exposure to sludge with high radiation doses. The primary risk to the public would be the potential for air emissions. Measures to ensure safety would include designing the pretreatment system to include shielding, redundancy, and remote operations; establishing procedures to ensure that chemicals are properly handled and that incompatible chemicals do not mix; designing the off-gas treatment system to limit routine atmospheric releases; processing small batch sizes to limit releases in the event of an upset condition.

Based on recent engineering evaluations and laboratory tests, the proposed chemical pretreatment would meet requirements for safe storage in new tanks (e.g., provide criticality control, eliminate pyrophoricity). Studies have indicated that gas generation and retention are not significant concerns (Daling, et al 1997). Based on this, it is expected that the pretreated K Basins sludge could be safely stored in a DST and treated and disposed with other tank waste.

Cost. The costs to implement Option 4(b) are provided in Table 4-6.

Table 4-6. Cost Estimates: Chemically Pretreat for Waste Acceptance Criteria and PCBs, Manage in New Tanks.

Cost Element	Cost ($000)
Sludge retrieval and consolidation (Cost Elements 1+2, Appendix B)	9,300
Sludge loadout and transport (Cost Elements 3+4+5, Appendix B)	10,900
Refine treatment for PCBs	500
Pretreatment to meet TWRS criteria and PCBs (Cost Elements 6+8, Appendix B)	37,300
Sludge off-load (Cost Element 9, Appendix B)	1,000
Construct new tanks (Cost Element 10, Appendix B)	27,000
Store in new tanks	220
Retrieve to vitrification plant	50
Incremental costs for vitrification and storage of glass canisters[a]	0-23,000
Total	**$86-109 M**

a. Additional vitrification cost depends on ability to blend K Basina sludge with other tank waste before vitrification; if none can be blended with other wastes before vitrification, an additional 37 canisters will be generated at $630 K million per canister.

4.8 OPTION 4(c): CHEMICALLY PRETREAT FOR WASTE ACCEPTANCE CRITERIA AND PCBS; MANAGE AT T PLANT

Option 4(c) consists of the following activities:

- Modifying an existing tank in T Plant to store the K Basins sludge
- Removing the K Basins sludge from the floor, pits, and canisters, consolidating it at staging areas in the basins, and transferring it to a pretreatment system in the 100-K Area
- Chemically pretreating the sludge for PCBs and to meet T Plant waste acceptance criteria for tank storage
- Transferring the sludge to T plant interim storage
- Retrieving the sludge to be treated, packaged, assayed, and certified at T Plant and disposed at the WIPP.

The key difference between this and Option 2 is that PCB treatment would not be required at T Plant.

Sludge Removal and Loadout. Canister, floor, and pit sludge from the K Basins would be collected, consolidated, and transferred to the pretreatment system as described for Option 1(a).

Pretreatment. The goal of pretreatment in this option is two-fold: (1) to meet waste acceptance criteria for interim storage at T Plant and (2) to remove/destroy PCBs prior to transferring waste to T Plant. As discussed in Option 2, waste acceptance criteria specific to interim storage of K Basins sludge in a tank at T Plant have not been established, but are likely to include requirements for criticality control and prohibitions on storage of pyrophoric radionuclides.

To meet the pretreatment goals of this option, the sludge would be chemically treated as described in Option 1(a); in addition, the pretreatment process would be optimized as described in Option 4(a) to concurrently remove/destroy PCBs. The proposed chemical treatment would be expected to adequately address issues of criticality control and pyrophoricity as well as reduce PCB concentrations to the TSCA standard of less than 2 ppm.

Assumptions related to pretreatment are the same as those presented in Option 4(a).

Interim Storage, Treatment, and Disposal. After pretreatment, the sludge would be pumped into transport packages, transferred to T Plant, and off-loaded to a tank in the plant for interim storage. Modifications required at T Plant to accommodate the sludge are described in Option 2. The sludge would be stored in the tank until such time as T Plant is modified to become the site facility for treating, packaging, assaying, and certifying remote-handled TRU waste. The sludge would then be retrieved from the tank and processed for eventual disposal at the WIPP. The interim storage, treatment, and disposal process would be the same as described in Option 2, with the notable exception that in-tank PCB treatment would not be required.

Assumptions related to interim storage, treatment, and disposal are the same as those presented in Option 2, with the exception that there would be no in-tank treatment for PCBs.

Technical Feasibility. It is assumed that the waste acceptance criteria for a tank in T Plant are similar to the TWRS waste acceptance criteria. The technical feasibility of pretreatment relative to meeting the TWRS waste acceptance criteria established for K Basins sludge is discussed in Option 1(a). In that discussion, it was concluded that the proposed pretreatment system appears to be capable of meeting the TWRS criteria, including nuclear safety and operational criteria.

The technical feasibility of enhancing the proposed pretreatment system to address PCBs is discussed in Option 4(a). In that discussion, it was concluded that it should be technically feasible to optimize the proposed system to achieve PCB treatment standards and that this would eliminate potential impacts of TSCA regulation at T Plant.

As discussed in Option 2, there is technical uncertainty associated with completing the modifications at T Plant in time to meet the TPA milestone for sludge removal. There is also substantial uncertainty as to whether T Plant will ultimately be the location for remote-handled TRU waste treatment and what the actual costs will be for wastes processed there. An advantage of this option over Option 2 is that the sludge would not have to be treated for PCBs at T Plant.

Finally, as with other options that rely on the WIPP for final disposal, there is uncertainty as to whether the K Basins sludge would be acceptable for disposal at the WIPP because the sludge derives in part from SNF. It is unknown whether the repository would accept the sludge and whether there would be additional treatment requirements.

Cost. The costs to implement Option 4(c) are provided in Table 4-7.

Table 4-7. Cost Estimates: Chemically Pretreat for Waste Acceptance Criteria and PCBs, Manage Sludge at T Plant.

Cost Element	Cost ($000)
Sludge retrieval and consolidation (Cost Elements 1+2, Appendix B)	9,300
Sludge loadout and transport (Cost Elements 3+4+5, Appendix B)	10,900
Refine treatment for PCBs	500
Pretreatment to meet T Plant criteria and for PCBs (Cost Elements 6+8, Appendix B)	37,300
Sludge off-load (Cost Element 9, Appendix B)	1,000
Modify and operate T Plant tank, including safety and regulatory documentation (Cost Element 11, Appendix B)	5,400
Storage at T plant (McKenney 1997)	7,300
Treat, package, assay, and certify to meet WIPP criteria (Cost Element 13, Appendix B)	22,900
Dispose at WIPP	0[a]
Total	**$95 M**

[a] Assumes that WIPP funding pays for transportation to and disposal at WIPP, no incremental cost to Hanford program.

4.9 OPTION 4(d): CHEMICALLY PRETREAT FOR WASTE ACCEPTANCE CRITERIA AND PCBS; MANAGE AT CWC

Option 4(d) consists of the following activities:

- Removing the K Basins sludge from the floor, pits, and canisters, consolidating it at staging areas in the basins, and transferring it to a pretreatment system in the 100-K Area

- Chemically pretreating and packaging the sludge to meet CWC waste acceptance criteria and for PCBs

- Transferring the sludge to the CWC for interim storage

- Transferring the sludge to a new facility to be treated (to meet WIPP requirements), packaged, assayed, and certified and disposed at the WIPP.

The key difference between this and Option 3 is that PCB treatment would not be required at the new remote-handled TRU waste treatment facility.

Sludge Removal and Loadout. Canister, floor, and pit sludge from the K Basins would be collected, consolidated, and transferred to the pretreatment system as described for Option 1(a).

Pretreatment. The goal of pretreatment in this option is two-fold: (1) to meet waste acceptance criteria for interim storage at the CWC and (2) to remove/destroy PCBs prior to transferring waste to the CWC. As discussed in Option 3, waste acceptance criteria specific to interim storage of K Basins sludge at the CWC have not been established, but general solid waste criteria suggest that pretreatment should include an acid dissolution/reprecipitation process similar to the pretreatment described in Option 1(a), followed by a drying process. The addition of neutron absorbers as part of pretreatment might or might not be necessary, depending on the results of a criticality evaluation.

As discussed in Option 4(a), the combination of acid dissolution and caustic precipitation would generally be expected to destroy PCBs. The system proposed in Option 3 would be optimized in this option to achieve PCB treatment standards. Assumptions related to pretreatment are the same as those listed in Option 3, with the exception that either simple drying or solidification could be considered because future PCB treatment would not be required. For purposes of this evaluation, it is assumed that a simple drying process would be used, in part because of the time required to develop an appropriate grout formulation that would be acceptable for final disposal and design and construct a grouting system that would meet safety and operational requirements.

After drying, the sludge would be transferred into containers that meet surface dose requirements for CWC.

Interim Storage, Treatment, and Disposal. The containerized sludge would be transported to the CWC and off-loaded for interim storage. It is anticipated that the containers would be contact-handled. They would be placed in a storage building at the CWC until such time as remote-handled TRU waste treatment/packaging capabilities are developed.

In this option, a new facility would be constructed to provide remote-handled TRU waste treatment/packaging capability for the entire Hanford Site. The K Basins solids would be treated, packaged, assayed, and certified at T Plant to meet WIPP waste acceptance criteria, then disposed at the WIPP. Assumptions regarding treatment and disposal are the same as for Option 3, with the exception of assumptions related to PCB treatment.

Technical Feasibility. The technical feasibility of pretreatment relative to meeting the general CWC waste acceptance criteria is discussed in Option 3. In that discussion, it was concluded that although there is uncertainty regarding the specific pretreatment requirements to meet CWC criteria, the proposed pretreatment system appears to address key technical and safety requirements associated with storing the slduge.

The technical feasibility of enhancing the proposed pretreatment system to address PCBs is discussed in Option 4(a). In that discussion, it was concluded that it should be technically feasible to optimize the proposed system to achieve PCB treatment standards and that this would eliminate potential impacts of TSCA regulation at other solid waste storage and treatment facilities.

It was concluded in Option 3 that storage at the CWC appears to be technically feasible. Chemical pretreatment for PCBs would eliminate TSCA impacts at solid waste facilities. Uncertainties related to interim storage at the CWC and treatment at a new remote-handled TRU waste treatment facility include:

- Specific criteria for storing K Basins sludge have not been developed.
- Uncertainties regarding acceptance at the WIPP. It is unknown whether the repository would accept the sludge and whether there would be additional treatment requirements.
- The location for treating, packaging, assaying, and certifying remote-handled TRU waste has not yet been selected; a new facility is one alternative.

- Prorated costs for packaging, assaying, and certifying the waste at the remote-handled TRU waste treatment facility could vary substantially depending on total remote-handled waste volume.

Regulatory Feasibility. No significant regulatory issues were identified for interim storage at the CWC. Potentially significant regulatory issues include:

- It is assumed that pretreatment would be conducted under CERCLA and would not require environmental permits; a change to this assumption could potentially delay this option.

- There are likely to be regulatory concerns regarding operation of a chemical pretreatment system in the 100-K Area because of the potential for radioactive, toxic, and regulated air emissions and proximity to the river.

- There have been no discussions with EPA Region 8 or the State of New Mexico to confirm that they will accept EPA Region 10's determination that the sludge is no longer regulated under TSCA following treatment.

Safety. The two major safety concerns associated with this option are (1) the safety of the pretreatment system itself and (2) the safety of interim storage in containers at the CWC. Safety issues related to the pretreatment system were discussed in Option 1(a). In summary, the chemical pretreatment system would present potential risks to workers because of the use of concentrated hazardous chemicals, the potential for violent chemical reaction, and the potential for exposure to sludge with high radiation doses. The primary risk to the public would be the potential for air emissions. Measures to ensure safety would include designing the pretreatment system to include shielding, redundancy, and remote operations; establishing procedures to ensure that chemicals are properly handled and that incompatible chemicals do not mix; designing the off-gas treatment system to limit routine atmospheric releases; and processing small batch sizes to limit releases in the event of an upset condition.

Safety related to interim storage at the CWC and final processing at a new remote-handled waste facility was discussed in Option 3.

Cost. The costs to implement Option 4(d) are provided in Table 4-8.

Table 4-8. Cost Estimates: Chemically Pretreat for Waste Acceptance Criteria and PCBs, Manage Sludge at CWC.

Cost Element	Cost ($000)
Sludge retrieval and consolidation (Cost Elements 1 and 2, Appendix B)	9,300
Sludge loadout and transport (Cost Elements 3, 4, and 5, Appendix B)	10,900
Pretreatment to meet CWC criteria (Cost Elements 6 and 8, Appendix B)	37,300
Storage containers (60 @ $25 per container)	1,500
Storage at CWC for 4 years	0
Treatment to meet WIPP criteria (Cost Element 13, Appendix B)	22,900
Dispose at WIPP	0[a]
Total	**$82 M**

[a] Assumes that WIPP funding pays for transportation to and disposal at WIPP, no incremental cost to Hanford program.

4.10 OPTION 5(a): THERMALLY PRETREAT FOR WASTE ACCEPTANCE CRITERIA AND PCBS; MANAGE AT T PLANT

Option 5(a) consists of the following activities:

- Removing the K Basins sludge from the floor, pits, and canisters, consolidating it at staging areas in the basins, and transferring it to a pretreatment system in the 100-K Area
- Thermally pretreating the sludge for PCBs and to meet T Plant waste acceptance criteria for container storage
- Transferring the sludge to T plant for interim storage
- Treating, packaging, assaying, and certifying the sludge at T Plant and disposing at the WIPP.

There are two key difference between this and Option 2: (1) PCBs would be removed as part of the pretreatment process and PCB treatment would not be required at T Plant and (2) thermal pretreatment would produce dry solids that would lend themselves to container storage rather than tank storage.

Sludge Removal and Loadout. Canister, floor, and pit sludge from the K Basins would be collected, consolidated, and transferred to the pretreatment system as described for Option 1(a).

Pretreatment. The goal of pretreatment in this option is two-fold: (1) to meet waste acceptance criteria for interim storage at T Plant and (2) to remove/destroy PCBs prior to transferring waste to T Plant.

Several thermal processes are available to treat PCBs. Some of these processes destroy the PCBs and others extract them from the waste matrix. Both incineration and vitrification are proven technologies that destroy PCBs using very high temperatures. Incineration has been selected for remediation of PCB-contaminated soil or sediment at over 60 CERCLA sites (EPA 1993) and at least four companies hold TSCA permits for incinerators (EPA 1997). A LLW incinerator has been permitted under TSCA and is in operation at DOE's Oak Ridge National Laboratory (DOE 1996d). One in situ vitrification unit has received a national TSCA permit as an alternate thermal destruction method for PCB-contaminated material (EPA 1997, GeoSafe 1997). Although traditional in situ vitrification would not be applicable to the K Basins sludge, stationary batch vitrification[5] could be used. Vitrification has been used at several sites where soil or sediment are contaminated with radionuclides. Thermal desorption is a physical separation technology that uses a heat exchange process to heat PCBs to a temperature high enough to volatilize and separate them from a contaminated solid medium. The PCBs can then either be destroyed in afterburners or collected to be destroyed at an incinerator. Several thermal desorption units have been permitted as physical separation units under TSCA (EPA 1997). Pilot-scale tests at Oak Ridge National Laboratory have demonstrated that thermal desorption at 600°C reduces PCB concentrations to below 2 mg/kg (Morris, et al, 1996), and a full-scale LLW thermal desorption unit has been designed for Sandia National Laboratories and is being fabricated (Richardson 1996). After any type of thermal treatment, the sludge would typically have the form of either a dry particulate (typical of incineration or thermal desorption) or a solidified mass (typical of vitrification).

It is likely that the temperatures resulting from thermal treatment would be sufficient to oxidize the metallic uranium and uranium hydrides and thus eliminate pyrophoricity. Concerns regarding gas generation would be reduced following thermal treatment because treatment would produce dry solids, eliminating radiolysis of water. Thermal treatment would not address criticality control, and in fact could increase concerns related to criticality control because thermal treatment would tend to concentrate the waste, including the fissile constituents, into a smaller volume. More extensive evaluation would be required to determine the combination of additional pretreatment and packaging necessary to ensure adequate criticality control during interim storage (and as necessary, for final disposal). Additional evaluation would also be required to identify any other K Basins-specific waste acceptance criteria at T Plant and to develop appropriate pretreatment and management methods to meet those criteria.

The thermal pretreatment method used for discussion purposes in this option is based on the mobile thermal desorption unit fabricated for Sandia. (The incineration and vitrification processes are discussed further in Appendix C.) The thermal desorption unit would be installed inside the CVD and have the capability to accept sludge from the K Basins sludge transport containers. The treatment system would consist of a dryer and an off-gas system; a decant system might be required at the front end to reduce the liquid content of the sludge prior to treatment. The dryer would operate at temperatures up to 600°C. The off-gas system would condense and collect the PCBs, which could then be taken to an off-site TSCA-permitted facility for destruction. The off-gas system would also include treatment for radioactive particulate and gases and toxic gases as appropriate. The pretreated sludge would either be containerized as-is from the thermal desorption unit or further pretreated to meet T Plant waste acceptance criteria.

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[5]In stationary batch vitrification, wastes or contaminated media are staged in an in-ground treatment cell for processing, and the vitrified material is removed after treatment for disposal elsewhere.

Additional pretreatment could also include solidifying the dry solids in preparation for final waste disposal at the WIPP.

Waste streams generated as a result of thermal desorption would include the following:

- Treated sludge. It is likely that the dry solids would designate as a remote-handled mixed TRU waste.

- Decanted water. If necessary, water would be decanted from the sludge prior to thermal desorption. The water would be returned to the K Basins to be managed as basin water.

- Contaminated off-gas. Other toxic, regulated, and radioactive constituents would be volatilized along with the PCBs. Toxic, regulated, or radioactive particulate might also be carried into the off-gas stream.

- Off-gas condensate. Volatiles such as the PCBs would be condensed into the liquid phase and collected. It is expected that the condensate would designate as LLW and be TSCA-regulated. Condensate would be transported to a permitted off-site location (such as the Oak Ridge National Laboratory incinerator) for treatment.

- Miscellaneous wastes. Other potential wastes include contaminated air filters, debris collected during initial sludge screening, contaminated equipment, etc. This debris would be designated and managed at existing solid waste management facilities.

Assumptions related to thermal pretreatment include:

- Pretreatment would be conducted as part of the CERCLA removal action, therefore, permits would not be required.

- The pretreatment system would be installed inside the CVD facility in the 100-K Area.

- Pretreatment would be performed using a system similar to the patented VAC*TRAX unit designed and being fabricated for Sandia. A system specific to the K Basins sludge would focus on upgrading containment, additional shielding, designing for remote operations, adding redundant systems, and more extensive off-gas treatment systems. Modifications might also be required to provide a critically-safe configuration of process vessels and to provide a front-end decant system to reduce the water content of the sludge.

- The VAC*TRAX unit was designed for LLW operations; it is assumed that design and fabrication costs would increase by a factor of 10 to account for remote operations, additional safety features, etc.

- The pretreated sludge would contain less than 2 ppm of PCBs and EPA would issue a PCB Certificate of Destruction for the sludge.

- For purposes of evaluating this option, it is assumed that the dry solids produced by the thermal desorption unit require no additional pretreatment to meet T Plant waste acceptance criteria.

- The particulate could be solidified (e.g., by grouting) as part of pretreatment; additional development work would be required to ensure that the solidification process results in meeting WIPP waste acceptance criteria. No estimate is available for the cost to solidify the sludge as part of pretreatment. For costing purposes, it is assumed that any further treatment such as solidification performed to meet WIPP waste acceptance criteria would be performed at the T Plant.

- T Plant has the capability to store remote-handled waste, therefore, containers with extensive shielding would not be required. For costing purposes, it is assumed that 60 containers are required at $5,000 per container.

Interim Storage, Treatment, and Disposal. The containerized solids would be transported to T Plant for interim storage. It is anticipated that the containers would require remote handling. They would be placed inside the T Plant until such time as remote-handled TRU waste treatment/packaging capabilities are developed.

In this option, T Plant would be selected as the location for a treatment/packaging facility for all Hanford remote-handled TRU waste. The K Basins solids would be treated, packaged, assayed, and certified at T Plant to meet WIPP waste acceptance criteria, then disposed at the WIPP. Assumptions regarding treatment and disposal are the same as for Option 2, with the exception of assumptions related to PCB treatment.

Technical Feasibility. The pretreatment system would be expected to be technically feasible for addressing PCBs. As discussed in the section on pretreatment, thermal desorption (and other thermal technologies) has been demonstrated nationwide as an effective means of treating PCB-contaminated soil and sediment (EPA 1993). The VAC*TRAX thermal desorption unit being fabricated for Sandia is an example of a unit that could be modified for application to K Basins sludge. Facilities to treat the PCB-containing condensate resulting from thermal desorption should be available at the time of sludge removal. One LLW incinerator is already operating at the Oak Ridge National Laboratory, and other TSCA-permitted LLW treatment units are planned for the Hanford Site and the Idaho National Engineering Laboratory.

There is substantial uncertainty regarding the technical feasibility of the pretreatment system with respect to nuclear and operational safety issues and how the pretreatment system would address those issues. Uncertainties include:

- The ability of the thermal system to oxidize pyrophoric materials
- Criticality control requirements during treatment due to concentration of the waste as a whole and fissile constituents
- Criticality control requirements for the dry solids
- The ability to adapt thermal desorption for remote operations.

It is anticipated that all of these issues could be addressed through appropriate design and engineering of the system, but substantial development work would be required. The time required for development and testing could potentially delay the sludge removal schedule.

As discussed in Option 2, there is also substantial technical uncertainty regarding the use of T Plant as a future remote-handled waste treatment and packaging facility. If a facility other than T Plant is selected for remote-handled waste processing, however, the containers with the K Basins sludge could readily be transferred to the selected facility.

Finally, as with other options that rely on the WIPP for final disposal, there is uncertainty as to whether the K Basins sludge would be acceptable for disposal at the WIPP because the sludge derives in part from SNF. It is unknown whether the repository would accept the sludge and whether there would be additional treatment requirements.

Regulatory Feasibility. There would likely be even greater regulator interest in thermal versus chemical pretreatment in the 100-K Area because the higher temperatures would result in an increased potential for radioactive and toxic emissions. The identification of appropriate controls and monitoring would require extensive consultation with the DOH (for potential radioactive emissions) and Ecology (for potential regulated and toxic emissions) and could result in delays in implementing pretreatment. It is possible that thermal treatment in the 100-K Area would not be accepted by the regulators; this would not preclude locating a thermal pretreatment system in the 200 Area, but this would require full permitting and could result in further delays.

The regulatory feasibility of interim storage and further processing at the T Plant are discussed in Option 2. The only significant regulatory issues were those related to PCB treatment. In this option, PCB treatment would not occur at T Plant so no significant regulatory issues would be expected.

For the thermally pretreated sludge to exit TSCA regulation, EPA Region 10 would need to issue a PCB Certificate of Destruction. There have been no discussions with EPA Region 8 or the State of New Mexico to confirm that they will accept EPA Region 10's determination that the sludge presented for disposal at WIPP is not TSCA-regulated.

Safety. There could be significant safety hazards associated with the high temperatures required for thermal pretreatment and the amount of stored energy involved in heating the sludge to the required temperatures. Although substantial design and process controls would be in place, thermal units present a greater risk to workers and the public in the event of an upset condition. Potential accidents could include pressurization, fires, and explosions. Safety documentation requirements for the system would likely be extensive, and could potentially delay implementation.

Cost. The costs to implement Option 5(a) are provided in Table 4-9.

Table 4-9. Cost Estimates: Thermally Pretreat for Waste Acceptance Criteria and PCBs, Manage Sludge at T Plant

Cost Element	**Cost ($000)**
Sludge retrieval and consolidation (Cost Elements 1 and 2, Appendix B)	9,300
Sludge loadout and transport (Cost Elements 3, 4, and 5, Appendix B)	10,900
Thermal pretreatment (Cost Element 7, Appendix B)	32,200
Storage containers (60 @ $5 K per container)	300
Storage at T Plant (4 years @ $20 K per year)	80
Treat, package, assay, and certify to meet WIPP criteria (Cost Element 13, Appendix B)	22,900
Dispose at WIPP	0[a]
Total	**$78 M**

[a] Assumes that WIPP funding pays for transportation to and disposal at WIPP, no incremental cost to Hanford program.

4.11 OPTION 5(b): THERMALLY PRETREAT FOR WASTE ACCEPTANCE CRITERIA AND PCBS; MANAGE AT CWC

Option 4(d) consists of the following activities:

- Removing the K Basins sludge from the floor, pits, and canisters, consolidating it at staging areas in the basins, and transferring it to a pretreatment system in the 100-K Area
- Thermally pretreating and packaging the sludge to meet CWC waste acceptance criteria and for PCBs
- Transferring the sludge to the CWC for interim storage
- Transferring the sludge to a new facility to be treated (to meet WIPP requirements), packaged, assayed, and certified and disposed at the WIPP.

The key difference between this and Option 3 is that PCB treatment would not be required at the new remote-handled TRU waste treatment facility.

Sludge Removal and Loadout. Canister, floor, and pit sludge from the K Basins would be collected, consolidated, and transferred to the pretreatment system as described for Option 1(a).

Pretreatment. The goal of pretreatment in this option is two-fold: (1) to meet waste acceptance criteria for interim storage at the CWC and (2) to remove/destroy PCBs prior to transferring waste to the CWC. General waste acceptance criteria for the CWC are described in Option 3.

To meet both of these goals, the sludge would be thermally treated as described in Option 5(a). Thermal treatment would be expected to reduce PCB concentrations to the required TSCA standards. Thermal treatment would also be likely to oxidize metallic uranium and uranium hydrides and thus reduce concerns regarding pyrophoricity. The impacts of thermal treatment relative to other CWC waste acceptance criteria have not been evaluated. For example, there has been no evaluation to determine requirements for criticality control for storing the dry solids, and the particle size resulting from thermal treatment is not known. It is possible that additional pretreatment would be required to address these criteria.

As part of pretreatment, the dry solids could be solidified by adding an immobilizing agent (e.g., portland cement, which would form a solid grout). The solidification formula would be designed to meet RCRA treatment standards for metal constituents in the sludge. The need for solidification would depend on (1) the properties of the dry solids, (2) requirements for criticality control, and (3) the cost-effectiveness of solidifying the sludge at the K Basins versus waiting for a remote-handled TRU waste treatment/packaging facility to be available. The CWC waste acceptance criteria require immobilization of small particle size waste; there is insufficient information on the thermal treatment process to determine expected particle sizes, so it is unknown whether immobilization prior to interim storage would be required. A solidification process to be used at the 100-K Area has not been evaluated, so the most cost-effective approach cannot be determined.

Following pretreatment, the particulate or solidified sludge would be packaged to meet CWC surface dose criteria and transferred to the CWC.

Assumptions related to pretreatment under this option are the same as for Option 5(a), with the following exceptions:

- For costing purposes, it is assumed that any treatment such as solidification performed to meet WIPP waste acceptance criteria is performed at the new remote-handled waste treatment facility.

- To meet surface dose rate requirements for interim storage at the CWC, the solids containers would be overpacked as described in Option 3. Approximately 60 containers would be required at a cost of $25,000 per container.

Interim Storage, Treatment, and Disposal. At the CWC, the containerized solids would be off-loaded, placed into interim storage, treated, and disposed as described in Option 3, with the exception that further treatment for PCBs would not be required.

Technical Feasibility. The technical feasibility of a thermal pretreatment system is discussed in Option 5(a). In summary, the technology is demonstrated to be very feasible for treating PCBs, but there are substantial safety and operational uncertainties related to applying thermal pretreatment to K Basins sludge. It is anticipated that issues could be addressed through appropriate design and engineering of the system, but substantial development work would be required. The time required for development and testing could potentially delay the sludge removal schedule.

The technical feasibility of interim storage at the CWC, treatment at a new remote-handled waste facility, and disposal at the WIPP is discussed in Option 3. In summary:

- Assuming sufficient and appropriate pretreatment, interim storage at the CWC should present few technical concerns

- There is substantial uncertainty regarding the choice of facility for remote-handled waste processing

- There are indications from WIPP that the sludge might not be accepted for disposal there, and it is unknown whether the repository would accept the sludge and whether there would be additional treatment requirements.

Regulatory Feasibility. The regulatory feasibility of thermal pretreatment was discussed in Option 5(a). There are likely to be significant regulatory concerns, particularly with respect to air emissions, and this could delay implementation or require that the thermal system be located elsewhere than in the 100-K Area. The pretreatment process appears to be feasible from the standpoint of meeting TSCA treatment standards.

The regulatory feasibility of interim storage at the CWC and processing at the new remote-handled waste facility is discussed in Option 3. The only significant regulatory issues identified in Option 3 were those related to PCB treatment. PCB treatment would not occur at the remote-handled waste processing facility in this option, so no significant regulatory issues would be expected.

For the thermally pretreated sludge to exit TSCA regulation, EPA Region 10 would need to issue a PCB Certificate of Destruction. There have been no discussions with EPA Region 8 or the State of New Mexico to confirm that they will accept EPA Region 10's determination that the sludge presented for disposal at WIPP is not TSCA-regulated.

Safety. As discussed in Option 5(a), there could be significant safety hazards associated with thermal pretreatment and safety documentation requirements for the system could potentially delay implementation.

Cost. The costs to implement Option 5(b) are provided in Table 4-10.

Table 4-10. Cost Estimates: Thermally Pretreat for Waste Acceptance Criteria and PCBs, Manage Sludge at CWC

Cost Element	Cost ($000)
Sludge retrieval and consolidation (Cost Elements 1 and 2, Appendix B)	9,300
Sludge loadout and transport (Cost Elements 3, 4, and 5, Appendix B)	10,900
Thermal pretreatment (Cost Element 7, Appendix B)	32,200
Storage containers (60 @ $25 K per container)	1,500
Storage at CWC	0
K Basins allocation of construction of new remote-handled TRU waste facility	7,500
Treat, package, assay, and certify to meet WIPP criteria (Cost Element 13, Appendix B)	22,900
Dispose at WIPP	0[a]
Total	**$84 M**

[a] Assumes that WIPP funding pays for transportation to and disposal at WIPP, no incremental cost to Hanford program.

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APPENDIX A

CHARACTERIZATION OF K BASINS SLUDGE

		KE Basin - Bounding (Maximum) Case				
		Weasel/Dummy	N. Loadout			
	Basin Floor	Tech View Pits	Pit	Canisters	Wash	Total
Volume (m^3)						
	25.8	16.2	6.2	7.9	3.2	59.3
Radionuclide Inventory (Ci)						
Am241	1460	165	8.05	1887.08	1400	4920.13
Bi212	92.3	33.8				126.1
Ce144/Pr	299	300		316.16	234	1149.16
Cm243/244	332	69.8		97	72	571.118
Co60	60.9	34.4	1.64	741	550	1387.94
Cs134	23	6.07		216.372	160	405.442
Cs137	38500	7410	74.3	71383	52800	170167.3
Eu152	18.3	10.3		5.3599	3.95	37.9099
Eu154	231	29.1	1.64	676.78	502	1440.52
Eu155	107	19	0.903	180.063	134	440.966
Nb94	11.7	3.25		0		14.95
Np237	0.222	0.114		0.36803	0.272	0.97603
Pu238	283	59.7	1.6	731.12	542	1617.42
Pu239/240	1170	219	9.74	2003.17	1490	4891.91
Ra226	572	160		0		732
Ru106/Rh	436	117		284.05	210	1047.05
Sb125	97.7	33.4		382.85	285	798.95
Sr90	35900	5440		54834	40500	136674
Tl208	309	104				413
Y-90					40500	40500
Pu241			137		30200	30337
Ba-137m			70.3		50000	50070.3
Chemical Inventory (kg)						
Ag	0.98	0.554				1.534
Al	1520	863	36.3	4.5695	6.780	2430.6495
B	19.9	11.3		0.001729	2.41E-03	31.204139
Ba	14.7	8.29	0.485	0		23.475
Be	0.686	0.357	0.0353	0.4446	0.650	2.1729
Ca	861	486	27.5	0		1374.5
Cd	1.99	1.12	0.249	0.001606	2.41E-03	3.363016
Cr	49.7	28.1	0.598	0.77805	1.150	80.32605
Cu	24.6	13.9	1.26	0.4446	0.660	40.8646
Fe	13600	7670	109	2.47	3.750	21385.22
K	66	37.3		0		103.3
Mg	125	70.8	3.46	0.1482	0.2250	199.6332
Mn	25.6	14.5	1.5	0.16055	0.2400	42.00055
Na	387	42.3	1.97	0.008151	0.01200	431.290151
Pb	28.1	15.9	0.42	0.040755	0.0605	44.521255
Se	9.8	5.54		0.003211	0.00465	15.347861
Sm	9.8	5.54		0.01729		15.35729
Tl	19.6	11.1		0		30.7
Zn	54.3	30.7	1.07	0		86.07
Zr	27.6	15.6		395.2	590	1028.4
U	11100	1110	47.2	5643.95	8,380	26281.15
Residue	9600	6100				15700

		KW Basin - Bounding (Maximum) Case				
		Weasel/Dummy	N. Loadout			
	Basin Floor	Tech View Pits	Pit	Canisters	Wash	Total
Volume (m³)						
	2.4	1.4	3.6	3	3.2	13.6
Radionuclide Inventory (Ci)						
Am241			4.83	713	1310	2027.83
Bi212					0	0
Ce144/Pr				32.6	59.8	92.4
Cm243/244				30.8	56.3	87.1
Co60			0.987	406	745	1151.987
Cs134				134	246	380
Cs137			44.6	35000	64200	99244.6
Eu152				2.66	4.9	7.56
Eu154			0.987	333	610	943.987
Eu155			0.542	84.1	154	238.642
Nb94					0	0
Np237				0.159	0.292	0.451
Pu238			0.958	292	538	830.958
Pu239/240			5.84	861	1580	2446.84
Ra226					0	0
Ru106/Rh				43.1	79	122.1
Sb125				185	338	523
Sr90				27800	50800	78600
Tl208					0	0
Y-90				27800	50800	78600
Pu241				18300	33500	51800
Ba-137m			42.2	33300	61000	94342.2
Chemical Inventory (kg)						
Ag						
Al			21.8	3.7	6.775	32.275
B				0.00131	2.41E-03	0.00372
Ba			0.291		0	0.291
Be			0.0212	0.354	0.65	1.0252
Ca			16.5		0	16.5
Cd			0.15	0.00131	2.41E-03	0.15372
Cr			0.359	0.625	1.1475	2.1315
Cu			0.755	0.361	0.66	1.776
Fe			65.2	2.04	3.75	70.99
K					0	0
Mg			2.08	0.121	0.225	2.426
Mn			0.9	0.131	0.24	1.271
Na			1.18	0.00656	0.012025	1.198585
Pb			0.252	0.033	0.0605	0.3455
Se				0.00253	0.00465	0.00718
Sm					0	0
Tl					0	0
Zn			0.645		0	0.645
Zr				322	590	912
U			28.3	4560	8380	12968.3

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APPENDIX B

COST ELEMENTS

This appendix develops the cost elements for the K Basins sludge management alternatives. Figure A-1 illustrates how the cost elements fit together in the overall cost of the alternatives. The following assumptions regarding sludge characterization were used in developing costs for all the alternatives:

1. Sludges from KE and KW Basins are managed in the manner.
2. Upper bounding sludge volume (KE plus KW): 70 m^3 (20,000 gallons) on a settled solids basis.
3. Solids content: 60 volume % on a settled solids basis.
4. The sludge is regulated as a dangerous waste (characteristic waste codes for heavy metals).
5. The sludge is regulated under TSCA due to the presence of PCBs.
6. Average TRU activity in bulk sludge: 60,000 nCi/g.
7. The sludge is regulated as a TRU waste.
8. Contact dose of containerized sludge: 23 rem/hr.

The following additional assumptions are common to all the alternatives:

1. Unless detailed estimates were available, project management costs were assumed to be 16% of construction costs.
2. Unless detailed estimates were available, system definition costs were assumed to be 18% of construction costs.
3. Unless detailed estimates were available, start-up costs (including acceptance test procedures [ATP], operating test procedures [OTP], operator training, and readiness testing) were assumed to be 11% of construction costs.

Cost Element 1: Design/Construction of Sludge Retrieval System

Scope: This activity consists of designing, procuring, installing, and testing the system that will collect sludge from the floor and pits of KE Basin and the pits in KW Basin and consolidate the sludge at selected staging areas within each basin.

Assumptions:

1. Prior to removing SNF from the KE Basin, about 60% of the floor sludge on and around the canisters will be retrieved to the Weasel Pit.
2. After the SNF is retrieved and the racks in the basins are removed, the remainder of the KE Basin floor and pit sludge will be retrieved and staged in the Weasel Pit.

Activity	**Cost ($K)**	**Basis of Estimate**
Project management	400	Project baseline
System definition	440	Project baseline
Design/procure equipment	1,060	Project baseline
Fabricate/deliver equipment	2,180	Project baseline
Install equipment	280	Project baseline
Safety documentation	340	Project baseline; includes retrieval system SAR update
ATP/OTP/Start-up	240	Project baseline
Total	**4,900**	

Cost Element 2: Sludge Retrieval and Consolidation Operations

Scope: This activity consists of operational costs associated with collecting sludge from the floor and pits of KE Basin and the pits in KW Basin and consolidating the sludge at selected staging areas within each basin.

Assumptions:

1. Includes all operational support required.

Activity	Cost ($K)	Basis of Estimate
Consolidate KE Basin floor and pit sludge in Weasel Pit	2,020	Project baseline
Consolidate KW Basin floor and pit sludge to staging location	1,480	Pending change request
K Basins operations support	850	Project baseline
Total	**4,400**	

Cost Element 3: Design/Construction of Sludge Loadout System

Scope: This activity consists of designing, procuring, installing, and testing the system that will retrieve the sludge from the staging area(s) in each basin and transfer it into the transport packages.

Assumptions:

1. To be pumpable, the slurry will contain basin water with solids at 20 volume %.

Activity	**Cost ($K)**	**Basis of Estimate**
Project management	490	Project baseline
System definition	560	Project baseline
Prepare conceptual/definitive design	1,440	Project baseline
Procure/fabricate equipment	1,510	Project baseline
Install equipment	1,570	Project baseline
Safety documentation	340	Project baseline
ATP/OTP/Start-up	170	Project baseline
Total	**6,100**	

Cost Element 4: Design/Construction of Sludge Transport System

Scope: This activity consists of designing, procuring, installing, and testing the system that will transport the sludge from the basins to the pretreatment system and from the pretreatment system to the interim storage facility in the 200 Area. This cost element is applicable to chemical treatment because it would result in a pumpable slurry following treatment. Detailed design of the transport system for the dry solids that would result from thermal treatment has not been performed. The design/construction of a transportation system for thermal treatment will cost more than shown in this cost element because it will require both a slurry transport system (such as this one) to transport the sludge to the pretreatment system and a dry transport system to transport the dry sludge to the interim storage facility. However, in the absence of other information, this cost element was also used for thermal treatment.

Assumptions:

1. Each transportation package consists of a trailer equipped with a single pressure vessel.
2. Each pressure vessel has a capacity of 6 m^3; each shipment will consist of 1.2 m^3 of sludge (on a settled solids volume basis) combined with basin water to meet pumpability requirements.
3. Transport of all the sludge will require about 60 shipments.
4. Four slurry transportation packages must be procured to meet the current 10 month transfer schedule.

Activity	**Cost ($K)**	**Basis of Estimate**
Project management	200	Project baseline
System definition	230	Project baseline
Design system	260	Project baseline
Fabricate/deliver equipment	1,270	Project baseline
ATP/OTP/Start-up	300	11% of fabrication costs
Safety documentation	160	Project baseline
Total	**2,400**	

Cost Element 5: Sludge Loadout and Transport Operations

Scope: This activity consists of operational costs associated with (1) retrieving the sludge from the staging area(s) in each basin and transferring it into transport packages, (2) transporting the packages to the pretreatment system in the 100-K Area, and (3) transporting the treated sludge using the same packages to the selected interim storage facility in the 200 Area.

Assumptions:

1. The transfer of the slurry requires 60 shipments spaced over a period of 10 months.
2. Cost of sampling treated sludge is included in Cost Element 8. Sampling costs are $2,000 per shipment.

Activity	**Cost ($K)**	**Basis of Estimate**
Loadout from KE Weasel Pit and transfers	1,100	Project baseline minus cost of sampling
Loadout from KW pit and transfers	500	Project baseline minus cost of sampling
Operations support, year 2000	720	Project baseline
Operations support, year 2001	130	Project baseline
Total	**2,400**	

Cost Element 6: Design/Construction of Pretreatment System to Meet Full TWRS Waste Acceptance Criteria

Scope: This activity consists of designing, procuring, installing, and testing the system that will pretreat the K Basins sludge to meet full acceptance criteria for interim storage in an existing DST. The pretreatment activities will be sufficient to ensure that the sludge can be stored safely in an existing DST and can later be retrieved from the DST. The acceptance criteria for interim storage of the K Basins sludge at other facilities have not been established, however, the TWRS criteria are assumed to be applicable to storage in either new tanks or storage in a modified tank at T Plant.

The chemical treatment system proposed in this scope is also anticipated to be sufficient to remove PCBs from the sludge. The only additional design/construction costs associated with chemical treatment for PCBs would be an additional $500 K in testing during design to optimize the chemical treatment to ensure adequate PCB treatment. The additional $500K is applicable to chemical treatment for PCBs.

Assumptions :

1. The chemical pretreatment system will be installed in a facility in the 100-K Area; for costing purposes, this is assumed to be the Cold Vacuum Drying facility adjacent to the K Basins.
2. Because the pretreatment will occur onsite under CERCLA, no permits are required for treatment.
3. Because of the high dose associated with the sludge, the pretreatment system will be designed with heavy shielding and substantial redundancy; process controls and operations will accommodate remote operations.
4. Emissions controls will include high-efficiency particulate air (HEPA) filters for radioactive and toxic particulates, a silver iodine reactor for gaseous iodine, a PCB collection system, and other controls determined to be necessary to meet air emissions control requirements.
5. Key DST acceptance criteria include: particle size (maximum of 50 microns), no unreacted metallic uranium, critically safe, and corrosion specifications (e.g., pH of 12 or greater, nitrite concentration of 0.011 or greater)
6. For costing purposes, it is assumed that pretreatment includes: it is assumed that pretreatment includes coarse screening (to remove debris), acid dissolution, addition of neutron absorbers, precipitation with caustic, and chemical adjustment.
7. The pretreatment system will be a batch operation.
8. T Plant acceptance criteria are not established, but will need to address issues similar to those associated with DST storage such as criticality control, gas generation and

retention, and pyrophoricity. For costing purposes, it is assumed that pretreatment for interim storage at T Plant will be the same as that for storage at an existing DST.

9. Acceptance criteria for new (standard) tanks are not established, but will need to address issues similar to those associated with DST storage such as criticality control, gas generation and retention, and pyrophoricity. For costing purposes, it is assumed that pretreatment for interim storage at new standard tank will be the same as that for storage at an existing DST.

Activity	**Cost ($K)**	**Basis of estimate**
Project management	3,500	16% of construction costs
System definition	3,900	18% of construction costs
Conceptual/definitive design	2,930	Engineering estimate
Perform testing[1]	310	Engineering estimate
Procure/fabricate equipment	13,200	Engineering estimate
Construction/installation	8,650	Engineering estimate
Safety documentation	2,080	PSAR ($50K) + PHA ($100K) + SA ($1,000K) + CSER ($50K) + Authorization Basis ($500K); 25% contingency.
ATP/OTP/Start-up	950	11% of construction costs
Total	**36,000**	

1. The cost shown is for testing relative to meeting waste acceptance criteria and applies to Alternative 2. Additional testing to demonstrate PCB treatment (Alternative 3) would increase this cost by $500K.

Cost Element 7: Design/Construct Thermal Treatment System for PCBs.

Scope: This activity consists of designing, procuring, installing, and testing the system that will thermally pretreat the K Basins sludge to remove PCBs such that the sludge is no longer TSCA-regulated. The costs are based on thermal desorption. Thermal treatment would result in a dry product that would not be appropriate for tank storage; interim storage at the CWC or T Plant is assumed.

Assumptions:

1. The thermal treatment system will be installed in a facility in the 100-K Area; for costing purposes, this is assumed to be the Cold Vacuum Drying facility adjacent to the K Basins.
2. Because the treatment will occur onsite under CERCLA, no permits are required for treatment.
3. The treatment system will be designed and shielded for remote operations.
4. The pretreatment system will be a batch operation.
5. The thermal treatment system will consist of modular units similar to the VAC*TRAX thermal desorption unit. The VAC*TRAX is being fabricated for Sandia National Laboratory at a cost of $1.8 million to treat low-level radioactive waste containing PCBs.
6. Because of the dose and fissile activity associated with the K Basins sludge, the unit will have to be modified to include substantial redundancy, heavy shielding, remote operations, etc. It will also have to include emissions controls for radioactive and toxic gases and particulate. A scaling factor of 10 is applied to the construction costs of the VAC*TRAX system to account for these requirements.
7. Treatment generates approximately 1200 pounds of PCB-contaminated carbon that designates as LLW.
8. The carbon will be disposed at the TSCA-approved LLW incinerator at Oak Ridge National Laboratory.

Activity	**Cost ($K)**	**Basis of Estimate**
Project management	2,900	16% of construction costs
System definition	3,200	18% of construction costs
Design	3,800	21% of construction costs
Construction	18,000	VAC*TRAX unit cost scaled up by a factor of 10.
Safety documentation	2,080	PSAR ($50K) + PHA ($100K) + SA ($1,000K) + CSER ($50K) + Authorization Basis ($500K); 25% contingency.
ATP/OTP/Startup	2,000	11% of construction costs
PCB secondary waste disposal	250	Rough order of magnitude
Total	**32,200**	

Cost Element 8: Sludge Pretreatment Operations

Scope: This activity consists of operational costs associated with (1) off-loading the sludge at the pretreatment system, (2) operating the pretreatment system, and (3) reloading the sludge into the transport packages. The cost also includes operational costs associated with sampling the treated sludge prior to shipment.

Assumptions:

1. The transfer of the slurry requires 60 shipments spaced over a period of 10 months.
2. A sample will be collected from each shipment and analyzed prior to transfer.
3. Each sampling event costs $2,000.
4. The treatment system will require 8 full-time employees for 1 year at a burdened cost of $120,000 per year.
5. Chemical costs are $200,000.

Activity	**Cost ($K)**	**Basis of Estimate**
Operations personnel	960	See assumptions
Chemical costs	200	See assumptions
Sampling costs	120	Project baseline
Total	**1,300**	

Cost Element 9: Design/Construction of Sludge Off-Load System.

Scope: This activity consists of designing, procuring, installing, and testing the system that will transfer the sludge from the transport package to the interim storage facility, if that interim storage facility is an existing DST. T Plant is already equipped with some remote-handled transfer capabilities; modification of these for the K Basins sludge is included in the cost to modify T Plant for K Basin sludge storage. New tanks will be designed with a built-in off-load system and storage at the CWC would not require a special off-load system.

Assumptions:

1. All metallic fuel and metal hydrides will have gone through initial oxidation.
2. The off-load system consists of the Sludge Receiving Station currently developed as part of the project baseline.

Activity	**Cost ($K)**	**Basis of Estimate**
Project management	80	Project baseline
System definition	110	Project baseline
Design	100	Project baseline
Construction modifications	630	Project baseline
ATP/OTP/Startup	70	11% of construction costs
Safety documentation and permitting	50	Rough order of magnitude
Total	**1,000**	

Cost Element 10a: Design/Construction of New Tanks

Scope: This activity consists of designing, procuring, installing, and testing new tanks that would provide segregated interim storage of the K Basins sludge. The tank system would include an off-load system to transfer the sludge from the transport package into the new tanks.

Assumptions:

1. The tanks will consist of multiple double-contained receiver tanks; the number will depend on the results of criticality control evaluations.
2. Design criteria shall be based on DOE Order 6430.1A and regulatory requirements for tank storage of dangerous waste and TSCA-regulated waste.
3. Total required tank capacity is 50,000 gallons.
4. The tanks will be situated in a below-grade vault to provide shielding.
5. The tanks will have a 25 year design life.
6. Current DST acceptance criteria and pretreatment requirements would be applied to new tanks.
7. The new tanks will be located at one of three sites: near the proposed TWRS Phase II vitrification plant (west of PUREX in the 200 East Area), near the SNF Canister Storage Building in the 200 East Area, or in the 200 West Area near other new tanks.
8. The tanks will have stand-alone instrumentation, monitoring, and control systems.
9. The tanks will be designed to accommodate off-loading the K Basins sludge from the transport packages; the off-load system will consist of double-encased pipe run above-ground from the package to the tank system.
10. The tank system will require dewatering after the slurry transfer to remove carry water; the water that is removed will be returned to the K Basins to be processed with the K Basins water.
11. The tank system will have the capability to retrieve all of the sludge (including the heel).
12. NEPA documentation shall be required for the new tanks and shall consist of an Environmental Assessment that is expected to result in a Finding of No Significant Impact rather than a determination that an EIS is required.
13. The new tanks will be permitted by interim status expansion under the existing DST Part A dangerous waste permit application.
14. Full safety documentation (PSAR, FSAR, CSER, TWRS authorization basis amendment) will be required.

Activity	**Cost ($K)**	**Basis of Estimate**
Project management	2,500	16% of total construction costs
System definition	2,800	18% of total construction costs
Tank design	2,600	Engineering estimate
Tank procurement/ fabrication	9,300	Engineering estimate
Tank construction	4,900	Engineering estimate
Off-load/retrieval system design	320	Engineering estimate
Off-load system procurement/fabrication	400	Engineering estimate
Off-load/retrieval system construction	1,200	Engineering estimate
Start up	670	11% of construction costs
Safety documentation	2,100	PSAR ($50K) + PHA ($100K) + SA ($1,000K) + CSER ($50K) + Authorization Basis ($500 K); 25% contingency
Environmental documentation	190	EA ($50K) + air emissions Notice of Construction ($50K) + DST RCRA permit modification ($50K); 25% contingency
Total	**27,000**	

Cost Element 11: Design/Construction for Modification of T Plant Tank

Scope: This activity consists of designing modifications to an existing tank in T Plant and procuring, installing, and testing the modifications that would provide segregated interim storage of the K Basins sludge.

Assumptions:

1. T Plant will be used as the Hanford site remote-handled waste processing facility.
2. An existing single-wall tank of sufficient capacity (including excess capacity to accommodate the initial transfer water) is available in T Plant.
3. Current DST acceptance criteria and pretreatment requirements would be applied to storing the K Basins sludge in the T Plant tank.
4. A new RCRA- and TSCA-compliant tank will be installed within the existing tank to provide double-contained storage. The tank will be made of stainless steel with a capacity of 250 m^3. It will have mixers to allow the tank to be stirred and mixed and to bring the sludge into a homogenous slurry that can be pumped from the tank.
5. Design criteria shall be based on DOE Order 6430.1A and regulatory requirements for tank storage of dangerous waste and TSCA-regulated waste.
6. The tank will have stand-alone instrumentation, monitoring, and control systems.
7. Some modifications will need to be made to T Plant to allow receipt of the sludge and transfer of the containers into the canyon. The extent of the modification has not been evaluated by T Plant staff. It is assumed that the transport containers can be brought through the railcar entrance and existing remote capability can be used for the majority of the transfer activities.
8. NEPA documentation shall be required for operation of the new tank and shall consist of an Environmental Assessment.
9. The modified tank will be permitted and operated in accordance with the existing T Plant Part A dangerous waste permit application.
10. Full safety documentation (PSAR, FSAR, CSER, TWRS authorization basis amendment) will be required.

Activity	Cost ($K)	Basis of Estimate
Project management	160	16% of total construction costs
System definition	180	18% of total construction costs
Tank modification design	210	21% of construction costs
Tank procurement/ fabrication	1,000	Engineering estimate
Tank construction/installation	1,000	100% of fabrication costs
Modification of existing T Plant off-loading capabilities	500	Engineering estimate assuming minimal modification required
Start up	110	11% of construction costs
Safety documentation	2,100	PSAR ($50K) + PHA ($100K) + SA ($1,000K) + CSER ($50K) + Authorization Basis ($500 K); 25% contingency
Environmental documentation	190	EA ($50K) + air emissions Notice of Construction ($50K) + Part A application modification ($50K); 25% contingency
Total	**5,400**	

Cost Element 12: Design/Construction and Operations for PCB Treatment at T Plant. This activity provides for treating the sludge in the modified tank at T plant to destroy PCBs and remove the sludge from TSCA regulation.

Assumptions:

1. A chemical treatment process that destroys PCBs and reduces the concentration of PCB in the sludge to less than 2 ppm will be used. Potential treatment methods are the addition of nitric acid or peroxide.
2. Some development and verification of the process to allow it to be applied to this sludge will be required. No new research and development will be needed.
3. Following chemical treatment the sludge will no longer be TSCA-regulated.
4. No secondary waste will be generated from the pretreatment.
5. PCB pretreatment costs will not be shared with other activities.
6. All costs shown include a 25 percent contingency.

Activity	Cost ($000)	Basis of Estimate
Project management	200	16% of process development cost
Selection and testing of process	1,300	ROM plus 25% contingency
Procurement of chemicals	50	ROM plus 25% contingency
Permitting and safety Documentation	500	ROM plus 25% contingency
Operations in T Plant	900	Two months of operations for 25% of the T Plant staff plus 25% contingency
Total	**3,000**	

Cost Element 13: Design/Construction and Operations for Treatment at T Plant to Meet WIPP Criteria. This activity includes grouting the K Basins sludge so that it will be compatible with the WIPP waste acceptance criteria.

Assumptions

1. T Plant will be used as the Hanford site remote-handled waste processing facility.
2. The sludge will be treated by immobilization (cementation or grouting) to meet criteria for free liquids.
4. An in-drum or in-canister grouting system will be used.
5. Normal chemical and material costs are included in the current costs of the operation of T Plant.
6. The K Basins sludge will be a small part of the volume of waste that will be treated in T Plant. The current projections are that the site will generate 1670 m^3 of remote-handled TRU waste over the next 35 years. Of that total volume about 400 m^3 will be particulate waste streams that could be treated in a similar mode to the K Basins sludges.
7. The cost to modify T Plant to make it the remote-handled treatment facility will cost about $66 M based on Table 5-1 of WHC-SD-WM-ES-341, Rev 0 and escalating costs by 6 percent.
8. Treatment will produce about 900 55-gallon waste drums; each remote-handled TRU canister can hold 3 drums, so shipment to the WIPP will require about 300 remote-handled TRU canisters.

Activity	Cost ($K)	Basis of Estimate
Modification to T Plant to make it the site RH treatment facility	4,100	Assume 5% of facility modification costs for KE Basin sludge (WHC-SD-WM-ES-341, Rev 0) + 25% contingency
Operations of treatment systems	18,800	50% of one year of operations of T Plant as the site remote-handled treatment facility (DOE/EM-0290)
Total	**22,900**	

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APPENDIX C

THERMAL TREATMENT OF PCBS

Three thermal treatment technologies were considered for PCB pretreatment, incineration, vitrification, and thermal desorption. A brief examination of the primary advantages and disadvantage of each technology was conducted to narrow this to one technology for further discussion in the life-cycle evaluation. This would not preclude using either of the other technologies, if thermal treatment is determined to be an appropriate path forward.

The following elements were considered in this examination:

- Evidence that the technology adequately treats PCBs
- Applicability to waste comparable to K Basins sludge
- Criticality control issues
- Pyrophoricity issues
- Operational safety concerns during pretreatment
- Requirements for downstream storage and disposal
- Flexibility in downstream storage and disposal
- Support facilities/area required to implement the technology
- Anticipated acceptance by regulators and the public.

Adequate PCB treatment. All of the technologies have successfully demonstrated the ability to meet TSCA treatment standards using full-scale operations to treat PCB-contaminated soil and/or sediments. The thermal destruction standard of 99.9999 percent destruction is applicable to incineration and vitrification; this destruction efficiency is typically a combination of combustion or pyrolization in the waste matrix and combustion in the off-gas of volatilized PCBs. Incineration has been in full-scale use for destroying organic contaminants for several decades. It has been selected for over 60 PCB-contaminated CERCLA sites (EPA 1988) and several incineration units, including a unit at the Oak Ridge National Laboratory, have received TSCA treatment permits based on the ability to meet the 99.9999 percent standard for PCBs (DOE 1996d, EPA 1997). Vitrification has been in development since the 1960s, but full-scale systems have only emerged more recently as a process to destroy organics; only one system is currently permitted under TSCA (EPA 1997). Vitrification was used to treat PCB-contaminated soil at a CERCLA site near Spokane, Washington, and achieved a 99.9999 percent destruction efficiency with feed concentrations of 17,800 ppm of PCBs (GeoSafe 1997).

The physical separation standard of less than 2 ppm per PCB congener in the final waste is applicable to thermal desorption. Several thermal desorption units have demonstrated the ability to meet that standard and have been TSCA-permitted (EPA 1993, 1997). The VAC*TRAX thermal desorption unit has demonstrated the ability to consistently reduce PCB concentrations from several hundred ppm to less than 1 ppm in the final waste matrix (Richardson 1996).

Applicability to waste comparable to K Basins sludge. Although all of the technologies have been applied to LLW, and vitrification has been applied to TRU waste, none of the technologies have been used to treat remote-handled waste. It is anticipated that using any of the technologies would require substantial redesign of existing treatment systems to provide adequate shielding and redundancy and accommodate remote operations.

The presence of other contaminants also affects applicability of the technologies. The use of incineration is often limited by the presence of heavy metals which will volatilize during incineration. Lead in particular volatilizes at most incinerator temperatures (EPA 1993). Heavy metals would not be expected to be a problem with vitrification or thermal desorption. Vitrification isolates heavy metals in the melt and the temperatures used for thermal desorption (up to 600°C) are insufficient to volatilize the metals.

All of the technologies are more effectively used on waste that has a low moisture content (EPA 1993). The K Basins sludge has a high water content (40 percent by volume). This would be considered the upper bound for effectiveness of the VAC*TRAX system (Richardson 1996); higher moisture levels would require decanting prior to treatment. Both incineration and vitrification would likely require decanting the sludge even at a water content of 40 percent for efficient operations and to avoid rapid pressurization of the off-gas system.

Criticality control. The thermal treatment process concentrates non-combustible components in the waste, thus, it would be expected that any of the thermal processes would require careful evaluation of the dynamics of the process to establish appropriate criticality control during treatment. This could require limiting batch size, adding neutron absorbers prior to treatment, designing critically-safe treatment vessels, etc..

Pyrophoricity. The K Basins sludge contains pyrophoric radionuclides in the form of metallic uranium and uranium hydrides. It is anticipated that the elevated temperatures of thermal treatment would oxidize these constituents and thus eliminate the characteristic of pyrophoricity, however, additional testing would be required to demonstrate this.

Operational safety. Safety is a significant issue in using thermal treatment systems. High temperatures reflect large amounts of stored energy and present the potential for pressurization and fire. Thermal desorption (at 600°C) is somewhat better than incineration (1,200-1,400°C) or vitrification (1,600-2,000°C) in this respect. Stationary batch vitrification might be somewhat better than incineration because the high-temperature melt is located below the ground surface.

There have been several accidents including fatalities related to incinerator operations, however, because incineration is more common than vitrification of thermal desorption, this is not necessarily indicative of relative safety. A fire occurred during a 1996 pilot test of in situ vitrification at Oak Ridge National Laboratory. The fire was caused by an upheaval of steam and molten glass on and around the collection hood that released pressurized steam and a small amount of molten glass. No personnel injuries occurred. A follow-up investigation indicated that the cause was unknown subsurface water; such an event could be avoided by characterizing the vitrification site prior to treatment.

One of the more difficult operational safety issues associated with stationary batch vitrification of K Basins sludge would be removing and packaging the vitrified sludge. Stationary batch vitrification process would result in a solidified monolith that would need to be broken up to be packaged for disposal. The monolith can be readily broken using conventional construction equipment (GeoSafe 1997), but breakup of a highly radioactive monolith would require substantially greater controls and remote handling capability both to protect workers and to prevent releases to the environment.

Requirements for downstream storage and disposal. Thermal desorption produces a dry particulate waste. When applied to a waste that is predominantly inorganic such as the K Basins slduge, incineration produces a slag-like product. Vitrification produces a solidified monolith than can be broken up and packaged in pieces. The products of incineration and vitrification would essentially be final wastes that would not be amenable to additional treatment.

It is currently assumed that because the K Basins sludge is designated as a TRU waste, that if it is managed via the Solid Waste Program it would go to the WIPP. There is some uncertainty regarding whether the WIPP would accept the sludge because it derives in part from SNF. If the sludge cannot go to the WIPP, it would have to be disposed at another location such as the national geologic repository. Waste form and packaging requirements have not been established for the repository. Any thermal treatment process that results in a final waste form would require additional development effort to ensure that it not only meets the pretreatment goals but also meets final disposal requirements. While there could be a cost-savings associated with a pretreatment method that can serve for final disposal, this would have to be balanced against the fact that the time required to ensure that incinerated or vitrified waste would meet disposal requirements could delay removal of the K Basins sludge.

Facility/area requirements. A thermal desorption unit the size of the VAC*TRAX unit could be accommodated inside the CVD. Commercial-scale incineration units require an area of 2 to 5 acres; a smaller scale unit would likely be appropriate for the K Basins sludge and would require a much smaller working area, however, it is unlikely that an incineration unit could be located inside the CVD because of the various ancillary equipment required. A batch vitrification system would require sufficient land area to construct a vitrification cell and accommodate support facilities. There is insufficient free area in close proximity to the K Basins to accommodate either an incineration unit or a vitrification cell and support facilities. Either incineration or vitrification could be performed elsewhere in the 100 Area or 200 Area, but this would take the pretreatment outside the CERCLA definition of "onsite" and thus subject them to full TSCA, air, and RCRA permitting. The schedule requirements for permitting a vitrification unit could potentially delay removal of the K Basins sludge, although this potential is less likely than with incineration because of the negative public response generally given to incinerators.

Acceptance by regulators and the public. There would likely be substantial regulator interest in thermal pretreatment in the 100-K Area because the high temperatures would result in an increased potential for radioactive and toxic emissions. The identification of appropriate controls and monitoring would require extensive consultation with the DOH (for potential radioactive emissions) and Ecology (for potential regulated and toxic emissions) and could result in delays in implementing pretreatment. It is possible that thermal treatment in the 100-K Area would not be accepted by the regulators and public; this would not preclude locating a thermal pretreatment system in the 200 Area, but would require full permitting and could result in delays. Based on the permitting experience of other incinerators in the Pacific Northwest, the schedule requirements for permitting an incinerator would be very likely to delay removal of the K Basins sludge.

In summary, the following factors particularly favor thermal desorption: (1) a thermal desorption unit could be installed inside the CVD, thus keeping treatment within the CERCLA definition of "onsite"[6] and precluding the need to obtain environmental permits, (2) the CVD would provide confinement for the treatment system, thus adding a substantial level of protection, (3) thermal desorption temperatures are substantially lower than those required for incineration or vitrification, thus reducing the potential risk inherent in stored energy systems, and (4) ease of material handling.

Incineration was not selected for more detailed evaluation because of the greater potential risk associated with higher-temperature operation and because the use of an incinerator in the 100 Area to treat sludge containing high activities of radionuclides would be unlikely to gain either regulator or public acceptance; and incinerator might be located in the 200 Area (further from Site boundaries) but then would be subject to full TSCA, air, and RCRA permitting.

The batch vitrification unit was not selected for because of the greater potential risk associated with the higher-temperature operation, land area requirements, uncertainties regarding qualification of the waste form, and difficulty in breaking up and packaging the solidified monolith.

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