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Systems Engineering Study for the Closure of Single-Shell Tanks

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Prepared for the U.S. Department of Energy
Office of Environmental Restoration and
Waste Management



Westinghouse
Hanford Company Richland, Washington

Hanford Operations and Engineering Contractor for the
U.S. Department of Energy under Contract DE-AC06-87RL10930



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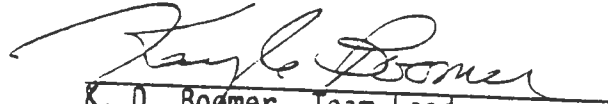
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**SYSTEMS ENGINEERING STUDY FOR THE
CLOSURE OF SINGLE-SHELL TANKS**

K. D. Boomer

ABSTRACT

This document provides the technical basis and recommended alternatives to be included in the Supplemental Environmental Impact Statement for single-shell tank closure at the U.S. Department of Energy's Hanford Site in Washington State. In preparing this document the Westinghouse Hanford Company has used systems engineering to provide a balanced approach for solving the complicated problem of single-shell tank closure.

This systems engineering study has developed several conclusions that will aid the U.S. Department of Energy in managing the single-shell tank waste. These conclusions include recommended alternatives for closure, characterization requirements, closure schedule, development requirements, facility requirements, and integration of double-shell tank and single-shell tank waste processing. The preferred alternative for single-shell tank closure will be determined in the Supplemental Environmental Impact Statement based on further evaluation of recommended alternatives.

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LIST OF TERMS

CERCLA	<i>Comprehensive Environmental Response Compensation and Liability Act of 1980</i>
D&D	decontamination and decommissioning
DHEHP	di-2-ethylhexyl phosphoric acid
DOE	U.S. Department of Energy
DOT	U.S. Department of Transportation
DQO	data quality objectives
DST	double-shell tank
Ecology	Washington State Department of Ecology
EHW	extremely hazardous waste
EIS	Environmental Impact Statement
EPA	U.S. Environmental Protection Agency
ERDA	Energy Research and Development Administration
FY	fiscal year
GTCC	greater than Class C (waste)
HDW-EIS	Hanford Defense Waste-Environmental Impact Statement
HEPA	High-Efficiency Particulate Air (Filter)
HLW	high-level waste
HVAC	heating, ventilating, and air conditioning
HWVP	Hanford Waste Vitrification Plant
ISCS	in situ chemical stabilization
ISD	in situ drying
ISV	in situ vitrification
LDR	land disposal restrictions
LLW	low-level waste
LTRR	long-term release risk
MEPAS	Multimedia Environmental Pollutant System
NCAW	neutralized current acid waste
NEPA-EIS	National Environmental Policy Act-Environmental Impact Statement
NPH	normal paraffin hydrocarbon
NRC	U.S. Nuclear Regulatory Commission
OU	operable unit
PFP	Plutonium Finishing Plant
PNL	Pacific Northwest Laboratory (formerly Battelle-Northwest)
PPU	past practice unit
PUREX	Plutonium-Uranium Extraction (Facility at Hanford Site)
RCRA	<i>Resource Conservation and Recovery Act</i>
REDOX	reduction-oxidation (process)
ROD	Record of Decision
RPP	RCRA Past Practice
SCWO	super critical water oxidation
SEIS	Supplemental Environmental Impact Statement
SREX	strontium extraction
SST	single-shell tank
STIR	short-term intruder risk
TBD	to be determined
TBP	tributyl phosphate process
TCLP	toxic characterization leach procedure
TRAC	Track RadioActive Components

LIST OF TERMS (continued)

Tri-Party Agreement	<i>Hanford Federal Facility Agreement and Consent Order</i>
TRU	transuranic (waste)
TRUEX	transuranic extraction
WAC	Washington Administrative Code
WC	waste classification
WCP	Waste Characterization Plan
WESF	Waste Encapsulation and Storage Facility
Westinghouse Hanford	Westinghouse Hanford Company
WIPP	Waste Isolation Pilot Plant
WTSOR	waste tank safety operation and remediation

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SYSTEMS ENGINEERING STUDY FOR THE CLOSURE OF SINGLE-SHELL TANKS

1.0 INTRODUCTION

This document provides the technical basis and recommended alternatives to be included in the Supplemental Environmental Impact Statement (SEIS) for single-shell tank (SST) closure. In preparing this document the Westinghouse Hanford Company (Westinghouse Hanford) has used systems engineering to provide a balanced approach for solving the complicated problem of SST closure. Two documents, *Single-Shell Tank Systems Analysis Description*, WHC-EP-0333 (Garfield 1990) and *Functional Requirements Baseline for the Closure of Single-Shell Tanks*, WHC-EP-0338 (Boomer et al. 1990) provided input to the systems engineering study.

The systems analysis description document (Garfield 1990) provides an overall description of the approach used to select alternative closure methods for further evaluation in the SEIS. The document also explains the relationship of systems engineering to other efforts associated with the SSTs. Westinghouse Hanford will update this system analysis description document periodically.

The functional requirements baseline document (Boomer et al. 1990) provides the performance criteria for defining closure technology options. The document provides requirements for each option, characterization data, regulatory requirements, facility requirements, and performance assessment requirements. Westinghouse Hanford will update the requirements document as the evaluation progresses.

Westinghouse Hanford has prepared this draft of the systems engineering study (referred to in planning efforts as the 60% Draft) for review by the National Academy of Sciences (NAS). This draft contains most of the pertinent data necessary to evaluate closure of the SSTs. Following review by the NAS and completion of analysis, the final document will be prepared and issued in early 1992.

1.1 BACKGROUND

National defense activities have generated radioactive waste since 1944 on the U.S. Department of Energy's (DOE) Hanford Site in Washington State. Liquid radioactive and chemical wastes from the nuclear material production and research activities were transferred to underground, reinforced concrete, steel-lined tanks (commonly referred to as SSTs and DSTs) for storage. The DOE and its predecessor organizations [the Manhattan Engineering District, U.S. Atomic Energy Commission (AEC), and Energy Research and Development Administration (ERDA)] discharged waste from reprocessing into the SST system from 1944 to 1971. Active use of the SSTs ceased in November 1980. Since 1980, only stabilization and isolation activities have occurred in the SSTs.

The SST system consists of 149 tanks grouped into 12 tank farms. The tanks have four different capacities:

- Sixteen tanks have a 210-m³ (55,000-gal) capacity
- Sixty tanks have a 2,000-m³ (500,000-gal) capacity
- Forty-eight tanks have a 2,900-m³ (750,000-gal) capacity
- Twenty-five tanks have a 3,800-m³ (1,000,000-gal) capacity.

The U.S. Army Corps of Engineers built the first SSTs in 1943 as part of the Manhattan Project. The AEC built the last SSTs in 1964. Since then, the ERDA and DOE have built 28 double-shell tanks (DST) to store waste.

1.1.1 Hanford Defense Waste Environmental Impact Statement

The DOE addressed disposition of SST waste (and other radioactive waste at the Hanford Site) in a series of documents that culminated with the *Final Environmental Impact Statement-Disposal of Hanford Defense High-Level, Transuranic and Tank Wastes, Hanford Site, Richland, Washington* [also known as the *Hanford Defense Waste Environmental Impact Statement (HDW-EIS)* (DOE 1987)]. The HDW-EIS Record of Decision (ROD) (DOE 1988b) presented the following five alternatives concerning the SSTs:

- Geologic Disposal Alternative--Retrieve, separate, process, package and transport to dispose of most of the SST waste in a geologic repository.
- In-Place Stabilization and Disposal Alternative--Dispose of SST waste in place, including dome filling and using a protective barrier and marker system. Waste processing will be limited to liquid removal. Some SSTs require interim heat removal capability.
- Reference Alternative--The reference alternative is identical to the In-Place Stabilization and Disposal Alternative.
- Preferred Alternative--Defer decisions on disposal of waste in the SSTs until additional development and evaluation are complete. In the interim, DOE will continue storage and maintenance of the SST wastes.
- No-Disposal-Action Alternative--Continue to store the waste in the existing tanks. The SSTs will be monitored and maintained. Ongoing activities, such as reduction of liquids in the SSTs, will continue. This case was analyzed in accordance with the requirements of the Council on Environmental Quality-*National Environmental Policy Act of 1969* (NEPA).

The DOE selected the preferred alternative and committed to conducting additional development and evaluation before making a final decision on disposal of the SST wastes. This additional development and evaluation includes the following:

1. Characterize radioactive and chemical waste constituents.
2. Demonstrate barrier performance by both instrumented field tests and modeling.
3. Determine the need and methods for improving the stability of the waste form.
4. Determine the need and methods for destroying and stabilizing hazardous waste constituents.
5. Develop and evaluate methods for retrieving, processing and disposing of the wastes.

The final HDW-EIS ROD commits to the preparation of a Supplemental Environmental Impact Statement (SEIS) for the SST waste at the Hanford Site. This systems engineering study initiates the analysis to prepare the SEIS of SSTs by evaluating technical options for taking care of the SST waste. The systems engineering study combines these options into alternatives for evaluation in the SEIS.

1.1.2 Hanford Federal Facility Agreement and Consent Order

Since completion of the draft HDW-EIS (DOE 1987) the regulation of the SSTs has changed. In May 1987, DOE issued a final rule stating that the hazardous waste components of DOE radioactive waste that are defined as hazardous waste under the *Resource Conservation and Recovery Act of 1976* (RCRA) are subject to the RCRA regulations. In November 1987, the U.S. Environmental Protection Agency (EPA) authorized the Washington State Department of Ecology (Ecology) to regulate mixed wastes within the state. Consequently, the SST wastes are jointly regulated by DOE (radioactive constituents), and the EPA and Ecology (hazardous chemical constituents). The final HDW-EIS was issued in December 1987 with the ROD issued in April 1988 (DOE 1988b).

To manage the hazardous waste at the Hanford Site, the DOE has entered into the *Hanford Federal Facility Agreement and Consent Order* [referred to as the Tri-Party Agreement (Ecology et al. 1990)]. The agreement provides for oversight of environmental restoration by the EPA and Ecology. The Tri-Party Agreement (Ecology et al. 1990) also provides a time line and methodology for remediating the Hanford Site.

Production operations at the Hanford Site have produced about 1,150 waste management units. These waste units have been grouped into 78 operable units (including four groundwater units) to assist in the management of final disposal activities. The SST system makes up the six operable units (listed below) that include SSTs, diversion boxes, catch tanks, contaminated soil from

spills, crib, valve pits, vaults, and septic tanks. Appendix C of the Tri-Party Agreement (Ecology et al. 1990) provides a complete description of these operable units.

- | | |
|--|---|
| <p>1. 200-BP-7
 241-B Tank Farm (16 tanks)
 241-BX Tank Farm (12 tanks)
 241-BY Tank Farm (12 tanks)</p> | <p>4. 200-TP-5
 241-TX Tank Farm (18 tanks)
 241-TY Tank Farm (6 tanks)</p> |
| <p>2. 200-PO-3
 241-A Tank Farm (6 tanks)
 241-AX Tank Farm (4 tanks)
 241-C Tank Farm (16 tanks)</p> | <p>5. 200-TP-6
 241-T Tank Farm (16 tanks)</p> |
| <p>3. 200-RO-4
 241-S Tank Farm (12 tanks)
 241-SX Tank Farm (15 tanks)</p> | <p>6. 200-UP-3
 241-U Tank Farm (16 tanks)</p> |

The Tri-Party Agreement (Ecology et al. 1990) subdivides elements of the six SST operable units into treatment, storage, and disposal (TSD) facilities and RCRA past practice units (PPUs). The SST TSD facilities consist of the tanks, currently associated piping, and soils contaminated by leaks from 66 SSTs. The PPU's include diversion boxes, a crib, a french drain, several septic tanks, double-contained receiver tanks, all unplanned releases, and all pipes and contaminated soil around and under these PPU's.

The TSD facilities require closure under the requirements of RCRA. The PPU's under RCRA require remediation of any contamination comparable to the requirements under the *Comprehensive Environmental Response, Compensation, and Liability Act of 1980* (CERCLA). The Tri-Party Agreement (Ecology et al. 1990) calls for the release of the draft SEIS in the year 2002 with final closure of the SST operable units by June 2018.

Several cribs and trenches received discharges from cascade SST operations. These cribs and trenches received waste from the last of three 22.86-m (75-ft) SSTs in a series. These waste management units are included in other operable units and are not covered by this analysis. Separate remedial investigation and feasibility study work plans are being developed for these waste units.

Interim management activities for the Hanford Site SST operable units will continue until implementation of the actions required for final closure and waste disposal. These interim activities include characterization of the tank wastes, soil, groundwater and ancillary equipment; stabilization to reduce the volume of liquids contained in the waste solids; surveillance to detect leaks, liquid intrusion, and changes in the radiological status of the contaminated solids; heat management to prevent excessive tank temperatures; tank isolation (i.e., sealing the tank piping and openings) to deter liquid intrusion; and monitoring of the groundwater for radionuclides and chemicals.

1.2 SYSTEMS ENGINEERING

Systems engineering (also referred to as systems analysis) views a task in its entirety to formulate an optimal course of action that addresses all of the factors necessary to manage a complex problem like closure of the SSTs. It is inherently an iterative process in the early stages of the program because of uncertainties about needed development data, waste characterization, and regulatory requirements. A structured analysis of all the available alternatives provides focus for the development work and an opportunity for dialogue among the DOE, Ecology, other federal agencies, the public, and Westinghouse Hanford.

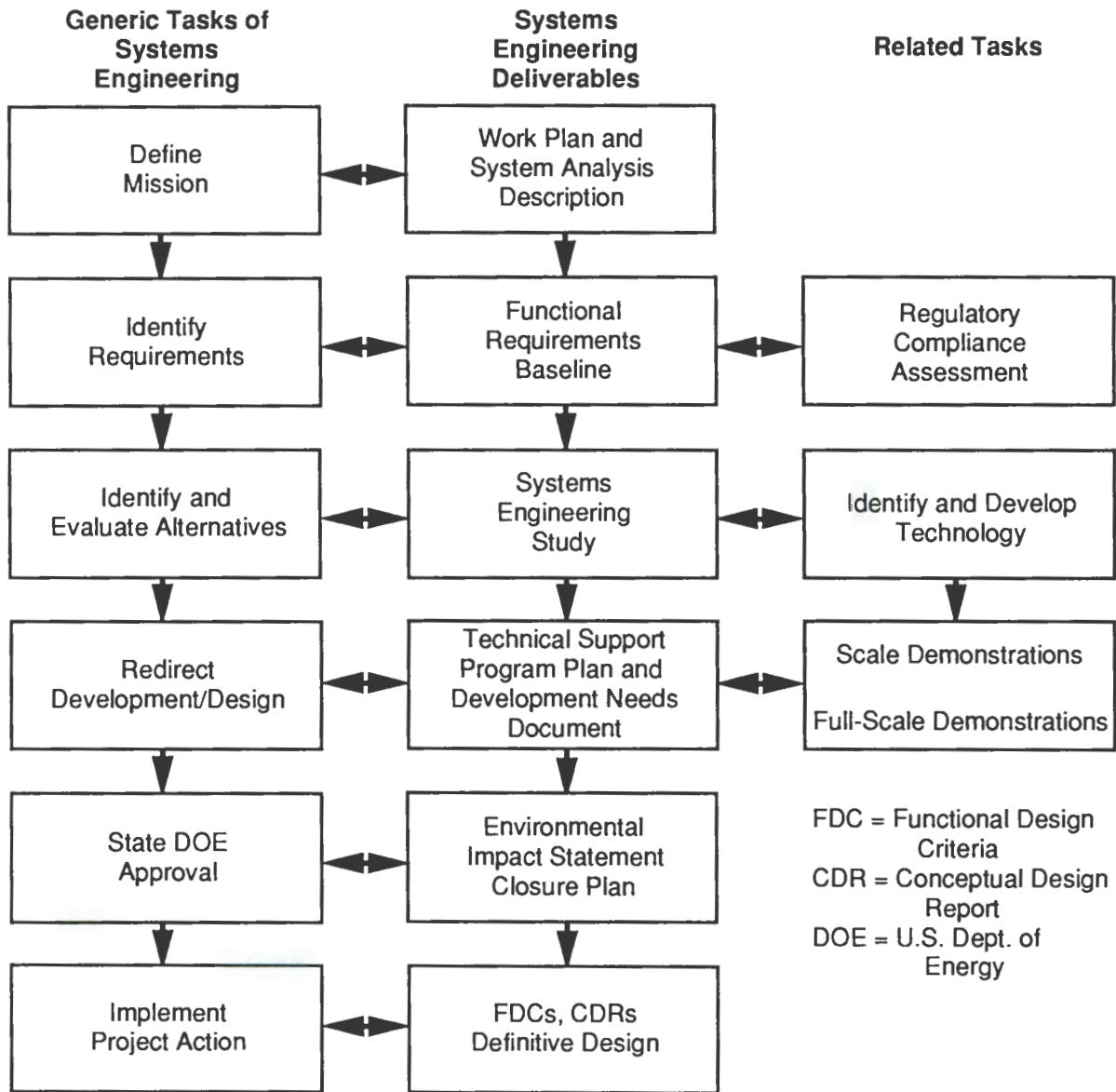
Westinghouse Hanford will use the systems engineering approach until final disposition of the SST system has occurred. The systems analysis description (Garfield 1990) provides a complete discussion of this approach and interaction with other programs. This approach will support the SEIS decision making process of the final closure scenarios in the SEIS ROD and be approved in accordance with the RCRA closure plan by Ecology. Systems engineering will include the following components:

- Define the mission and goals
- Define the public participation plan
- Identify functional requirements for the major elements of the system
- Identify alternatives available to complete the mission
- Evaluate alternatives for configuration and design of the system
- Select alternatives to be included in the SEIS for further evaluation based on objective comparison
- Document the recommendation in the draft environmental impact statement (EIS).

Figure 1-1 depicts the relationship among the system engineering tasks, specific deliverables, and other related tasks. The Tri-Party Agreement (Ecology et al. 1990) provided the mission and goals for the closure of the SST system. Figure 1-2 shows the relationship between public acceptance and the technical aspects of SST closure. The functional requirements baseline (Boomer et al. 1990) completed the second step and a portion of the third step. The systems engineering study completes the third step. Future documents will complete the remaining steps.

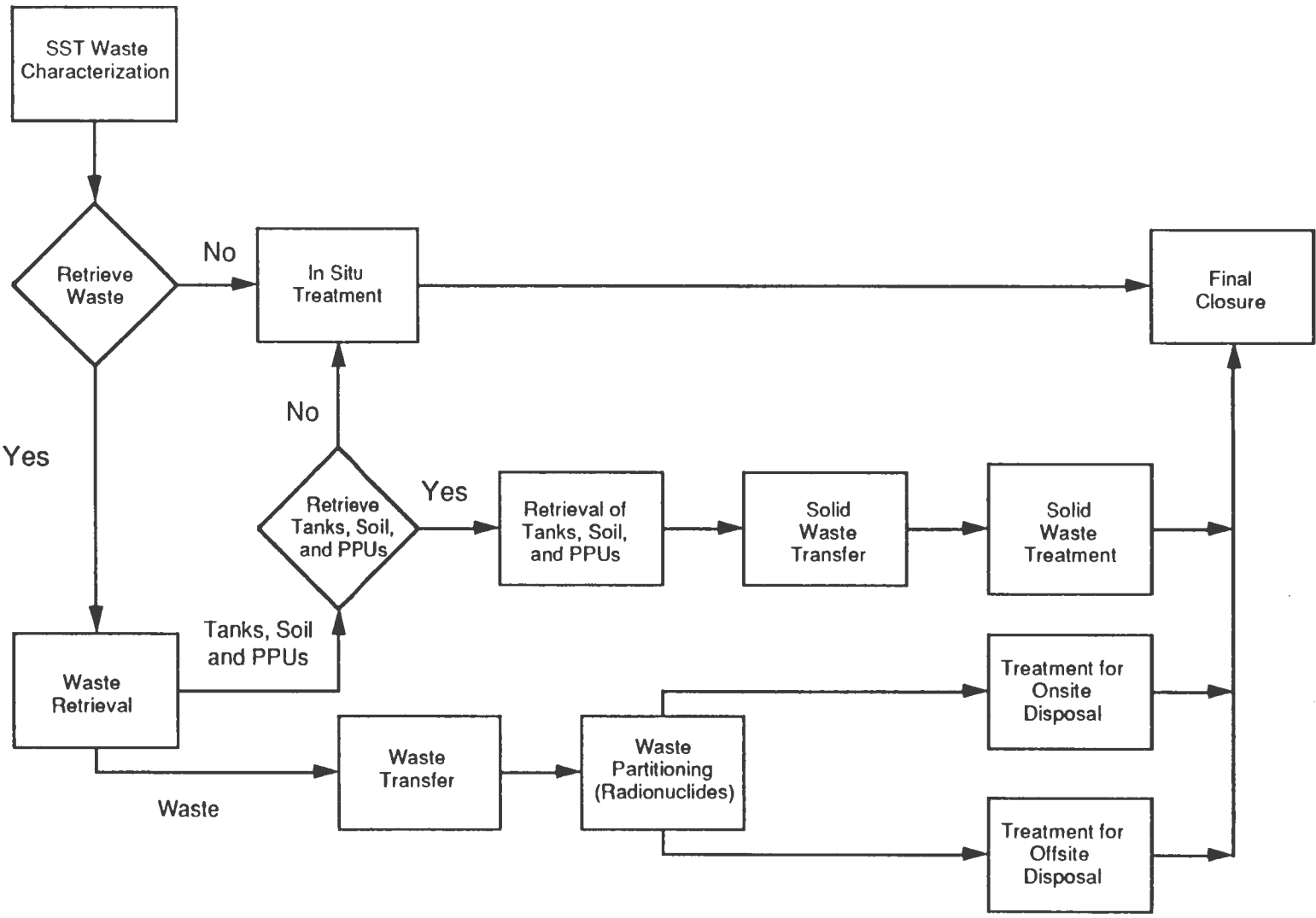
The iterative nature of systems engineering does not allow inclusion of the second and third steps entirely into either the functional requirements baseline or the engineering study. The process of identifying functional requirements must take into account feasible alternatives. The functional requirements baseline had to evaluate alternative concepts as a starting point for developing functional requirements. Further analysis of a concept during an engineering study no doubt will produce additional functional requirements. Thus, as the engineering study progresses, functional requirements will be

Figure 1-1. Systems Engineering.



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Figure 1-2. Single-Shell Tank Closure Functions.



SST = Single-Shell Tank
PPU = Past Practice Unit

added to the functional requirements baseline document. Additionally, the baseline authors have included material appropriate for the engineering study in the baseline so that current understanding of the issues would be in one document until the engineering study becomes available.

At completion of the engineering study, Westinghouse Hanford will know the relative cost and risks associated with each potential option. Parties of the Tri-Party Agreement (Ecology et al. 1990) can select a single option or multiple options for further analysis. These options will be included in the *Draft Single-Shell System Closure/Corrective Action Work Plan* (DOE/RL 89). The functional requirements will be updated at that time.

1.2.1 Mission Statement

The SST disposal program mission is as follows:

The overall mission of the SST disposal program is to develop, evaluate and implement methods for ultimate disposal of the SST operable units, in compliance with the applicable regulations, standards, and permit requirements. The disposal methods must prevent significant adverse impact to the biosphere, protect the long-term health and safety of the general public, and maintain worker exposure to 'as low as reasonably achievable' (ALARA).

1.2.2 Public Acceptance

Public acceptance is an important factor in selecting the final alternative for the disposal of the SSTs at the Hanford Site. The DOE will seek public input in the decision-making process and will include public involvement activities in addition to those required by NEPA. Appendix A, Section A.1 provides the public participation plan.

The DOE recognizes that acquiring public input throughout this process is the best way to ensure the ultimate selection of an alternative that will be acceptable to the public and technical community, and to expend limited resources in the most efficient manner. Each alternative for cleaning up the SSTs requires time, money, and radiological risk. Public input will help determine a preferred alternative that best balances worker and general public radiation exposure, environmental impacts, and cost.

Public acceptance activities first will seek to create a base of understanding concerning the SST closure process to allow the public the best opportunity to comment in a knowledgeable and meaningful manner on the SST disposal issues. Public acceptance activities will include developing and coordinating a meaningful public consensus on the best alternative for disposing of the SST waste and tanks.

Input will be solicited from the general public on a national, state, regional, and local basis. Experience shows that certain audiences are most likely to participate. Those individuals or groups that have shown a prior

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interest will be targeted for participation in this process by direct mailings or personal contact. These groups include, but are not limited to the following:

- Nuclear utilities
- Repository officials, including Nevada community and state officials
- Transportation corridor states and communities
- Hanford Defense Waste EIS distribution list
- Northwest Citizens Forum on Defense Waste
- Members of the public registered for Hanford Site information at Tri-Party Agreement (Ecology et al. 1990) and Five-Year Plan (DOE-RL 1990) meetings
- Federal, state, and local government officials including congressional officials, the Nuclear Waste Advisory Council, Hanford Advisory Committee members, and tribal representatives
- Special interest environmental groups
- Media
- Members of the technical community.

The input of the general public also will be solicited through mass media avenues and presentations to audiences such as academic groups, service and civic groups, political groups such as the League of Women Voters, economic development groups, labor unions, nuclear groups, citizen groups, and agricultural groups.

The public participation activities will broaden throughout the NEPA process and could include such things as focus groups and a citizens' forum. These activities would be in addition to hearings and other activities required for the NEPA process. The following specific activities will be initiated in coordination with the release of this study:

- Distribution of a summary, in layman's terms, of this study to interested groups and individuals, and available to the general public
- Workshops for the public to discuss the alternatives
- A Speaker's Bureau presentation on the study for interested groups
- Information for the media.

Comments from the public will be used to narrow the alternatives for further study. Public input at this time will help DOE officials make decisions on future research and development activities and assist in the preparation of the SEIS on the disposition of the SSTs.

1.2.3 Functions

Various efforts have defined the functions associated with closure of the SSTs. Pacific Northwest Laboratory (PNL) conducted the latest evaluation (Aitken et al. 1990) before Westinghouse Hanford's systems engineering study. The systems engineering study reviewed the Aitken study and drew applicable information from it. As part of the Westinghouse Hanford's systems engineering effort, functions were developed independently. These functions are shown in Figure 1-2 and come from analysis presented by Garfield (1990). Appendix A contains a description of how the functions were defined.

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National Environmental Policy Act of 1969, Public Law, 42 USC 4321 et seq.

Resource Conservation and Recovery Act of 1976, Public Law 94-580, 90 Stat. 2795, 42 USC 6901 et seq.

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2.0 SUMMARY AND CONCLUSIONS

This systems engineering study evaluates technical options for SST closure, supports the NEPA/EIS decision making process, and recommends an integrated alternative for closure. The closure involves accomplishing the functions identified in Section 1.0, Figure 1-2. Technology options were identified and evaluated to accomplish each function, shown in Figure 2-1. These options were combined into 16 integrated alternatives shown in Table 2-1. The integrated alternatives provide for the use of each technology option at least once.

2.1 SUMMARY

Closure of the SST operable units addresses the SSTs, waste, and ancillary equipment associated with the tank farms. The study develops technology options for either an in situ disposal or retrieval and disposal options for all systems. Figure 2-1 shows the logic and technology options involved in closure of the SSTs. Diamonds represent decisions required in the process and blocks represent technology options.

The option(s) selected for closure of the SSTs must provide the best overall disposition of the SST and waste. Regulations provide a framework for pursuing all of the action options shown in Figure 2-1. The no-action option provides the baseline for comparing other alternatives, as required by the NEPA regulations.

The retrieval decision will depend on the contents of the SSTs, the risks involved by the proposed closure, and the benefits derived from retrieval. If in situ disposal can provide adequate safeguards for the public and the environment, the need for waste retrieval will diminish.

Figure 2-2 shows cost and relative environmental releases for integrated alternatives. Alternatives 4 and 16, with the best cost and performance (shown in the lower-left corner), use in situ vitrification (ISV). Alternative 4 uses ISV to treat all of the waste in place. Alternative 16 retrieves some of the waste and then uses ISV for the empty tanks and remaining waste.

Initial characterization of the SST waste (Phase I) is scheduled for completion by September 1998. Phase II characterization work will follow Phase I and will provide more extensive characterization of tank waste. The processes developed during this study use the waste characteristics identified in the Track RadioActive Components (TRAC) computer code and process knowledge.

Both in situ disposal and waste retrieval consider options for 'clean' closure of the SSTs and closure of the SSTs as landfills, in compliance with the hazardous waste regulations. In situ disposal does not partition the radioactive waste, but may use treatments to remove or reduce the hazardous chemical inventory. Retrieval of the waste allows partitioning of the

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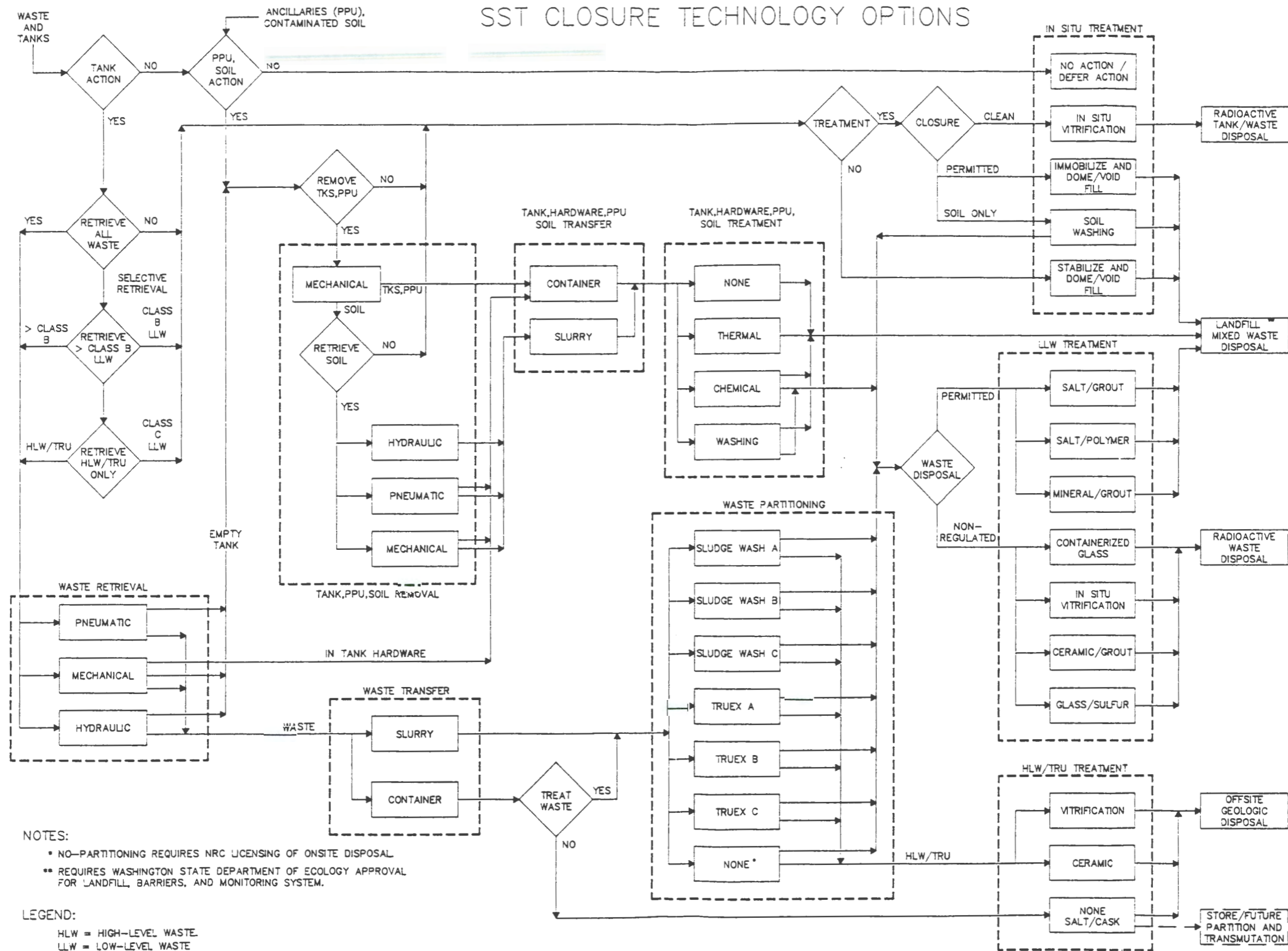
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Table 2-1. Integrated Single-Shell Tank Closure Alternatives.

ALTERNATIVE	RETRIEVAL TECHNOLOGY		WASTE TREATMENT TECHNOLOGY				TANK FARM CLOSURE		
	WASTE RETRIEVAL	WASTE TRANSFER	IN SITU TREATMENT	RETRIEVED WASTE TREATMENT			TREATMENT TECHNOLOGY		
				PARTITION	LLW	TRU/HLW	TANK	SOIL	PAST PRACTICE UNITS
<u>DEFERRED ACTION</u>									
1			CONTINUED STORAGE						
<u>IN SITU ALTERNATIVES</u>									
2			STABILIZE				DOME FILL	BARRIER ONLY	STABILIZE
3			IMMOBILIZE				GROUT FILL	IN SITU IMMOBILIZE	IMMOBILIZE
4			IN SITU VITRIFICATION				IN SITU VITRIFICATION	IN SITU VITRIFICATION	IN SITU VITRIFICATION
<u>RETRIEVE AND TREAT ALTERNATIVES</u>									
5	HYDRAULIC/DECON	SLURRY		TRUEX C	SALT/GROUT	VITRIFICATION	GROUT FILL	IN SITU WASH/IMMOBILIZE	DECON/STABILIZE
6	MECHANICAL	SLURRY		SLUDGE WASH C	MINERAL/GROUT	VITRIFICATION	REMOVE/IMMOBILIZE	REMOVE/IMMOBILIZE	REMOVE/IMMOBILIZE
7	PNEUMATIC	SLURRY		TRUEX B	SALT/POLYMER	VITRIFICATION	GROUT FILL	IN SITU IMMOBILIZE	IMMOBILIZE
8	MECHANICAL/DECON	SLURRY		SLUDGE WASH B	CERAMIC/GROUT	HIP CERAMIC	DOME FILL	BARRIER ONLY	STABILIZE
9	PNEUMATIC/DECON	SLURRY		TRUEX A	GLASS/SULFUR	VITRIFICATION	DOME FILL	IN SITU WASH	DECON/STABILIZE
10	MECHANICAL	CASK		SLUDGE WASH A	GLASS/CONTAINER	VITRIFICATION	REMOVE/DECON	REMOVE/CHEMICAL	REMOVE/DECON
11	HYDRAULIC	SLURRY		TRUEX A	IN SITU VITRIFICATION	VITRIFICATION	IN SITU VITRIFICATION	IN SITU WASH	DECON/STABILIZE
12	MECHANICAL	CASK		NONE		NONE-SALT/CASK	REMOVE/LANDFILL	REMOVE/LANDFILL	REMOVE/LANDFILL
13	PNEUMATIC	CASK		NONE		VITRIFICATION	REMOVE/THERMAL	REMOVE/THERMAL	REMOVE/THERMAL
14	HYDRAULIC	SLURRY		NONE		CERAMIC PELLETS	REM/DECON/IMMOBILIZE	REM/DECON/IMMOBILIZE	REM/DECON/IMMOBILIZE
<u>SELECTIVE RETRIEVAL ALTERNATIVES</u>									
15	MECHANICAL	CASK	STABILIZE	TRUEX A	SALT/GROUT	VITRIFICATION	DOME FILL	BARRIER ONLY	STABILIZE
16	PNEUMATIC	SLURRY	IN SITU VITRIFICATION	TRUEX A	IN SITU VITRIFICATION	VITRIFICATION	IN SITU VITRIFICATION	IN SITU VITRIFICATION	DECON/STABILIZE

SST CLOSURE TECHNOLOGY OPTIONS



NOTES:

- * NO-PARTITIONING REQUIRES NRC LICENSING OF ONSITE DISPOSAL
- ** REQUIRES WASHINGTON STATE DEPARTMENT OF ECOLOGY APPROVAL FOR LANDFILL, BARRIERS, AND MONITORING SYSTEM.

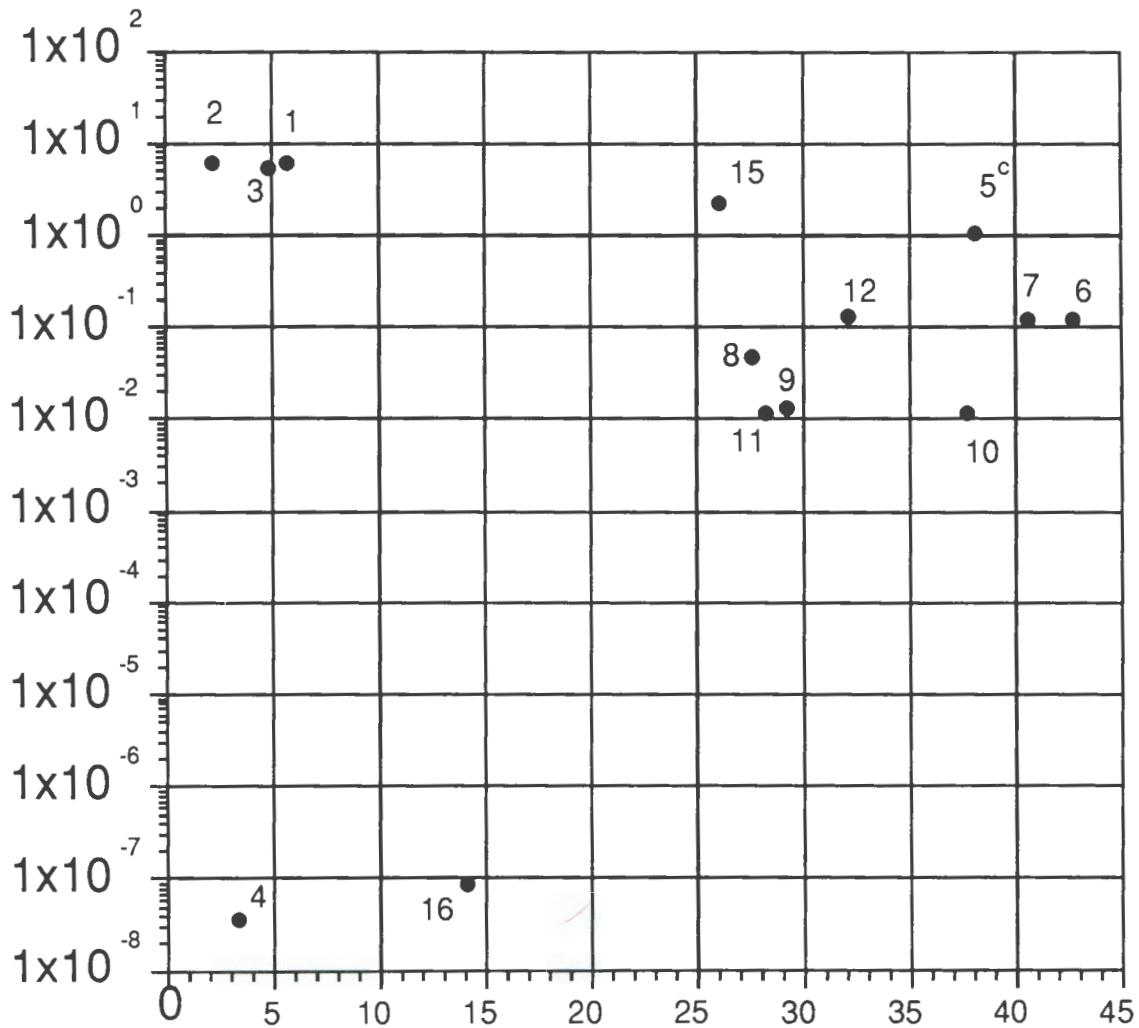
LEGEND:

- HLW = HIGH-LEVEL WASTE
- LLW = LOW-LEVEL WASTE
- PPU = PAST-PRACTICE UNIT
- TRU = TRANSURANIC

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Figure 2-1. Single-Shell Tank System Closure Technology Options.

Figure 2-2. Cost and Environmental Releases for Integrated Alternatives.^{a,b}



^aIdentification number next to data point corresponds to Table 2-1 integrated alternatives.

^bIntegrated Alternatives 13 and 14 greater than \$100 billion.

^cSummed fractions of allowable groundwater concentration limits will be (approximately a factor of 10) lower when vapor diffusion barrier is incorporated into model for Integrated Alternative 5.

radioactive waste into a low-level waste (LLW) fraction and a high-level waste (HLW) and/or transuranic (TRU) waste fraction. Both fractions are mixed waste with the bulk of the hazardous chemicals being in the LLW fraction. After partitioning, the waste fractions are treated to a leach-resistant waste form before disposal.

The SSTs contain TRU, low-level, and high-level mixed waste. The radionuclides in the SSTs come from the reprocessing of irradiated fuel. The Nuclear Regulatory Commission (NRC) identifies this type of waste as HLW. However, because the waste has been treated and contains only a fraction of the original curie content, the waste may qualify as incidental LLW. If the NRC determines that the SSTs contain HLW, the in situ disposal of SST would require licensing by the NRC.

In addition to a total in situ disposal or retrieval decision, a preliminary methodology has been developed for selective retrieval alternatives based on the NRC's risk-based, commercial LLW classifications. Although the DOE does not use the NRC's commercial LLW classes, this methodology provided a framework to identify quantifiable risk levels for radionuclide retrieval. The NRC definitions of Class B, Class C, and greater than Class C (GTCC) waste provide the major decision points in this methodology. The GTCC case corresponds to in situ treatment and disposal of all the SST waste. The Class C cases include in situ treatment and disposal of all the SST waste and selective retrieval and treatment. The Class B case includes selective retrieval and treatment.

2.1.1 Characterization of Single-Shell Tank Waste

The SSTs contain neutralized waste from fuel reprocessing. The main activity remaining in the SSTs comes from ^{137}Cs (10 MCi at the end of stabilization) and ^{90}Sr (47 MCi), and their decay daughters. In addition the SSTs contain from 52 to 70 KCi of TRU isotopes.

The SSTs contain 240,000 Metric Tons of chemical waste as salt cake and sludge. Sodium nitrate makes up 93 wt% of the tank waste. The salt cake consists almost entirely of NaNO_3 , NaNO_2 , NaOH , and NaAlO_2 . The sludge consists of metal oxides and hydroxides that precipitated out of the waste solution during neutralization.

The processes selected in this study for retrieval and treatment alternatives do not depend on a more detailed analysis of the SST waste. Leave options defined in the HDW-EIS (DOE 1987) require the current characterization program. Retrieval and treatment processes selected can accommodate several orders of magnitude variation in process stream concentration. If particular components in a stream require additional processing, operations will be added to the design basis through the redefined functional requirements baseline.

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2.1.2 Technology Options

Technology options fall into two broad categories: retrieval and in situ. These two types of options are combined in the integrated alternatives, but first are discussed singularly as methods for dealing with all of the waste. Both categories develop methods to treat the waste to a leach-resistant waste form. The integrated alternatives technologies are applied to the fraction of waste for which they are best suited.

2.1.2.1 Retrieval Technology Options. Closure of the tanks using retrieval requires an extensive processing complex to dispose of the retrieved waste. This complex consists of elements for retrieval, transfer, waste receipt and storage, partitioning, and treatment for disposal. Because the retrieved waste is a mixed waste, at least part of the processing complex would be designed to handle mixed waste.

Waste retrieval could occur with a hydraulic, mechanical, or pneumatic system. A hydraulic system (sluicing) injects liquid into the tank to dislodge and dissolve the waste. Pumps transfer the liquid and waste out of the tank. Mechanical and pneumatic systems position the waste recovery equipment in contact with the waste. This equipment conditions and transfers the waste out of the tank. Major liquid additions to support sluicing are restricted because some of the tanks leak.

Mechanical retrieval of the waste from the SSTs would require removal of both the waste and in-tank equipment. The retrieval equipment must remove the in-tank equipment because the in-tank equipment could interfere with waste retrieval. The retrieval system selected must account for a variety of mechanical properties of the waste that would affect the efficiency of retrieval.

Waste transfer moves all waste and equipment to be removed from the tanks. The decision on waste transfer equipment depends on the volume of SST waste recovered. The benefits of slurry transfer would dominate at higher volumes. At small volumes, cask transfer avoids the high construction cost of a slurry pipeline.

This study examines six partitioning process options: Sludge Wash A, Sludge Wash B, Sludge Wash C, TRUEX A, TRUEX B, and TRUEX C. These process options provide increasing recovery of radionuclides from the waste. The Sludge Wash A option accomplishes the least amount of partitioning by separating salt cake and sludge. The Sludge Wash C and TRUEX C options accomplish the greatest amount of partitioning. Figure 2-3 shows the process steps used for each option.

The waste treatment selected for onsite disposal depends on the partitioning option used and the barriers installed. The following are seven treatment technology options for onsite disposal of waste:

1. Salt disposed of in a grout
2. Salt disposed of in a polymer

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3. Denitrated salt waste disposed of in grout
4. Vitrified waste disposed of in a container
5. In situ vitrification of retrieved waste
6. Waste in ceramic pellets placed in a grout matrix
7. Waste in glass shards placed in a sulfur cement.

These options were selected from known radioactive and chemical waste treatments. The logic for selection is provided in Chapter 7.0. Figure 2-4 shows the process steps involved in these treatments.

The offsite waste treatments allow for disposal of the HLW and/or TRU waste fraction in a deep geologic repository. Use of borosilicate glass and tailored ceramic as treatments for HLW are considered in this document. After processing at the Hanford Site, this fraction will comply with the waste form criteria for repository acceptance and transportation. Figure 2-5 shows the process steps involved in each treatment.

Closure requires further work on the tanks and ancillary equipment after waste retrieval. If any wastes or contaminated soils remain after retrieval, RCRA regulations require the SST system closure as a landfill. Complete removal of tanks and contaminated soils or application of ISV to the empty tanks and contaminated soils may provide an approved closure method not requiring the RCRA barriers and monitoring. If these options prove impractical, barriers and monitoring are necessary for closure as a landfill.

2.1.2.2 In Situ Disposal Technology Options. In situ disposal considers three options for closure of the tank farms: stabilization, chemical stabilization, and vitrification. Stabilization and in situ chemical stabilization require closure of the tank farms as a mixed waste landfill. Chemical stabilization reduces the hazard of the chemical waste in the tanks. Closure of the tank farms as a regulated RCRA landfill or unregulated LLW disposal requires negotiation with the regulators.

In situ vitrification chemically treats the waste and may allow closure of the tank farms as a nonhazardous radioactive waste site subject to sampling and verification. Vitrification may allow deregulation because all hazardous chemicals in the tank either become fixed in the glass ceramic matrix, decompose, or volatilize during vitrification subject to sampling and verification by regulatory agencies.

2.1.2.3 Facilities for Closure. Facilities used for all options require compliance with DOE and/or hazardous waste facility requirements. The requirements address construction of new facilities and the use of existing facilities [i.e., the B Plant and the Plutonium-Uranium Extraction (PUREX) Plant]. Design requirements for these facilities generally fall into four categories: structural, effluent control, safety classifications, and regulatory compliance.

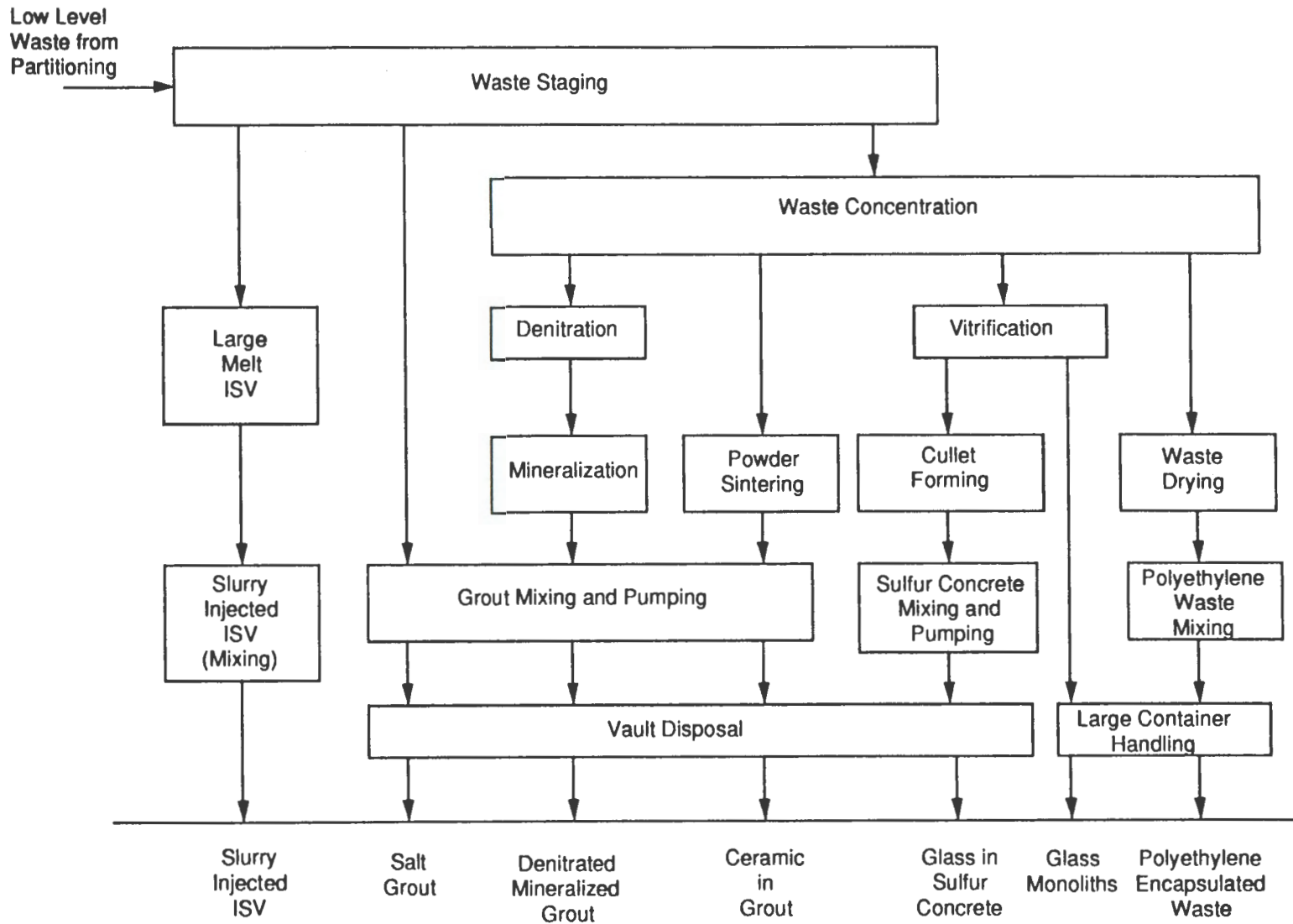


Figure 2-4. Onsite Treatment.

HL/TRU WASTE TREATMENT FOR OFF SITE DISPOSAL

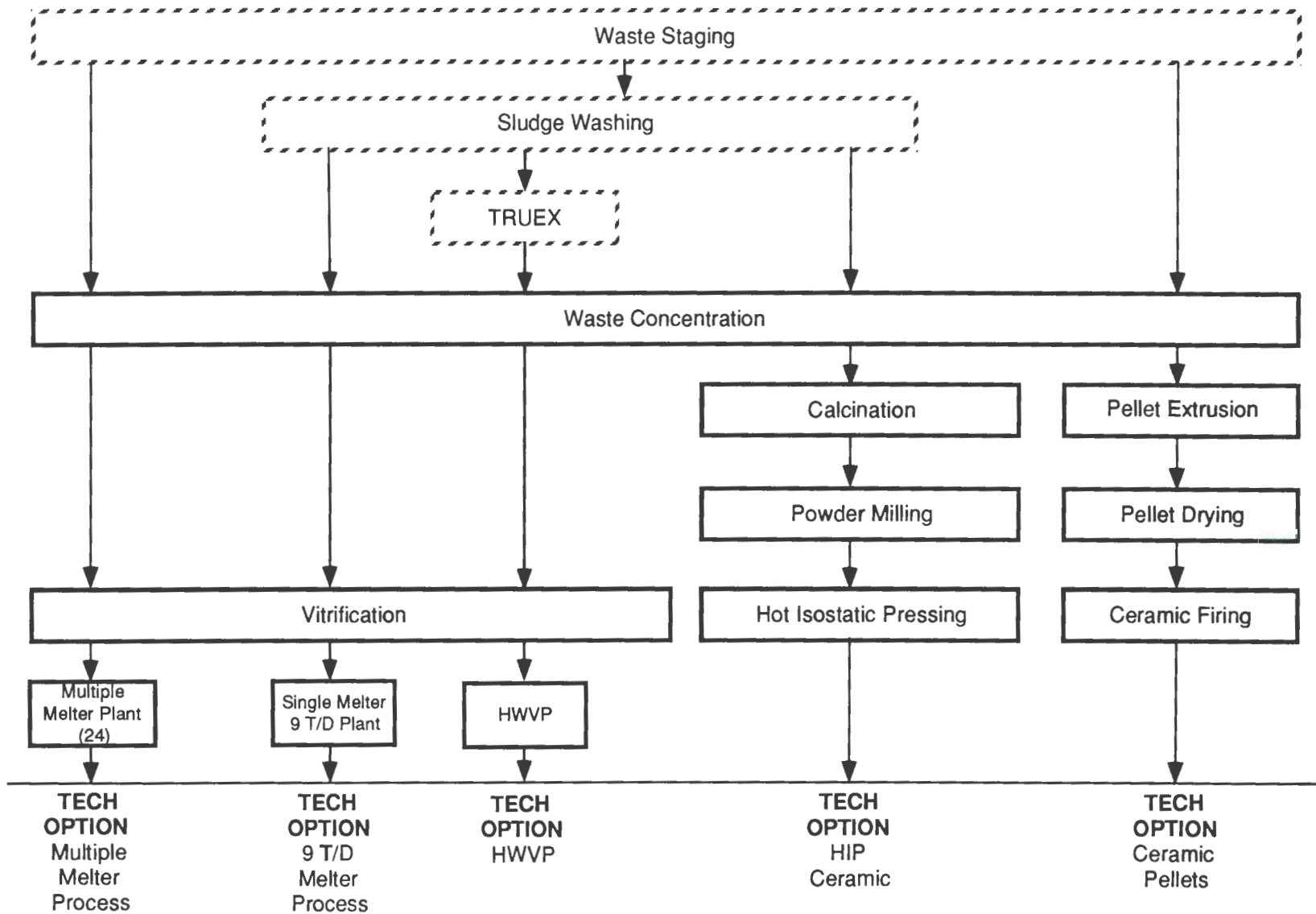


Figure 2-5. Offsite Treatment.

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2.1.3 Integrated Alternatives

Technology options are combined into integrated alternatives for SST closure. The large number of potential combinations of closure alternatives (derived by simply evaluating all of the technology options) requires selection of integrated alternatives. The selected sets of integrated alternatives provide one or more applications of each technology option.

Chapter 4.0 contains a preliminary evaluation and description of the integrated alternatives. The alternatives were rated in seven categories with weights as shown in Table 2-2.

Table 2-2. Evaluation Criteria and Assigned Weights.

Evaluation criteria	Weight
Public acceptance	1
Environmental release	2
Regulatory compliance	2
Occupational safety	1
Technical feasibility	1
Schedule compatibility	1
Costs	2

Each alternative has received ratings from 1 (Poor) to 5 (Excellent) in each category. Alternatives were compared using two methods: sum and product. Both methods multiplied the rating by the weights assigned. The sum method adds these results to give the final score. The product method multiplies these results to get the final score.

The results of evaluating the integrated SST closure alternatives can be summarized (see Table 2-3) by discussing three groups of alternatives.

Table 2-3. Alternatives Grouping.

Group	Normalized sum	Normalized product	Integrated alternatives
1	<68	<1	1, 12
2	68 to 86	1 to 15	2, 3, 5, 6, 7, 8, 10, 13, 14, 15
3	>86	>15	4, 9, 11, 16

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Group 1 alternatives defer or dispose of untreated SST waste as a mixture of soluble salts and sludge. These alternatives may be unacceptable to the public for long-term closure. Alternative 1 is not proposed as a closure method; it is included as a reference for comparison. Alternative 12 may be unacceptable to the public because it merely transports the untreated waste to another state for disposal in a new geologic repository.

Group 2 alternatives represent the middle ground of alternatives with higher release rate waste forms for onsite disposal and intensive retrieval and treatment operations resulting in higher chronic releases, higher personnel exposure, higher accident potential, higher technical development risk, and higher costs. The intermediate overall scores occur even with retrieved waste partitioning processes which have superior performance.

Group 3 alternatives rate high as a result of maximum treatment of residual tank wastes, soils, and PPU's. Alternatives 4, 11, and 16 treat these wastes by ISV to produce the maximum performing waste form. Alternative 9 provides maximum treatment of these wastes by greater than 99.9% waste retrieval (effectively decontaminating the tank internal surfaces), in situ washing of soil to retrieve previous tank waste leaks, and decontamination of PPU's. All Group 3 alternatives treat the bulk hazardous waste constituents through vitrification. This treatment results in destruction of hazardous nitrates, nitrites, and organics; and converts heavy metals to low-leach-rate glass/ceramics. Alternatives 4, 11, and 16 use in situ vitrification. Alternative 9 uses a high-capacity glass melter and encapsulation of glass cullet in a sulfur cement matrix.

2.2 CONCLUSIONS

This systems engineering study has developed several conclusions that will aid the DOE in managing the SST waste. These conclusions include a group of baseline alternatives for the SEIS, characterization requirements, schedule, interim waste stabilization, development requirements, facility requirements, and integration of DST and SST waste processing.

2.2.1 Baseline Closure Alternatives

The Group 3 integrated alternatives provide a baseline of alternatives for closure of the SSTs based on the systems engineering evaluation to be scheduled in the SEIS. Alternative 16 selectively retrieves waste from 18 to 25 of the tanks, partitions the retrieved waste, and vitrifies all of the waste (LLW, HLW/TRU, and waste remaining in the tanks, soil, and PPU's). Two alternatives retrieve all of the waste from the SSTs and partition the waste. One of these retrieval alternatives (number 11) vitrifies all of the wastes. The other retrieval alternative (number 9) vitrifies the HLW/TRU and LLW fractions and uses in situ washing techniques to remove waste from the tanks, soil, and PPU's. The final alternative (number 4) vitrifies all of the waste without retrieval.

Two factors favor baseline closure alternatives over the other 12 integrated alternatives.

- The amount of untreated waste remaining after retrieval and treatment is minimized.
- The waste form of material disposed of onsite and offsite is less mobile.

For maximum programmatic flexibility, Alternative 16 is the recommended baseline for SST closure. The other three alternatives only remain as backup strategies because of the uncertainties associated with Alternative 16. These uncertainties are as follows:

- Successful conclusion of the retrieval and partitioning programs
- Successful conclusion of ISV program
- Successful conclusion of the selective retrieval program.

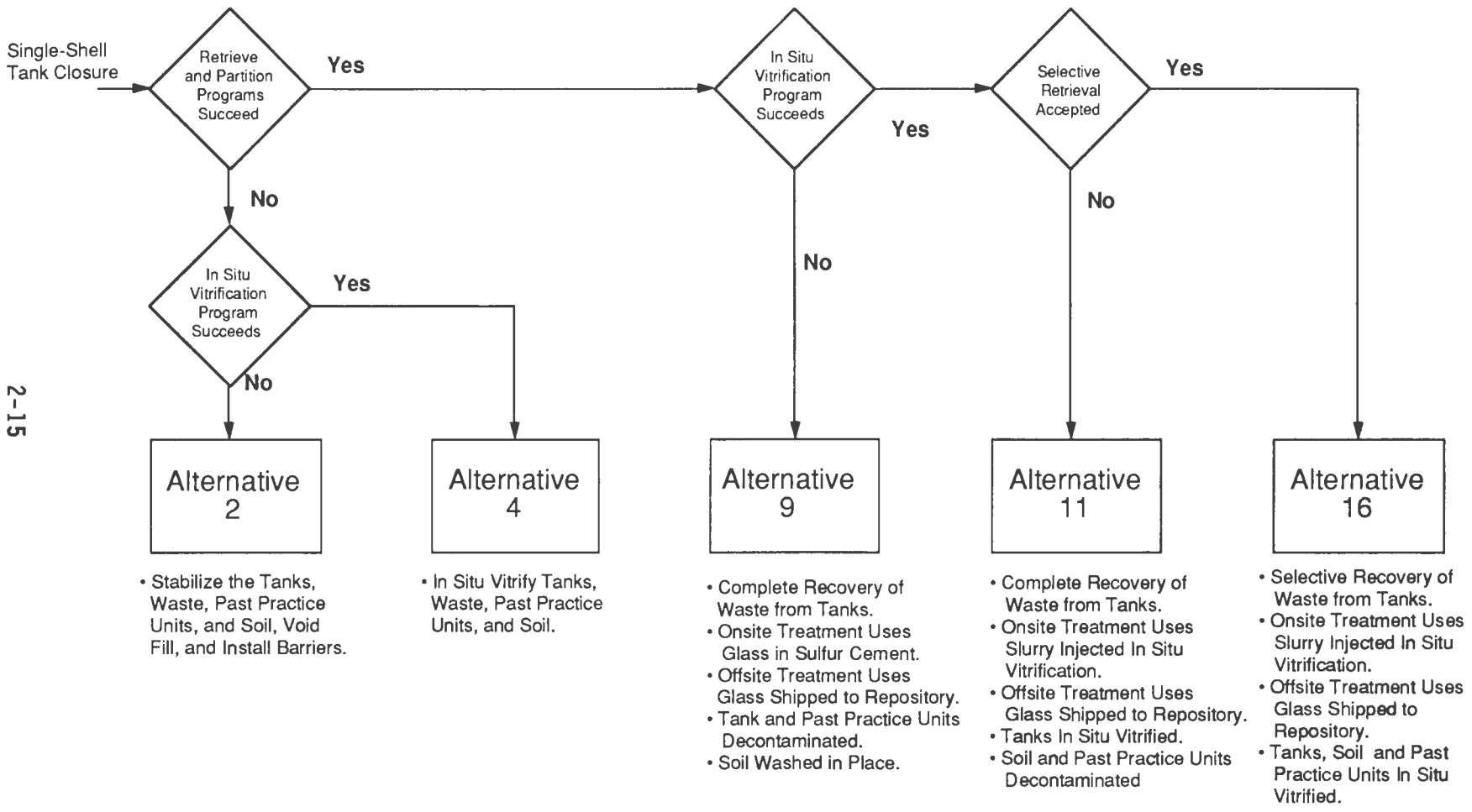
The uncertainties and alternatives are shown in Figure 2-6. If either public acceptance or regulatory statutes require complete retrieval, one of the two complete retrieval cases would become the baseline. Alternative 11 serves as the main backup alternative because it uses the same technologies as Alternative 16. If the in situ vitrification development program fails, Alternative 9 would become the baseline. If retrieval or partitioning development programs fail, Alternative 4 would become the baseline. If both retrieval and in situ vitrification programs fail, Alternative 2 is the fallback alternative. Alternative 2 is the HDW-EIS (DOE 1987) reference alternative.

The recommended alternatives to be included in the SEIS for further evaluation are the Group 3 integrated alternatives (4, 9, 11, and 16) the HDW-EIS reference alternative (Integrated Alternative 2), and the required no-action alternative (Integrated Alternative 1). Completion of the Systems Engineering Study with additional data may alter these recommended SEIS alternatives.

2.2.2 Factors Limiting Integrated Alternative Performance

The integrated-alternative evaluation reveals that two attributes dominate the overall ranking of integrated alternatives. The two principal attributes are (1) residual wastes left after retrieval, soil contaminated from previous leaks, and PPU's and (2) LLW form, including partitioned LLW, residual tank waste, soil, and PPU's. Increasing the degree of waste partitioning to greater than 99.9% is not an effective way to improve the onsite performance assessment because (1) retrieval is not likely to be more than 99.0% efficient and (2) contamination outside the tanks in the soil and PPU's is not improved by partitioning.

Figure 2-6. Baseline Integrated Alternatives and Uncertainties.



Tank residues, soil, and PPU's represent greater than one-half of the total onsite disposal for all retrieval and waste partitioning scenarios considered. The waste forms for onsite disposal have a significant impact on performance as described in Chapter 7.0 for the partitioned LLW fraction. The waste form for tank residuals, soil, and PPU's have similar ranges of four or more orders of magnitude in impact on long term performance assessment.

The net result of combining the two principal SST closure drivers is that reduction of releases from residual wastes, soil, and PPU's is more effective than increasing the partitioning performance on retrieved wastes. This result is reflected by the high-rating Alternative 4 (no retrieval and partitioning of the SST waste) and Alternative 16 (retrieve and partition 75% of the radionuclides in the SST wastes). The high ratings are because of superior performance of low leachability glass waste forms.

2.2.3 Characterization

At the end of the current sampling program, Westinghouse Hanford will have characterized the waste for hazard designation purposes, using the procedures in WAC 173-303-070 *Designation of Dangerous Waste* (Ecology 1990) [e.g., *Test Methods for the Evaluation of Solid Waste, Physical/Chemical Methods* (EPA 1986)]. If the DOE either retrieves waste (as with the DST waste) or treats the waste in place, a less rigorous characterization program may be negotiated with the regulators to support these options. Sampling of the waste after retrieval will provide a more homogenous specimen than in situ techniques. In situ treatment operations will provide steps to physically change the waste or provide a stable matrix to immobilize the waste. Characterization samples may be taken after in situ treatment to confirm treatment effectiveness.

2.2.4 Schedule

The current schedule for the Tri-Party Agreement (Ecology et al. 1990) will require changes in planning to meet construction and permitting requirements. If tasks are conducted sequentially (with respect to design, permitting and construction) the first treatment facilities will not be ready until after 2018. Final closure of the SSTs is scheduled to occur by June 2018 and requires construction of interim storage tanks for retrieved wastes.

To meet the Tri-Party Agreement (Ecology et al. 1990) date for SST closure, one option is to accelerate current plans. The SEIS can start in 1992 instead of 1999 (after Phase I characterization is complete) as currently planned. As stated previously, the characterization requirements for the recommended alternatives are being reviewed to support an accelerated SEIS and may not need to be complete before initiation of the SEIS. The new date for the SEIS accelerates development requirements by the same amount of time. This study assumes a 1996 issuance of the SEIS and ROD.

Schedules that support the alternatives are shown in Figures 2-7, 2-8, and 2-9. Figure 2-7 shows the schedule necessary for in situ treatment.

Figure 2-7. In Place Disposal Schedule.

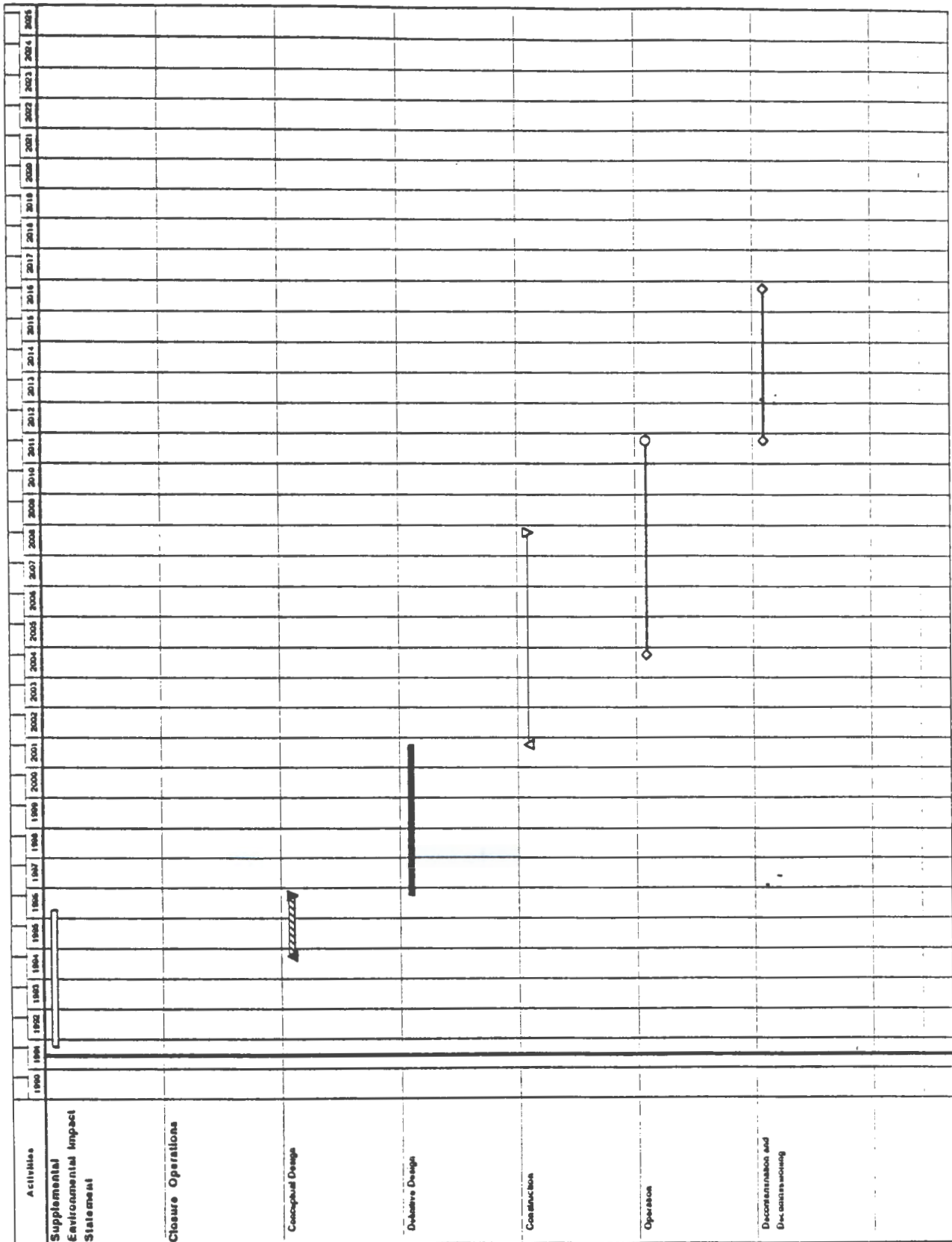


Figure 2-8. Retrieval Schedule.

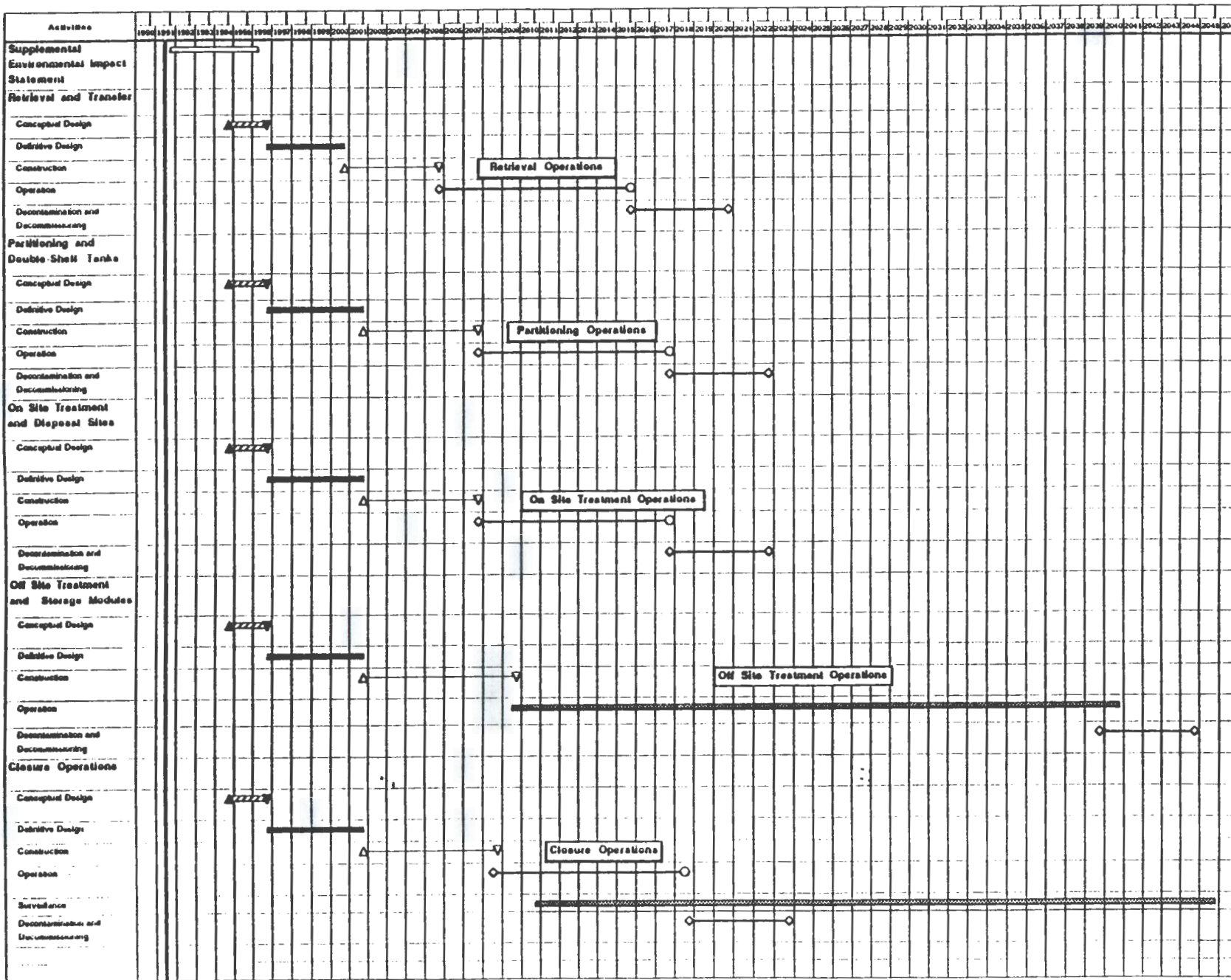


Figure 2-9. Selective Retrieval Schedule.

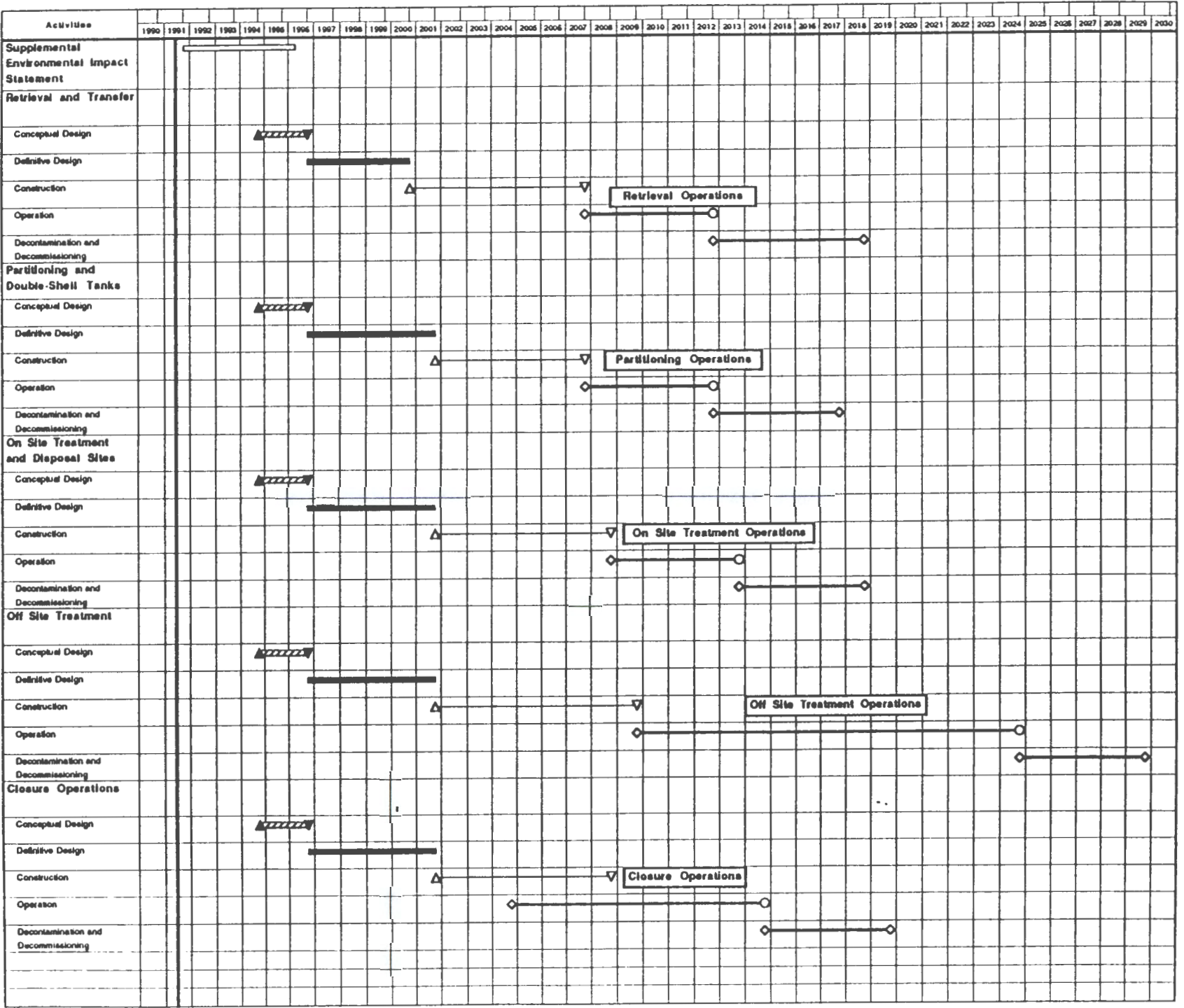


Figure 2-8 shows the schedule necessary for retrieval of all SST wastes. Figure 2-9 shows the schedule for selective retrieval.

All 16 alternatives can meet the 2018 date for closure of the SSTs. Meeting this date requires a varying amount of lag storage for each alternative (see Table 2-4). The alternatives with retrieval and processing of the waste from 149 tanks requires 24 or more additional tanks to meet the closure. If closure moves out 2 yr, retrieval and processing in Alternatives 5, 6, 8, 9, 10, and 11 occur on a compatible schedule eliminating the need for 2 yr (24 tanks) of lag storage. If closure moves out 4 yr, retrieval and processing in Alternative 13 occur on a compatible schedule eliminating the need for 3-1/2 yr (40 tanks) of lag storage. The Alternatives 7, 13, and 14 require 30 yr of processing. To eliminate their lag storage requirement (85 tanks) requires delaying SST closure 32 yr.

2.2.5 Development Requirements

The technologies needed for closure require a significant amount of development. The most advanced of new technologies proposed [transuranium extraction (TRUEX) and strontium extraction (SREX)] to manage the SST waste have not moved past the laboratory scale. Plant design can be accomplished from laboratory data. The risks associated with designing a plant solvent extraction system without pilot-plant data and testing are moderate but acceptable.

Waste form is the area requiring the most investigation. Improving the waste form can reduce the release source term by up to six orders of magnitude. Other areas requiring development, retrieval and partitioning, can only reduce the source term by one or two orders of magnitude. The waste forms to evaluate consist of both retrieved waste and in place waste. Following partitioning, retrieved waste can be treated by a variety of processes such as grout, polyethylene, ceramics, and glasses. In place treatments are limited to grouts and vitrification.

2.2.6 Cost Estimates

Extensive construction is necessary to support the facility requirements of some alternatives. The planned review of Tri-Party Agreement (Ecology et al. 1990) schedules may effect facility requirements to allow SST closure in the year 2018. Faster recovery increases the amount of interim tank storage required, because partitioning and treatment process rates cannot match the recovery rate.

Table 2-5 provides a summary of total capital and operating costs for the 16 integrated alternatives listed in Table 2-1 and evaluated in this study.

Table 2-4. Integrated Alternative Tank Storage Requirements
Number of Million-Gallon Tanks.

Function	Integrated alternative															
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
Retrieval staging	NA	0	0	0	2	2	2	2	2	2	2	0	2	2	2	2
Retrieval lag storage	NA	0	0	0	24	24	85	24	24	24	24	0	0	0	0	0
Retrieval/partitioning lag	NA	0	0	0	2	2	0	2	2	2	2	0	0	0	2	1
Retrieval/partitioning decoupling																
Subtotal		0	0	0	26	26	85	26	26	26	26	0	0	0	2	1
LLW lag storage	NA	0	0	0	1	1	1	1	1	1	1	0	0	0	1	1
Partitioning receipt	NA	0	0	0	2	2	2	2	2	2	2	0	0	0	2	1
Partitioning/LLW treatment decoupling	NA	0	0	0	18	7	2	2	2	2	2	0	0	0	18	2
Qualification/formulation	NA	0	0	0	1	1	1	1	1	1	1	0	0	0	1	1
LLW treatment feed	NA	0	0	0												
Subtotal		0	0	0	22	11	6	6	6	6	6	0	0	0	22	5
HLW/TRU lag storage	NA	0	0	0	0*	0	0	0	0*	0	0*	0	85	85	0*	0*
Retrieval/HLW treatment lag	NA	0	0	0	5*	12	0*	12	5*	12	5*	0	0	0	4*	2*
Partitioning/HLW treatment lag	NA	0	0	0	0	0	2*	0	0	0	0	0	0	0	0	0
Partitioning/HLW treatment decoupling	NA	0	0	0	2	2	2	2	2	2	2	0	2	2	2	2
HLW treatment feed	NA	0	0	0												
Subtotal		0	0	0	7	14	4	14	7	14	7	0	87	87	6	4
DST Total	0	0	0	0	57	53	97	48	41	48	41	0	89	89	32	12
Usable DSTs (1990's construction)	NA	NA	NA	NA	8	8	8	8	8	8	8	NA	8	8	8	8
New DSTs required	0	0	0	0	49	45	89	40	33	40	33	0	81	81	24	4
Recycle water lag storage	NA	0	0	0	4	4	4	4	4	4	4	0	2	2	4	2

DST = double-shell tank.
 HLW = high-level waste.
 LLW = low-level waste.
 NA = not applicable.
 TRU = transuranic.
 *Includes one aging waste tank.

Table 2-5. Single-Shell Tank Closure Capital and Operating Costs.

Alternative	Costs		Total
	Capital (Billions)	Operating (Billions)	
Deferred action			
1	0.0	5.8	5.8
In situ alternatives			
2	0.6	1.4	2.0
3	1.9	2.1	4.0
4	2.1	1.6	3.7
Retrieve and treat alternatives			
5	13.3	24.7	38.0
6	12.0	29.7	41.7
7	8.6	30.8	39.4
8	8.6	17.7	26.3
9	7.7	20.0	27.7
10	13.3	26.8	40.1
11	6.6	19.2	25.8
12	14.7	16.5	31.2
13	17.3	94.8	112.1
14	10.2	112.0	122.2
Selective retrieval alternatives			
15	7.6	17.5	25.1
16	5.2	8.0	13.2

2.2.7 Interim Waste Stabilization

Activities associated with ameliorating the safety concerns (high heat, ferrocyanide, hydrogen, and organic salts) may have an impact on the closure alternatives. Until recently, the only preclosure activities were aimed at liquid removal and tank isolation. If safety investigations cause more rigorous stabilization activities to take place, material added to the tanks can have a serious impact on closure technologies selected.

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Efforts in resolving safety concerns have not progressed to the point where a determination can be made. The first sampling of a ferrocyanide tank is scheduled for FY 1992. First sampling of an organic salt tank has not been scheduled. Plans of action will be prepared after the sample data are analyzed. No definitive plans have been developed for core sampling an organic tank.

2.2.8 Integration of Single-Shell and Double-Shell Tank Waste Processing

The DOE has separate programs for addressing DST and SST wastes. This separation was developed when the DST and SST waste had significantly different planned dispositions as stated in the HDW-EIS (DOE 1987) (i.e., retrieval of DST waste and in place disposal of SST waste). If both wastes are retrieved, separate processing schemes may not be warranted.

The recommended Alternative 16 has time available to process DST wastes during and after the SST mission, matches well with the proposed DST rebaseline, and minimizes HWVP standby time. Use of Alternative 16 to process Neutralized Current Acid Waste (NCAW) supernatant and other DST wastes adds 3 to 5 yr to the SST mission, reduces potential DST LLW releases to the groundwater by a factor of 100,000, and eliminates nitrate contamination of the groundwater in the event of grout vault vapor barrier failure. The DST disposal program is based on a 10,000-yr life of engineered vapor diffusion barrier on the grout disposal vaults.

2.3 REFERENCES

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3.0 SINGLE-SHELL TANK WASTE CHARACTERIZATION

This chapter provides the baseline information used by systems engineering to evaluate SST alternatives. The current database comes from the TRAC, process information used to prepare the HDW-EIS (DOE 1987), and core samples. The members of the Tri-Party Agreement (Ecology et al. 1990) deemed this data insufficient to comply with the RCRA characterization requirements. However, the data provides sufficient information for the engineering study.

Westinghouse Hanford's characterization program, in support of the Tri-Party Agreement (Ecology et al. 1990), will provide sufficient information to designate the waste in accordance with Washington (State) Administrative Code (WAC) 173-303-070 *Designation of Dangerous Waste* (Ecology 1990). The first phase of this program will take samples from all the tanks and analyze the data by September 1998. Westinghouse Hanford will conduct verification testing of the initial phase results. Other goals of the program are as follows:

- Determine the properties of the waste and other components to provide basic data for handling and transporting the waste.
- Provide information to support the performance assessment and risk analysis evaluations.

The information contained in this chapter describes the analyses of SST wastes in support of final closure decisions. The methods used to treat and/or dispose of the SST waste will depend on the current and future regulations for dangerous waste. These regulations will protect the public and the environment from the radioactive and hazardous substances contained in the waste.

3.1 WASTE CHARACTERIZATION

The waste characteristics vary from tank to tank in radionuclide content and chemical and physical properties because of the different nuclear fuel processing schemes used over the years and the variety of blending, evaporating, and admixturing schemes. An extensive SST waste characterization program is being conducted by Westinghouse Hanford for the DOE as detailed in the *Waste Characterization Plan for the Hanford Site Single-Shell Tanks* (WCP) (Winters et al. 1990).

3.1.1 Facility Description

Between 1943 and 1964, 149 SSTs were built for the storage of radioactive waste in the 200 West and 200 East Areas of the Hanford Site. These SSTs are located in 12 tank farms with 4 to 18 tanks in each farm. No waste has been added to the tanks since November 1980. However, water is added to two of the tanks for heat management purposes (Tanks 241-C-105 and 241-C-106). Pumpable interstitial liquid and supernatant waste are removed from SSTs and transferred to DSTs for interim storage. The DSTs are a tank-in-tank design and were placed into service beginning in 1971.

The 149 SSTs have four different volumes: 210 m³, 2,000 m³, 2,900 m³ and 3,800 m³.

The Tri-Party Agreement (Ecology et al. 1990) grouped the SSTs into six RCRA TSD Operable Units. This includes all SSTs, soil contaminated by SST leaks, and RCRA past practice (RPP) units (i.e., tank ancillaries used during the operating life of the tanks such as pipelines, encasements, diversion boxes, etc.). Appendix I contains a complete description of operable units. Table 3-1 contains information on the tanks.

Table 3-1. Single-Shell Tank Farm Information.

Tank farm	Number of tanks	Tank volume (m ³)	Construction dates	Operation period
200 East Area				
241-A	6	3,800	1954-55	1956-80
241-AX	4	3,800	1963-64	1965-80
241-B	12	2,000	1943-44	1945-78
	4	210		
241-BX	12	2,000	1946-47	1948-80
241-BY	12	2,900	1948-49	1950-79
241-C	12	2,000	1943-44	1946-80
	4	210		
Subtotal	66	146,480		
200 West Area				
241-S	12	2,900	1950-51	1952-80
241-SX	15	3,800	1953-54	1954-80
241-T	12	2,000	1943-44	1945-79
	4	210		
241-TX	18	2,900	1947-48	1949-80
241-TY	6	2,900	1951-52	1953-79
241-U	12	2,000	1943-44	1946-80
	4	210		
Subtotal	83	211,080		
Total	149	357,560		

3.1.1.1 The 100 Series Tanks. The 100 Series tanks consist of reinforced concrete with interior carbon steel liners along the bottom and sides. The tank capacities vary depending on the height of the tanks. All 133 tanks in this series have a 22.9-m dia., with domed tops and have capacities of 2,000 m³, 2,900 m³, or 3,800 m³. The below-grade invert elevations of the tanks range from 11.3 m to 15.5 m. The tanks have a minimum 1.8 m of soil cover over the dome.

The 2,000-m³ and 2,900-m³ tanks were originally arranged in 'cascades' of three, four, or six tanks; i.e., the tanks were arranged in a manner so that when the first tank in a cascade was filled it overflowed to the second tank, then to the third tank, and so on. The 2,000-m³ and 2,900-m³ tanks in the B, BX, BY, C, S, T, TX, TY, and U Tank Farms are specific to this arrangement.

Access to the tanks is provided by risers penetrating the dome of the tanks. Technology is being developed for the addition of risers to some tanks if evaluation of the potential for biased results because of sampling through existing risers exists. Risers vary in diameter from 10.2 to 106.7 cm. The number of risers available for sampling varies from tank to tank, depending on the number of risers existing on the tank, location on the tank, and the equipment that may be in or around the riser. The maximum number of potentially available risers is 11.

3.1.1.2 The 200 Series Tanks. Similar to the 100 Series in construction, the sixteen 200 Series tanks do not have domes, have a 6.1-m dia., and have a capacity of 210 m³. The flat-topped tanks have inverts located 11.3 m below grade and have approximately 3.7 m of soil cover. These 16 tanks are located in the B, C, T, and U farms in groups of four.

3.1.1.3 In-Tank Equipment. Many SSTs have received equipment and materials discarded from various experiments and development activities used during the tank's operating history. This hardware includes a myriad of hand measuring tapes, sampling bottles, sundry devices (historically used in single-shell operations), experimental fuel elements, shroud tubes, plastic bottles, and cobalt slugs. Also included is large, installed equipment, such as air lift circulators, thermocouple trees, coils, and sluicers. Section 3.1.3.3 (Chemical and Physical Properties) and Table 3-7 provide additional information and a listing of these materials.

3.1.1.4 Ancillary Equipment. Ancillary equipment associated with the tank farms was used for liquid transfer between the tanks. The equipment consists of the diversion boxes, valve pits, jumper pits, CR vault, septic tanks, cribs, and catch tanks.

3.1.1.5 System Status. After determining that the tanks would not receive additional waste, the DOE removed the SSTs from service in November 1980 and started a program to interim stabilize the tanks by removing pumpable liquid. Interim stabilization occurs in three stages:

1. Partial Interim Isolation--Removal of all equipment except risers and piping necessary for jet pumping.
2. Interim Stabilize--Removal of all pumpable liquid from the SST to limit the liquid source for leaks. Jet pumping (also known as

salt well pumping) continues until a flow rate of 0.2 L/min is reached. At the completion of jet pumping a tank may not have more than 18.9 m³ of supernatant and 190 m³ of interstitial liquid. This criteria applies to all remaining SSTs yet to be stabilized.

3. Interim Isolation--Removal of all equipment except riser and equipment necessary for monitoring the waste after jet pumping. All penetrations to the tanks are blanked off as the final stage of interim stabilization. The blanks prevent water from entering the tanks.

As of November 1990, 105 SSTs have been interim stabilized and 94 have been declared interim isolated. All SSTs will undergo interim stabilization operations before disposal. This interim stabilization and isolation effort is scheduled for completion by September 1996 in accordance with Tri-Party Agreement milestone M-05-09 (Ecology et al. 1990). The Waste Tank Safety, Operation, and Remediation (WTSOR) has placed additional safety-based requirements on the stabilization program. These requirements caused delays in the original stabilization, but the DOE plans to meet the original goals of the program.

Westinghouse Hanford has established an interim groundwater monitoring program for the SSTs. This program is intended to be equivalent to an interim-status hazardous waste land disposal facility system as specified in 40 CFR 265, Subpart F (EPA 1990e). Twelve sampling wells have been drilled near the SST to provide upgradient and downgradient monitoring required. Another 11 wells are planned in FY 1991.

3.1.2 Waste Sources Origination

The SSTs contain irradiated fuels processing waste from nine plutonium production reactors. The chemical separation plants processed 85,000 Mg of heavy metal that had an average burn-up of less than 5,000 MWd/mg. Before transfer to the SSTs, sodium hydroxide or sodium carbonate was added to make the waste alkaline to minimize tank corrosion. Sodium nitrite and nitrate have been added to some wastes to control tank corrosion. Thus, the processing of the irradiated fuels and treatment of the resulting waste have produced alkaline solids and liquids containing radionuclides and hazardous chemical constituents.

Most of the waste stored in SSTs was generated by the following chemical processing operations.

- Bismuth Phosphate (BiPO₄) Process (1944-1956)--The BiPO₄ process was a carrier-precipitation chemical-separation scheme for the recovery of plutonium from irradiated reactor fuels.
- Reduction-Oxidation (REDOX) Process (1951-1967)--The REDOX process used solvent extraction with methyl isobutyl ketone (hexone) to recover and separate uranium and plutonium from the irradiated reactor fuel.

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- Tributyl Phosphate Process (TBP) (1952-1957)--The TBP solvent-extraction process, also known as the Uranium Recovery Process, was designed to recover uranium from stored waste generated by the BiPO_4 process.
- Ferrocyanide $[\text{Fe}(\text{CN})_6]$ Scavenging Operations--The $\text{Fe}(\text{CN})_6$ scavenging operations were conducted in U Plant and in-farm (i.e., the 241-CR facility). The TBP waste was treated with potassium ferrocyanide and sodium ferrocyanide along with nickel ions to precipitate cesium nickel ferrocyanide.
- Plutonium-Uranium Extraction (PUREX) Process (1955-1972)--The PUREX solvent extraction process uses tributyl phosphate diluted in Normal Paraffin Hydrocarbon (NPH) to recover and separate uranium and plutonium from irradiated reactor fuel.
- B Plant Waste Fractionation Process (1965-1976)--The B Plant waste fractionation process separated strontium and cesium, including the heat-generating ^{90}Sr and ^{137}Cs isotopes from the fuel reprocessing wastes.

The REDOX and PUREX processes are the second- and third-generation chemical processes that recovered plutonium, uranium, and neptunium from irradiated reactor fuel. These processes used various reducing and oxidizing agents to control the valence state of the actinides. The strontium from the B Plant waste fractionation process was separated using a di-2-ethylhexyl phosphoric acid (DHEHP) solvent-extraction process. This process used various complexing agents to prevent transition metal extraction. The cesium isotope, also from the B Plant process, was purified by ion exchange. The strontium and cesium later were converted to fluoride and chloride salts, respectively, and encapsulated in the Waste Encapsulation and Storage Facility (WESF).

Other wastes that were sent to the SSTs in smaller volumes include research and development program waste, facility and equipment decontamination wastes, laboratory waste, and Plutonium Finishing Plant (PFP) waste. The PFP uses a TBP solvent extraction process to recover and purify plutonium from plutonium scrap. The TBP in the PFP process is diluted in carbon tetrachloride, whereas the TBP in the PUREX Plant processed is diluted in NPH that is similar in composition to kerosene with C_{10} to C_{15} hydrocarbon chains.

3.1.3 Waste Composition

The SSTs store a total of about $140,000 \text{ m}^3$ of waste. Of this waste, about $2,300 \text{ m}^3$ is supernate, $89,000 \text{ m}^3$ is salt cake, and $48,000 \text{ m}^3$ is sludge as classified in the *Tank Farm Surveillance and Waste States Summary Report for March 1991* (Hanlon 1991). The salt cake consists of the various salts formed from the evaporation of alkaline waste. On transfer of the evaporator slurry into the SSTs, some of the salt precipitated with the sludge. The sludge consists of the solids (hydrous metal oxides) precipitated from the neutralization of acid waste before being transferred to the SSTs. As a result of the precipitating salt, roughly 50% of the reported sludge volume is salt cake. The liquids exist as supernate and interstitial liquid in the tanks. Some of the salt cake and sludge SSTs contain an estimated $23,000 \text{ m}^3$

of drainable interstitial liquid. Table 3-2 shows the amounts for each tank farm of salt cake, sludge, and liquids (Hanlon 1990).

The SSTs mostly contain inorganic waste, although relatively small amounts of plant solvents were entrained during fuel reprocessing and water-soluble complexing agents and carboxylic acids were added in the B Plant fractionation process. A listing of all nonradioactive chemicals known to have been used at production plants and support facilities that transferred waste to SSTs has been documented in *Inventory of Chemicals Used at Hanford Production Plants and Support Operations (1944-1980)* (Klem 1990). Specific chemicals that may have been transferred to the SSTs (Klem 1990) and that appear on the *Dangerous Waste Sources List*, WAC 173-303-9904 (Ecology 1990) include carbon tetrachloride, methylene chloride, methyl isobutyl ketone, acetone, and ethyl ether. Chemical reaction (for example, oxidation-reduction, neutralization, precipitation) and radiolysis has converted many of these chemicals into different compounds.

Dangerous Waste Sources are discussed in WAC-173-303-082 (Ecology 1990) and listed in WAC 173-303-9904 (Ecology 1990). On the Dangerous Waste Sources list, chemicals from only the groups of sources numbered F001, F002, F003, and F005 are likely to be found in the SSTs. These wastes are considered to be dangerous waste sources if they were used as solvents before being discarded to the SSTs.

3.1.3.1 Waste Composition (Track-RadioActive-Components Based). Radioactive inventories of the tank farms were prepared from TRAC data. The TRAC computer model combines reactor fuel discharge records, process flowsheets, tank farm records, decay calculations, and solubility data to predict the radionuclide distribution. An explanation of the model and the database by which TRAC simulates waste generation and tank farm operations is provided in Appendix C.

The HDW-EIS (DOE 1987) used the information contained in TRAC and process knowledge to form the initial estimates of waste compositions in the SSTs. The TRAC calculates tank by tank inventories for 65 radionuclides and 30 nonradioactive chemical components in each of the 149 SSTs. Currently, the TRAC predictions are considered the most comprehensive radionuclide information available. The total existing tank waste inventories reported by TRAC are in close agreement with estimates generated by previous models. Waste transfers after January 1, 1981, have not been accounted for because much of the liquid inventory has or will eventually be removed by jet pumping. The characterization program will provide information on waste composition from its ongoing sampling program (Winters et al. 1990). Tables 3-3 through 3-6 and Table 3-8 will be updated as the information becomes available.

3.1.3.2 Radionuclide Compositions. Initial estimates of radionuclide inventories are listed in Table 3-3. The total radionuclide inventory was based on RIBD and ORIGEN2 computer modeling of the spent fuel. The TRAC code then distributed the radionuclides among various tank farms and tanks based on (1) transfers from process facilities to the waste management system and (2) chemical solubilities. The radioactive components consist primarily of fission product radionuclides such as ^{90}Sr and ^{137}Cs , and actinide elements such as uranium, plutonium, and americium.

Table 3-2. Single-Shell Tank Volume Inventory Summary.

ZOUW	# Tanks	Saltcake (kilogal)	Sludge (kilogal)	Supernate (kilogal)	Total (kilogal)	Vol % Salt	Vol % Sludge	Vol % Supernate	Drainable Liquid in Solids (kilogal)	Drainable Liquid % in Solids Volume	% Total Salt	% Total Sludge	% Total Supernate	% Total Drainable Liquids	% Total Volume
S	12	4765	1171	46	5982	79.7	19.6	0.7	1245	21.0	20.2	9.3	7.7	19.9	16.3
SX	15	2845	1529	94	4468	63.7	34.2	2.1	1192	27.3	12.1	12.1	15.8	19.0	12.1
T	16	0	1991	74	2065	0.0	96.5	3.5	189	9.5	0.0	15.7	12.4	3.0	5.6
TX	18	6659	241	5	6905	96.4	3.5	0.1	250	3.6	28.3	1.9	0.8	4.0	18.8
TY	6	64	571	3	638	10.0	89.5	0.5	31	4.9	0.3	4.5	0.5	0.3	1.7
U	16	2744	638	168	3550	77.3	18.0	4.7	1138	33.6	11.6	5.0	28.2	18.2	9.6
ZOUW Total	83	17,077	6141	390	23,608	72.3	26.0	1.7	4045	17.4	72.6	48.6	65.4	64.4	64.2
ZOUE															
A	6	972	556	8	1536	63.2	36.2	0.6	439	28.7	4.1	4.4	1.3	7.0	4.2
AX	4	884	19	3	906	97.6	2.1	0.3	370	41.0	3.8	0.2	0.5	6.0	2.5
B	16	345	1697	15	2057	16.8	82.5	0.7	164	8.0	1.5	13.4	2.5	2.6	5.6
BX	12	155	1333	50	1538	9.9	86.7	3.3	160	10.8	0.7	10.6	7.2	2.5	4.2
BY	12	4115	723	48	4886	84.2	14.8	1.0	934	19.3	17.5	5.7	8.1	14.9	13.3
C	16	0	2049	177	2226	0.0	92.0	8.0	168	7.5	0.0	16.4	25.6	2.8	6.1
ZOUE Total	66	6471	6377	301	13,149	49.1	48.5	2.3	2,235	17.4	27.6	50.9	43.6	35.6	35.8
Site Total	149	23548	12518	691	36,757	64.0	34.1	1.9	6,280	17.4	100.0	100.0	100.0	100.0	100.0

Note: Data compiled from November 1990 Waste Tank Status Report

Table 3-3. Existing Single-Shell Tank Waste Radionuclides Inventory.

(Decayed to December 1990 ^a)			
Radionuclide	Radioactivity (becquerel)	Half-life (years)	Mass (kilogram)
²⁴¹ Am	1.0 E+15	4.3 E+02	8
²⁴³ Am	7.0 E+11	7.9 E+03	0
¹⁴ C	1.1 E+14	5.7 E+03	0.5
²⁴⁴ Cm	3.1 E+12	1.8 E+01	0
¹³⁵ Cs	2.7 E+12	3.0 E+06	82
¹³⁷ Cs	4.4 E+17	3.0 E+01	140
¹²⁹ I	8.9 E+11	1.7 E+07	150
⁶³ Ni	1.1 E+16	9.2 E+01	4
²³⁷ Np	1.2 E+12	2.1 E+06	47
²³⁸ Pu	1.7 E+13	8.7 E+01	0
²³⁹ Pu	8.1 E+14	2.4 E+04	360
²⁴⁰ Pu	2.0 E+14	6.6 E+03	24
²⁴¹ Pu	2.1 E+15	1.4 E+01	0.5
²²⁶ Ra	1.2 E-04	1.6 E+03	0
¹⁰⁶ Ru	8.5 E+11	1.0 E+00	0
¹⁵¹ Sm	2.5 E+16	8.7 E+01	25
¹²⁶ Sn	2.1 E+13	1.0 E+05	20
⁹⁰ Sr	1.7 E+18	2.8 E+01	330
⁹⁹ Tc	5.9 E+14	2.1 E+05	930
²³⁵ U	7.4 E+11	7.1 E+08	9,400
²³⁸ U	1.7 E+13	4.5 E+09	1,400,000
⁹³ Zr	1.6 E+14	1.5 E+06	1,600

NOTE: Radionuclide inventories listed in this table do not include all decay daughters.

^aValues taken from RHO-RE-ST-30-P, Table 2-10, (RHO 1985).

3.1.3.3 Chemical and Physical Properties. Initial estimates of chemical inventories by ionic species are listed in Table 3-4. Table 3-5 provides the same data, given by chemical compound. The salt cake consists primarily of sodium nitrate and sodium nitrite. These two salts compose about 93 wt% of the salt cake. The sludge consists of metal oxides and hydroxides of iron and manganese that precipitated out of the caustic SST solutions. These values originally were reported in the HDW-EIS (DOE 1987) and were estimated using a study of the original flowsheets.

Mechanical handling properties for the waste range from dry crystalline material that is nearly as hard as concrete, to mushy wet solids that have no structural integrity. Preliminary mechanical properties are shown in Table 3-6. These properties will be revised as data become available from the waste characterization program.

In addition to the reprocessing wastes, the SSTs received small quantities of 'unique' materials. Table 3-7 lists these materials by tank. The table is based on incomplete historical records and awaits further refinement through the waste characterization program. The materials are noted in this document because they constitute part of the SST radionuclides and chemical waste inventory not previously covered by SST waste data.

3.1.3.4 Tanks on Operating Restrictions. Many of the SSTs have conditions or compositions that require the tanks to have operating and surveillance restrictions concerning safety. Currently, there are four such categories: ferrocyanide, high heat, potential hydrogen gas generation, and high organic content tanks. The ferrocyanide and hydrogen gas generating tanks have been declared an Unreviewed Safety Question because of their potential for release of high-level waste due to uncontrolled increases in the temperature or pressure. The high heat tanks are designated as such because they generate over 40,000 Btu/h. They are listed for their potential for release of high-level waste because of uncontrolled increases in the temperature. Organic chemicals are potentially flammable and mixtures of organic material with nitrate and nitrite salts potentially can deflagrate. These tanks are also listed for their potential for release of high-level waste because of uncontrolled increases in the temperature or pressure. These restrictions are precautionary and will remain in place until further notification. Table 3-8 provides a list of these tanks.

3.2 ONGOING CHARACTERIZATION

The design of the Tri-Party Agreement (Ecology et al. 1990) characterization program comes from an ongoing PNL study (Droppo 1991). This study provides a preliminary ranking of closure-related analytes based on risk calculations, regulatory guidelines, and the concentration threshold (CT) concepts for the SST Waste Characterization Program. The CT concept for each carcinogen and noncarcinogen analyte is defined to be that concentration at which its contribution to a risk- or waste-class calculation is judged to be

Table 3-4. Ionic Chemical Species Associated with Existing Single-Shell Tank Radioactive Wastes.^a

Chemical ^a	Total bulk sludge (Mg)	Total bulk salt cake (Mg)	Liquid (Mg)
Al	1,100	630	490
Bi	260		
Ca	130		
Cd	4		
Ce	230		
Cr	96		
Fe	630		
Hg	0.9		
Mn	120		
Na	15,000	34,000	2,300
Ni	180		
Sr	37		
Zr	250		
CO ₃	1,200	410	40
Cl	40		
F	800		5
Fe(CN) ₆	320		
NO ₃	15,000	80,000	1,800
NO _x	2,000	1,500	1,300
OH	5,200	2,400	1,600
PO ₄	7,400	1,200	160
SO ₄	500	1,100	
Cancrinite ^b	2,700		
Organic Carbon			200
H ₂ O	26,000	13,000	4,200
Total	79,197	134,240	12,095

NOTE: Most minor components (<100 Mg total) are not listed.

^aValues taken from RHO-RE-ST-30P, Table 2-5 (RHO 1985).

^bKnown silica additions are assumed to have reacted with aluminates and hydroxides to form cancrinite (assumed to be 2NaAlSiO₄·0.52NaNO₃·0.68H₂O).

Table 3-5. Estimated Mass of Nonradioactive Chemical Components of Existing Single-Shell Tank Wastes After Completion of Jet Pumping.

Chemical	Total sludge (Mg)	Total salt cake (Mg)	Interstitial liquid (Mg)
NaNO ₃	20,000	110,000	2,500
NaNO ₂	3,000	2,300	1,900
Na ₂ CO ₃	1,700	730	70
NaOH	4,200	2,000	740
NaAlO ₂	950	1,900	1,500
Na ₂ SO ₄	740	1,700	
Na ₃ PO ₄	12,500	2,100	280
Cancrinite*	2,700		
Al(OH) ₃	2,300		
Ce(OH) ₃	320		
Cr(OH) ₃	190		
Cd(OH) ₂	5		
Fe(OH) ₃	1,200		
Sr(OH) ₂	50		
BiPO ₄	380		
CaCO ₃	320		
F ⁻	800		5
Cl ⁻	40		
Hg ⁺			
MnO ₂	190		
Ni ₂ Fe(CN) ₆	500		
P ₂ O ₅ ·24WO ₂ ·44	20		
ZrO ₂ ·2H ₂ O	430		
Organic			200
H ₂ O	26,000	14,000	4,800
Totals (Mg)	79,000	135,000	12,000

NOTE: This table taken from RHO-RE-ST-30P, page 2-11 (RHO 1985).

*Known silica additions are assumed to have reacted with aluminates and hydroxides to form cancrinite (assumed to be 2NaAlSiO₄·0.52NaNO₃·0.68H₂O).

Table 3-6. Preliminary Mechanical Properties.

Mechanical property	Range	Basis
Bulk density	1.2 to 1.9 g/cm ³	Core samples to date
Particle size distribution	0.1 to 20 μm	Core samples to date
Viscosity	TBD	
Volumetric heat generation	TBD	
Thermal conductivity	TBD	
Penetrometer test	0-10, cohesive >100, dilatant	Core samples to date
Thermal analysis	TBD	
Specific heat	TBD	
Settled solids (vol%)	TBD	
Centrifugal solids (vol%)	TBD	
Miller number	TBD	
Shear strength	10,000-100,000 dyne/cm ²	Synthetic sludge
Solids settling rate	TBD	
Water (wt%)	TBD	

TBD = to be determined.

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Table 3-7. Unique Contents Single-Shell Tanks.

Tank	Contents
101-BX	7 m ³ of ARC-359/organic ion exchange resin added in 1972
102-BX	95 Mg of diatomaceous earth added in January 1972
105-BY	57 Mg of Portland cement added in _____
107-SX	41 Bottles of neutralized waste from 100 F Area, each with <1 gram of ²³⁹ Pu
110-SX	16 Plastic bottles or containers (7.6 cm diameter by 137.2 cm long) containing following total masses: 113 g U Natural 53 g U Depleted 6 g U Enriched 204 g ²³⁹ Pu
113-SX	41 Mg of diatomaceous earth added in April 1972
116-TX	95 Mg of diatomaceous earth added in November 1972
117-TX	41 Mg of diatomaceous earth added in January 1971
106-TY	27 Mg of diatomaceous earth added in February 1972
101-U	Tank used for disposal of solid waste: Six cask loads of experimental fuel elements, shroud tubes, and samarium "poison" ceramic ball containing: 1530 g 4.5% U enriched 6 g Pu 6.75 E+15 Bq ⁶⁰ Co 2.6 E+12 Bq mixed fission products ⁶⁰ Co Slugs with 2.6 E+12 Bq ⁶⁰ Co
104-U	55 Mg of diatomaceous earth added in May 1972

Table 3-8. Tanks on Operating Restrictions.

Ferrocyanide >1,000 moles	High heat >40,000 Btu/h	Hydrogen flammable gas generation	Organic salts >10 wt% TOC like compounds
102-BX	104-A	101-A	103-B
106-BX	105-A	101-AX	103-C
110-BX	105-C	103-AX	102-S
111-BX	106-C	102-S*	106-SX
101-BY	107-SX	111-S	105-TX
103-BY	108-SX	112-S	118-TX
104-BY	109-SX	101-SX	106-U
105-BY	110-SX	102-SX	107-U
106-BY	111-SX	103-SX	
107-BY	112-SX	104-SX	
108-BY	114-SX	105-SX	
110-BY		106-SX*	
111-BY		109-SX	
112-BY		110-T	
108-C		103-U	
109-C		105-U	
111-C		108-U	
112-C		109-U	
101-T			
107-T			
118-TX ²			
101-TY			
103-TY			
104-TY			

TOC = total organic carbon.

*These tanks also contain >10 wt% organic salts.

NOTE: Values taken from WHC-EP-0182-35, Tables 1 through 4,
(Hanlon 1991.)

significant. The CT values are based on 1% of the cumulative risk index¹ for each ranking option (Long-Term Release Risk [LTRR], Short-Term Intruder Risk [STIR], and Waste Classification [WC]) and for each tank farm group.

The risk index for each case is calculated by a different method. The LTRR is calculated by using the Multimedia Environmental Pollutant System (MEPAS). The MEPAS code is a computer simulation program that determines the risk indices for each analyte. While the MEPAS code considers atmospheric, groundwater, surface water, and overland releases as well as all major exposure pathways, LTRR option is based on a tank leaking to the groundwater. A risk-based analysis was performed to provide a relative ranking of known, suspected, and regulatory analytes of concern in the SST waste. The STIR is calculated using the three generic NRC farm intruder scenarios: the Intruder-Construction Scenario, the Intruder-Discovery Scenario, and the Intruder-Agriculture Scenario. The WC is calculated using the National Institute for Occupational Safety and Health Registry values divided by the weights found in WAC 173-303-084, *Dangerous Waste Mixtures* (Ecology 1990).

The ongoing characterization effort uses the three ranking methods to aid in identifying the significant analytes by health risk and regulatory criteria. The three ranking options used the TRAC code analytes concentration estimates as the input. Even though TRAC does not accurately estimate tank inventories well enough to make closure decisions, the data can be used as input for ranking the SST analytes.

3.2.1 Ranking Options

One of the first steps in characterizing waste is to determine the most important analytes based on risk to public health and regulatory guidelines. The basis for the ranking uses three ranking options: long-term, short-term, and regulatory risk concerns. Long-term release risk concerns are based on risks to the public over a time period greater than a single lifetime (70 yr) using site- and waste-specific data to determine potential health effects to current and future generations. A time period of 10,000 yr was used for the MEPAS groundwater analysis because of the effects of soils delaying the contaminates arrival at the receptor. Short-term intruder risk is used to determine an analyte's potential to produce health impacts when there is the possibility of using or coming into contact with the toxic or radioactive constituent. The STIR method considers risk for only one lifetime (70 yr). As a check on analyte priorities generated through the long-term and short-term intruder-risk methods, an alternative ranking system (known as the waste classification ranking system) was generated based on guidance from the NRC [10 CFR 61, *Land Disposal of Low-level Radioactive Waste* (NRC 1988)] and Ecology [WAC 173-303-084, *Dangerous Waste Mixtures* (Ecology 1990)]. The analytes that were (and that are still being) considered for this analysis were taken from the WCP (Winters et al. 1990).

¹ The cumulative risk index for carcinogens and noncarcinogens is a summation of the computed risk indices for each SST analyte for a given tank farm group.

3.2.2 Priorities

Closure-related analyte priorities were established by categorizing analytes into three types: I, II, and III. The Type I and II analytes also were subdivided into two categories each (IA and IB; IIA and IIB) to provide a more detailed picture of the ranking. Type I analytes have the greatest potential for significant public health impacts and are estimated to provide at least 99% of the cumulative health risk. Type II analytes are estimated to have little to insignificant potential for public health impacts, having been estimated to contribute the next 0.99% of the cumulative health risks. Type I and II analytes, therefore, are estimated to contribute a combined total of at least 99.99% of the cumulative health risks. By comparison, the Type III analytes have an insignificant potential for public health impacts, because they are estimated to contribute less than 0.01% of cumulative health risk.

Once all the risk indexes are computed, analytes are divided into two categories: carcinogen and noncarcinogen. Carcinogenic analytes (those known or suspected to cause or induce cancer) include radionuclides and hazardous chemicals. Noncarcinogenic analytes are known or suspected to cause some type of health effect (ranging from irritation of the eyes to destruction of organ tissue). All radionuclides in this analysis and arsenic are assumed to be carcinogens. All nonradioactive chemicals in SST waste, except arsenic, are defined by the EPA's definition of noncarcinogens.

The combined rankings of SST analytes (identified as Priority Case 1), which are based on all three ranking options, are shown in Table 3-9. The analyte is assigned to a particular type based upon the highest rank of the three options. Thus, if an analyte scores Type I-A, Type II-A, and Type II-A, the combined ranking is the highest score, I-A. If the scores are Type II-B, II-A, II-B, the score is II-A. Analytes that are not Type I-A, I-B, II-A, or II-B for any of the ranking scenarios are categorized as Type III analytes.

The analyte selection criteria are identified at the bottom of Table 3-10. As additional information is gathered through the characterization of the tank waste, it will be possible to reduce conservatism in the analysis. The ranking of some analytes probably will change.

Although not currently recommended, an alternate set of priorities was developed for comparison purposes (identified as Priority Case 2 in Table 3-9). Priority Case 2 gives more emphasis to the long-term risk ranking option by shifting all the short-term intruder risk and waste classification ranking analytes down one category (for example, from Type I-A to I-B). This may be more consistent with current societal values, which place the greatest emphasis on the reduction of public health impacts through prevention of release and migration scenarios (where groundwater is contaminated). Otherwise, the process for determining the combined ranking score was the same as in Priority Case 1.

Priority Case 2 ranking gives a more even distribution of analytes for each category than Priority Case 1 ranking with little change in the Type III analyte list and shifts more analytes from Type I-A to I-B.

Table 3-9. Combined Single-Shell Tank Analyte Ranking. (sheet 1 of 2)
(Priority Case 1)

Carcinogen				
Type I-A	Type I-B	Type II-A	Type II-B	Type III
^{241}Am	$^{242\text{m}}\text{Am}$	^{244}Cm	^{243}Am	^{225}Ac
^{14}C	^{63}Ni	$^{93\text{m}}\text{Nb}$	^{242}Cm	^{227}Ac
^{137}Cs	^{238}Pu	^{237}Np	^{234}U	^{242}Am
^{129}I	^{241}Pu	Arsenic		^{245}Cm
^{239}Pu	^{235}U			^{135}Cs
^{240}Pu				^{231}Pa
^{90}Sr				^{210}Pb
^{99}Tc				^{210}Po
^{238}U				^{223}Ra
^{90}Y				^{225}Ra
				^{226}Ra
				^{106}Ru
				^{79}Se
				^{151}Sm
				^{229}Th
				^{230}Th
				^{234}Th
				^{233}U

NOTES:

Type I-A analytes include 0.00 to 90.00% of cumulative ranking index.

Type I-B analytes include 90 to 99% of cumulative ranking index.

Type II-A analytes include 99 to 99.9% of cumulative ranking index.

Type II-B analytes include 99.9 to 99.99% of cumulative ranking index.

Type III analytes include 99.99 to 100% of cumulative ranking index.

Table 3-9. Combined Single-Shell Tank Analyte Ranking. (sheet 2 of 2)
(Priority Case 1)

Noncarcinogen				
Type I-A	Type I-B	Type II-A	Type II-B	Type III
Al	Ba	Ag	Be	C ₂ O ₄
Bi	C ₆ H ₅ O ₇	Fe(CN) ₆	C ₂ H ₃ O ₃	Ce
Cr ⁺⁶	Cd		Ca	Cl
EDTA	CN		Hg	Cu
F	CO ₃		K	La
Fe	HEDTA		Sb	SeO ₄
Mn	Pb		V	Sn
Na	SiO ₃			Sr
Ni	SO ₄			WO ₄
NO ₂	Zr			
NO ₃				
OH				
PO ₄				

EDTA = ethylenediametetraacetic acid.

HEDTA = hydroxyethylethylenediaminetriacetic.

NOTES:

Type I-A analytes include 0 to 90% of cumulative ranking index.

Type I-B analytes include 90 to 99% of cumulative ranking index.

Type II-A analytes include 99 to 99.9% of cumulative ranking index.

Type II-B analytes include 99.9 to 99.99% of cumulative ranking index.

Type III analytes include 99.99 to 100% of cumulative ranking index.

Table 3-10. Alternate Combined Single-Shell Tank Analyte Ranking. (sheet 1 of 2)
(Priority Case 2)

Carcinogen				
Type I-A	Type I-B	Type II-A	Type II-B	Type III
^{14}C	^{241}Am	$^{93\text{m}}\text{Nb}$	^{242}Cm	^{225}Ac
^{129}I	$^{242\text{m}}\text{Am}$	^{63}Ni	^{244}Cm	^{227}Ac
^{99}Tc	^{137}Cs	^{238}Pu	^{237}Np	^{242}Am
^{238}U	^{239}Pu	^{241}Pu	^{234}U	^{243}Am
	^{240}Pu		Arsenic	^{245}Cm
	^{90}Sr			^{135}Cs
	^{90}Y			^{231}Pa
				^{233}Pa
				^{210}Pb
				^{210}Po
				^{223}Ra
				^{225}Ra
				^{226}Ra
				^{106}Ru
				^{79}Se
				^{151}Sm
				^{229}Th
				^{230}Th
				^{234}Th
				^{233}U

NOTES:

Type I-A analytes include 0.00 to 90.00% from long-term release risk (LTRR) rankings only.

Type I-B analytes include 90 to 99% from LTRR and 0 to 90% from short-term intruder risk (STIR) and waste classification (WC) rankings.

Type II-A analytes include 99 to 99.9% from LTRR and 90 to 99% from STIR and WC rankings.

Type II-B analytes include 99.9 to 99.99% from LTRR and 99 to 99.9 from STIR and WC rankings.

Type III analytes include 99.99% to 100% from LTRR and 99.9% to 100% from STIR and WC rankings.

Table 3-10. Alternate Combined Single-Shell Tank Analyte Ranking. (sheet 2 of 2)
(Priority Case 2)

Noncarcinogen				
Type I-A	Type I-B	Type II-A	Type II-B	Type III
EDTA	Al	Ba	Ag	C ₂ H ₃ O ₃
F	Bi	C ₆ H ₅ O ₇	Be	C ₂ O ₄
NO ₂	CN	Cd	Fe(CN) ₆	Ca
NO ₃	Cr ⁺⁶	CO ₃	Hg	Ce
	Fe	HEDTA	Sb	Cl
	Mn	Pb	V	Cu
	Na	SO ₄		K
	Ni	SiO ₃		La
	OH	Zr		SeO ₄
	PO ₄			Sr
				Sn
				WO ₄

EDTA = ethylenediametretraacetic acid.

HEDTA = hydroxyethylethylenediaminetriacetic.

NOTES:

Type I-A analytes include 0.00 to 90.00% from long-term release risk (LTRR) rankings only.

Type I-B analytes include 90 to 99% from LTRR and 0 to 90% from short-term intruder risk (STIR) and waste classification (WC) rankings.

Type II-A analytes include 99 to 99.9% from LTRR and 90 to 99% from STIR and WC rankings.

Type II-B analytes include 99.9 to 99.99% from LTRR and 99 to 99.9 from STIR and WC rankings.

Type III analytes include 99.99 to 100% from LTRR and 99.9 to 100% from STIR and WC rankings.

3.2.3 Track Radioactive Components Code

Because TRAC provides both an indication of the location of some waste constituents and concentration estimates for all 149 SSTs, it was used to develop a preliminary sort of the SSTs. The TRAC data were used to classify waste by hazardous chemical and radionuclide content. Because of the limited capabilities and inaccuracies of the TRAC program, these classifications are not formal regulatory classifications, but are used only to provide technical guidance until actual characterization data are available.

The TRAC code was used to generate estimates of the amounts and concentrations of radionuclides in each of the SSTs. During FY 1985 and 1986, wastes in 15 SSTs were core sampled and analyzed. Although some chemical (metals and anions) and physical analyses were performed, the focus of the analyses was on radionuclides. This is because TRAC only included stable chemicals that were needed for determining the solubilities of the radionuclides. The applicable hazardous waste regulations are based solely on chemical constituents. The TRAC and laboratory data are based on anion and cation data.

This difference required combining ions to make neutral compounds so the waste could be compared to regulated waste. In deciding how to combine ions, conservative assumptions had to be made. These assumptions resulted in a more stringently regulated waste than might actually exist. Acids were eliminated from the list because the caustic neutralization and the high pH of the tanks. All chloride and nitrite compounds were eliminated because of their high solubility. If the formation of two compounds were possible with a given ion, the more hazardous one was formed first, with any remaining ion credited to a listed but less dangerous compound.

Only radionuclides were analyzed also because the samples were being taken to verify the TRAC program, which focuses on radionuclides. Evaluation of these data against TRAC predictions resulted in the use of the TRAC code as a general predictive tool to guide the selection of the SST for sampling. It must be stated that the agreement between actual sample results and TRAC estimates is not adequate to allow the use of TRAC to characterize SST wastes. However, the TRAC database will provide technical guidance until actual characterization data are available.

3.2.4 Reference Tank 110-B Data Analysis

To address the issues of potential errors in inventory estimates with tank sampling, sample handling, analytical techniques, and horizontal variance (within a tank), plans include sampling and analysis within several risers from a 'reference' tank. Two single-shell reference tanks were sampled during 1989 to provide (1) information on the vertical and horizontal homogeneity of SST waste, (2) an idea of how the TRAC inventory data compares with actual tank inventories, (3) an estimate of sampling and analysis variability, and (4) information for sampling and analysis development tasks. Tanks 110-U and 110-B were the reference tanks sampled. These two tanks were selected because they were from two different waste types. The following is a preliminary comparison of the analytical core composite results (based on three core

samples) from the 110-B tank, the analyte ranking results, and the TRAC data. These results are presented because they indicate some important consequences for future SST waste characterization.

3.2.5 Data Comparison

Analyte concentrations from core samples of reference Tank 110-B were compared with Tank 110-B TRAC data. The preliminary results are presented in Tables 3-11 and 3-12 and are based on a subset of all the samples and cores taken from the tank. A more complete set of data and results will be available soon. These results are preliminary and should be used as indicators and not as final results.

The analyte concentrations measured from the core samples were used to compute an average concentration for each analyte detected in the tank. The comparison of Tank-110-B-measured concentration and the TRAC-predicted concentration indicates that for all but two analytes the concentrations are within an order of magnitude. Analytes ^{129}I and ^{237}Np (Tank-110-B-measured concentration) are based on detection limits and, therefore, are not a true measure of the analytes in the tank. The solubility limits for radionuclides are based on NaNO_3 releases; therefore, no values are provided in Table 3-11. The TRAC inventory compared well with Tank-110-B-sampled data (arsenic, beryllium, mercury, antimony, and vanadium are not estimated by TRAC). This indicates that the TRAC estimates are close to the measured data in the tank.

No transuranic analytes were identified as being present in sufficient quantities to present significant long-term release risks. The core samples indicate that many of the analytes' measured concentrations are similar among different core samples. This suggests that Tank 110-B is horizontally homogeneous, although it must be cautioned that these data and analyses are preliminary (data was taken from three of the five risers sampled during the first two characterization phases). Thus, Tank 110-B inventory agrees with the waste classification of Tank 110-B tank using TRAC inventories, which indicated that this tank contained greater-than-Class-C (GTCC) and TRU wastes.

3.3 DATA QUALITY OBJECTIVES

An SST data quality objectives (DQO) group was formed at the request of the Environmental Programs Office to identify the SST waste characterization needs to satisfy technical requirements for decisions regarding closure of the SST operable units. The Systems Engineering team is using the DQO process to determine the type and quality of data needed to develop the most efficient method(s) of closing the SST operable units.

The DQO process ensures that the following are considered at the right time so resources are expended effectively:

- Characterization needs
- Environmental data needs

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Table 3-11. Comparison of Different Concentrations for Type I and II Analytes.

Analyte name	Average 110-B concentration (Bq/g)	TRAC 110-B concentration (Bq/g)	Ratio of average concentration to TRAC concentration	Solubility limit (Bq/g)	Analytical method detection limit (Bq/g)
²⁴¹ Am	3.06 E+03	9.51 E+03	1:3.1		3.00 E+01
^{242m} Am	1.22 E+01	3.62 E+01	1:3.0		3.0 E+01 ^b
¹⁴ C	5.18 E+02	9.07 E+02	1:1.8		3.00 E+01
¹²⁹ I	7.2 E-01 ^a	4.51 E+00	1:6.3		3.7 E+02
²³⁷ Np	5.6 E+00 ^a	8.84 E-02	6.3:1		5.9 E+01
²³⁸ Pu	1.07 E+02	9.40 E+01	1.1:1		3.0 E+01 ^b
²³⁹ Pu	4.33 E+03	1.81 E+03	2.4:1		3.00 E+01
²⁴⁰ Pu	1.44 E+02	4.51 E+02	1:3.1		3.0 E+01 ^b
⁹⁹ Tc	5.92 E+02	2.72 E+03	1:4.6		9.3 E+01
²³⁴ U	3.03 E+00	2.26 E-02	134:1		1.9 E+00 ^b
²³⁵ U	1.08 E-01	3.17 E+00	1:2.9		1.9 E+00
²³⁸ U	1.71 E+01	6.25 E+01	1:3.7		1.90 E+00

TRAC = track radioactive components.

^aIndicates that the detection limit was used for the 110-B sample concentration.

^bIndicates that a different isotope's detection limit was used for this analyte.

Table 3-12. Comparison of Different Concentrations for Type I and II Analytes.

Analyte name	Average 110-B concentration (µg/g)	TRAC 110-B concentration (µg/g)	Ratio of average concentration to TRAC concentration	Solubility limit (µg/g)	Analytical method detection limit (µg/g)
As	2.15 E+01	---	---	1.92 E+02	3.30 E+00
Be	4.19 E+00 ^a	---	---	5.02 E+02	1.00 E-03
CN	3.43 E+00	0.00 E+00	0.0	6.11 E-01	1.00 E-02
Cr ⁺⁶	6.83 E+01	3.82 E+02	1:5.6	7.89 E+02	6.70 E-03
EDTA	3.91 E+02	0.00 E+00	0.0	1.56 E+01	TBD
F	1.79 E+03	4.18 E-40	4.2 E+42:1	1.97 E+03	1.80 E+01
Hg	9.26 E-01	---	---	1.78 E+02	1.80 E-02
Na	1.15 E+04	2.98 E+04	1:2.59	5.11 E+04	1.26 E-01
NO ₂	1.03 E+04	0.00 E+00	0.0	6.94 E+04	3.70 E+01
NO ₃	1.85 E+05	7.66 E+04	2.4:1	7.28 E+03	4.00 E+01
Sb	2.34 E+03 ^a	---	---	4.70 E+03	4.67 E-01
SO ₄	1.15 E+04	1.17 E-09	9.8 E+12:1	4.70 E+03	3.70 E+01
V	3.63 E+01	---	---	4.70 E+03	9.80 E-03

TBD = Indicates value is to be determined.

TRAC = track radioactive components.

^aIndicates that the detection limit was used for the 110-B sample concentration.

^bIndicates that a different isotope's detection limit was used for this analyte.

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- Data quality requirements
- Balance of time and cost versus data quality.

The DQO process (Figure 3-1) is to be used as a management tool to ensure the collection of necessary and sufficient data of the type and quality required to make informed decisions with confidence, and to integrate the DQO process with the SST characterization activities. Data Quality Objectives are important to the SST characterization program for the following reasons:

- Identifies and coordinates the multiple data users and their data needs related to interim stabilization and final disposal
- Forces data users and data collectors to plan to derive maximum benefit from each sampling operation
- Provides logical framework for evaluating characterization and disposal alternatives.

The object is to develop a harmonized set of explicit requirements for planning, implementing, and reviewing environmental data operations involving the characterization, remediation, and verification of cleanup of a waste site and facilities involved with mixed and hazardous waste.

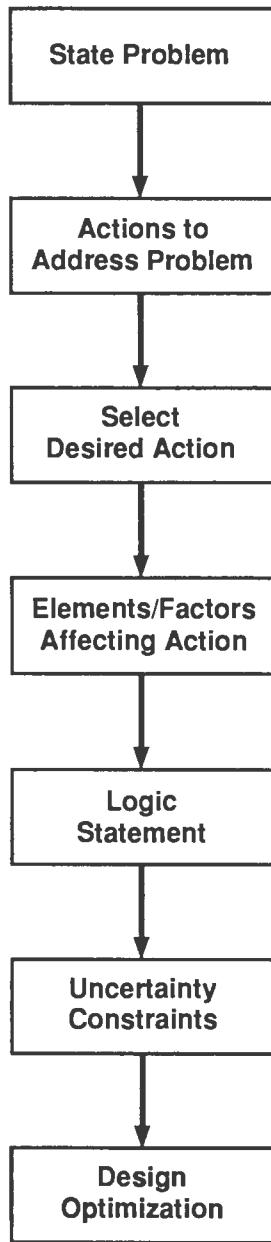
The DQO process was created by and is being used throughout the EPA, is referenced in the Tri-Party Agreement (Ecology 1990), and is supported by DOE. It can be an excellent management tool if it is used properly. It will help in reaching disciplined, structured, and cost-effective decisions. However, the DQO process is only a tool; to be effective, it should be integrated with the overall management process of SST characterization.

3.4 REGULATORY COMPLIANCE

Department of Energy Order 5820.2A, *Radioactive Waste Management* (DOE 1988), specifies regulatory requirements for SST closure activities and the management of associated radioactive wastes. A parallel regulatory document (Smith 1991) provides an account of regulatory requirements that are expected to affect the feasibility and design of options for closure of the SSTs and identify functional requirements derived from these regulations. This section identifies sources of the requirements and summarizes those requirements briefly to provide a bridge to the regulatory document.

In addition to DOE Order 5820.2A and other DOE orders, the EPA, NRC, Ecology, and the Washington State Department of Health affect SST closure through established regulations, anticipated regulations, licenses or permits, and conditions imposed on plan approval for the disposal of the SST waste. The DOE has primary authority over the management of the radionuclides in the SSTs. An NRC license is required for any high-level waste disposal at the Hanford Site. The DOE also is subject to EPA radiation protection regulation and guidance. The DOE has agreed to subject the radionuclides in the SSTs to state RCRA authority with remediation and corrective action [but not closure, as such (Ecology 1989)].

Figure 3-1. Data Quality Objectives Process.



H9107024.1

The state and federal governments share authority over the management of the hazardous chemical constituents of wastes in the SSTs. The DOE has submitted a RCRA Part A permit application for the SSTs, and the Tri-Party Agreement (Ecology et al. 1990) for closure of these units as interim status RCRA TSDs.

3.4.1 Waste Classification

The DOE currently classifies SST waste as Tank Waste and has taken no final position on whether the waste types are high- or low-level under NRC regulation, or dangerous or extremely hazardous waste under state RCRA regulations. The DOE has deferred final waste classification because the chemical and radioactive composition of the waste can only be approximated for lack of accurate historic data and because of extensive post-separation processing, waste mixing, chemical reactions, and radiolysis during storage.

The post-separation processing has recovered uranium and scavenged and recovered ^{137}Cs and ^{90}Sr . This processing as well as in-tank solidification and evaporator crystallizer operations has significantly homogenized the initial waste streams. Sampling and analysis of the waste has been initiated to provide a more accurate characterization and will be complete by 1998.

3.4.1.1 Radioactive Waste. Potential radioactive classifications for the tank waste can range from HLW to LLW. Classification of the tank waste as HLW does not depend on the activity levels in the waste, but on the source of the waste. The definition of HLW waste includes waste from fuel reprocessing, but excludes incidental wastes.

The DOE and NRC definitions for HLW differ. Both identify irradiated nuclear fuel and reprocessing waste as sources of HLW. The NRC also classifies the solids derived from reprocessing waste as HLW. The DOE classifies these solids as HLW, if they contain a combination of TRU and fission products in concentration requiring permanent disposal. The DOE definition follows that of the NRC in an advanced notice of final rule making in 52 FR 5993 (EPA 1987). The NRC did not adopt this definition in 53 FR 4111 (EPA 1988).

The NRC exempts incidental waste from the HLW classification. Waste from defense reprocessing has been identified previously as incidental waste. The original exemption noted in 35 FR 17532 addressed decontaminated salt waste at the Savannah River Plant. The salt waste contained Class B levels of radionuclides. The NRC deemed the salt waste incidental waste. Preliminary data indicate that some fraction of the SST waste will exceed current criteria of TRU waste (waste contaminated with alpha-emitting TRU radionuclides with halflives greater than 20 yr and concentrations greater than 100 nCi/g of the waste matrix).

3.4.1.2 Hazardous Waste. In the RCRA Part A permit application for the SST, Westinghouse Hanford and DOE Field Office, Richland identify SST waste as ignitable and corrosive. The state identifies the waste as extremely hazardous waste (EHW). The Part A permit application also contains characteristic waste codes D002 through D011. The waste codes D004 through D011 represent heavy metals (beryllium, cadmium, chromium, mercury, nickel,

selenium, and silver). These metals and their associated compounds also are listed on the dangerous waste constituents list under WAC 173-303 (Ecology 1990). Ecology may require removal of all dangerous waste and dangerous waste constituents upon closure of a TSD facility.

Under WAC 173-303-101 (Ecology 1990), NaNO_3 (a major constituent of SST wastes), is sufficiently toxic to be classified as a dangerous waste. Whether the mixtures of NaNO_3 and other material in the SSTs would be classified as toxic dangerous waste under these state criteria will not be known until additional waste characterization data are available. Single-shell tank sludges consist mainly of oxide and hydroxide precipitates and may or may not be toxic. The residual liquids contain contaminants from either the salt cake or sludge and may or may not be toxic.

Westinghouse Hanford and the DOE will reexamine RCRA waste classification issues for SST wastes as additional data become available and will revise waste designation on the SST Part A filing as appropriate. Waste designations may change as a result of waste treatment during the SST closure process.

3.4.2 Radioactive Waste Disposal Requirements

DOE Order 5820.2A (DOE 1988) provides requirements for the disposal of high-level, TRU, and low-level radioactive wastes. Single-shell tank closure will require disposal of at least two of these categories of waste. This order distinguishes between newly generated and/or easy to recover wastes and old and/or difficult to recover wastes. Disposal of newly generated waste must comply with all of the requirements stated in the order. The DOE Field Office, Richland must evaluate recovery and alternatives for disposal of the old wastes, in accordance with the order's requirements, against disposal in place.

Near-surface disposal of SST waste as radioactive waste is subject to regulation by DOE, the NRC, and the EPA. Disposal of radioactive LLW is regulated by DOE. Disposal of HLW requires an NRC license. The NRC determines if SST waste is HLW or LLW. All disposal of radioactive waste is subject to radiation protection standards established by the EPA.

Regulatory requirements applicable to onsite disposal of radioactive waste are a function of the waste type. The DOE expects that because of past partitioning practices and planned partitioning before disposal, the waste planned for near-surface disposal will be classified as incidental waste that does not require NRC oversight as HLW and, therefore, can be disposed of as LLW. The DOE position is consistent with the NRC rule making record for 10 CFR 50, Appendix F.

3.4.2.1 Low-Level Waste. Low-level waste disposal is regulated principally under DOE Order 5820.2A (DOE 1988) and generally is consistent with the spirit and intent of the NRC and draft EPA regulations except for lack of a performance assessment time frame specification (performance assessment from a design standpoint is discussed in Section 6.2). This order sets performance objectives for radiation exposures, requires adequate and cost-effective treatment, and requires a site-specific performance assessment. Disposal

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methods selected under this order should be functionally equivalent to the performance required under NRC regulations for non-DOE LLW with similar radionuclide characteristics.

3.4.2.2 Transuranic Waste. It is the intent of DOE that TRU waste be treated, packaged, and sent to the Waste Isolation Pilot Plant (WIPP). Near-surface disposal of recovered TRU waste can be considered an alternative only if the waste in question cannot be certified or otherwise approved for WIPP or if the DOE has determined, with the concurrence of the EPA administrator that the TRU waste does not need the degree of isolation provided by a geologic repository. The DOE will consider waste recovery, treatment, and/or vitrification plans when determining whether the SST wastes in their final form are TRU.

3.4.2.3 High-Level Waste. Retrieval and processing of easily recovered HLW, followed by disposal in a geologic repository, is required by DOE Order 5820.2A (DOE 1988). This order also requires evaluation of disposal options for difficult to recover HLW, such as in-place stabilization and retrieval and processing. Neither current DOE orders nor NRC regulations address the near-surface disposal of HLW. If the DOE determines that in situ disposal of HLW is appropriate for waste the NRC classifies as HLW, key regulatory requirements probably will be established in new NRC regulations or as NRC license conditions.

3.4.3 Treatment, Storage, and Disposal of Hazardous Waste Requirements

The SSTs currently are classified as RCRA hazardous waste storage and treatment tanks. Closure of these tanks involves waste removal and/or treatment, and closure of the tanks under RCRA. If retrieved or unretrieved wastes remain hazardous after treatment, RCRA hazardous waste disposal requirements also must be met. Finally, retrieved SST waste is stored before and after treatment but before disposal.

3.4.3.1 Recovery and Treatment Requirements. Waste recovery operations and non-thermal treatment of SST waste in situ or following retrieval are subject to RCRA requirements for tank operations. The process of in situ vitrification of SST wastes may be subject to special requirements imposed in the Hanford Site's RCRA permit.

3.4.3.2 Single-Shell Tank Closure. The SSTs currently are classified as RCRA interim-status tanks, and must be closed as specified in a state-approved closure plan, whether some or all wastes are retrieved, and even if any wastes left in place are nondangerous. The RCRA regulations (40 CFR Part 264, Subpart J), allow clean closure of hazardous waste tanks and also closure as a landfill if it is impractical to remove contaminated soil at closure. The provision to allow treatment and storage tanks to close as landfills is based on EPA's clarification of the definition of a landfill. Ecology decides if the SSTs can be reclassified as a landfill. Also, it is possible that closure with ISV could be classified as land treatment, or that DOE and Westinghouse Hanford may be required to secure a new RCRA permit for ISV. All of these types of closure must conform to a state-approved plan, except when a plan may impose requirements that are inconsistent with the AEA.

The basic objective of RCRA closures is to minimize the risk of future release of hazardous constituents that can threaten human health or the environment. A groundwater monitoring system and a final cover are required for landfill closure. Specifications for a cover probably will be highly dependent on the final waste form. If the final waste form is rendered nondangerous, the cover is required only to meet radiological performance standards, which may include a minimal native soil cover.

3.4.3.3 Storage. The storage of hazardous material occurs before and after treatments steps. The requirements for storage mandate that the tanks used for hazardous waste storage must contain the material and provide for leak detection.

3.4.3.4 Land Disposal Restrictions. Treated SST waste that is still dangerous waste must meet federal and state land disposal standards before land disposal if the waste exceeds applicable LDR standards. These requirements will be important if waste characterization shows that SST wastes are in fact EHW or if significant concentrations of methylisobutyl ketone (an F003 listed waste) still can be detected in SST wastes. If all reasonable treatment measures to reduce hazards to human health and the environment are used before land disposal, state law allows land disposal of mixed waste at federal facilities. In situ treatment that meets this test will probably be accepted as adequate treatment by the EPA, in response to a DOE rulemaking petition.

An alternative to meeting land disposal restriction standards is to deregulate treated SST wastes. Treated SST wastes remain subject to the federal RCRA program unless they no longer exhibit a hazardous waste characteristic [i.e., corrosivity, ignitability, reactivity, or toxic characterization leach procedure (TCLP) toxicity] and are 'delisted' by the EPA in response to a petition. Waste that meets these requirements is still subject to the state RCRA program unless they do not exceed the dangerous waste criteria for (biological) toxicity, persistence, or carcinogenicity set out in WAC 173-303-101 through -103 (Ecology 1990) and is also delisted by the state.

3.4.4 Transportation Requirements

Regulations applicable to the transportation of wastes from the SSTs have been issued by the Department of Transportation (DOT), NRC, DOE, and Ecology. Many of the requirements in these regulations are applicable to transportation external to Hanford Site facility transportation.

3.4.4.1 Hazardous Waste. State requirements for transporters of dangerous waste address identification numbers, manifests, containers, labels, and reports. These requirements apply to offsite transportation (i.e., transportation on roads accessible to the public) and do not apply to transportation within the 200 East or 200 West Areas. However, the Hanford Site policy is to comply with these requirements for all onsite transport of hazardous waste.

The DOT requirements for transportation of hazardous waste are indicated in 49 CFR 161 (DOT 1986). These regulations detail the federal requirements

for identification numbers, manifests, containers, labels and reports. For onsite transportation, only identification and accumulation portions apply. If waste is to be accumulated for more than 90 days, a permitted storage facility is required. However, if waste is in transport, a 10-day limit is imposed by WAC 173-303-240(5) (Ecology 1990).

3.4.4.2 Radioactive Waste. The DOT requirements for transportation of radioactive waste are indicated in 49 CFR 173 Subpart I (DOT 1983). Included are container requirements based on radionuclide content, external radiation limits, and labeling. These requirements do not apply to transportation within an establishment. Transportation within a permitted pipe line would meet this definition. Interfacility transportation by container vehicle may not meet this definition.

The DOE Order 5820.2A (DOE 1988) gives direction for the transportation of radioactive waste based on radioactivity and radionuclide content. For HLW, double containment is mandated.

3.4.4.3 Mixed Waste. Mixed waste, as defined in 49 CFR 173, must be transported to meet all the requirements for all hazards of that waste. The DOE Order 5820.2A (DOE 1988) commits to comply with all applicable federal, state, and local laws. It allows for deviation from these regulations for onsite transportation where it is not economically or technically practical to meet them, provided a safety analysis is performed, and administrative controls that offer an equivalent degree of safety are specified.

3.4.5 Other Regulatory Requirements

State and federal regulations also will require the control of air emissions from SST closure operations and the management of associated liquid effluents and secondary wastes. These regulatory programs are expected to have a much less significant impact on the feasibility and design of SST closure options and requirements for the closure of RCRA facility and for the management of hazardous and radioactive wastes.

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4.0 EVALUATION OF ALTERNATIVES

The evaluation of integrated system alternatives for the closure of SSTs is presented in this chapter. The following sections describe the integrated alternatives being considered, the criteria or attributes for evaluation, the methodology employed to rank the integrated alternatives, and the presentation of evaluation results and summary observations.

4.1 DESCRIPTION OF INTEGRATED ALTERNATIVES

The technology options within functions that can be used in an integrated alternative are shown in Chapter 2.0, Figure 2-1. Tens of thousands of permutations and combinations are possible in definition of integrated alternatives. Sixteen integrated alternatives are defined that provide at least one example of each technology option for each function as shown on Table 4-1.

The number of alternatives was limited to provide a manageable set of alternatives for evaluation while representing the entire range of technology options available. The evaluation of other integrated alternatives can be developed using the data provided for each technology option in the following chapters and appendixes. The 16 integrated alternatives are described in the following sections on deferred action, in situ treatment, retrieval and treatment, and selective retrieval alternatives.

4.1.1 Deferred-Action Alternative

The deferred-action alternative represents the baseline case of no action taken for waste treatment and provides a comparison baseline for environmental impacts.

4.1.1.1 Integrated Alternative 1. Integrated Alternative 1 represents no action with continued storage of SST waste. This alternative is the no-disposal action alternative for SST waste presented in the HDW-EIS (DOE 1987). The tanks and waste are maintained in the interim-stabilized condition. This condition represents the completion of salt well pumping and removal of pumpable liquids and isolation activities as defined in the Tri-Party Agreement (Ecology et al. 1990). The SSTs would contain some drainable liquids in this alternative.

4.1.2 In Situ Alternatives

The in situ alternatives treat tank waste in place for ultimate disposal in place. The in situ treatment and disposal require NRC licensing of onsite disposal of HLW.

4.1.2.1 Integrated Alternative 2. Integrated Alternative 2 treats the tank waste in place with removal of all drainable liquids by drying. Closure of each tank farm and PPU with associated contaminated soil will be performed by

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Table 4-1. Integrated Single-Shell Tank Closure Alternatives.

ALTERNATIVE	RETRIEVAL TECHNOLOGY		WASTE TREATMENT TECHNOLOGY				TANK FARM CLOSURE		
	WASTE RETRIEVAL	WASTE TRANSFER	IN SITU TREATMENT	RETRIEVED WASTE TREATMENT			TREATMENT TECHNOLOGY		
				PARTITION	LLW	TRU/HLW	TANK	SOIL	PAST PRACTICE UNITS
<u>DEFERRED ACTION</u>									
1			CONTINUED STORAGE						
<u>IN SITU ALTERNATIVES</u>									
2			STABILIZE				DOME FILL	BARRIER ONLY	STABILIZE
3			IMMOBILIZE				GROUT FILL	IN SITU IMMOBILIZE	IMMOBILIZE
4			IN SITU VITRIFICATION				IN SITU VITRIFICATION	IN SITU VITRIFICATION	IN SITU VITRIFICATION
<u>RETRIEVE AND TREAT ALTERNATIVES</u>									
5	HYDRAULIC/DECON	SLURRY		TRUEX C	SALT/GROUT	VITRIFICATION	GROUT FILL	IN SITU WASH/IMMOBILIZE	DECON/STABILIZE
6	MECHANICAL	SLURRY		SLUDGE WASH C	MINERAL/GROUT	VITRIFICATION	REMOVE/IMMOBILIZE	REMOVE/IMMOBILIZE	REMOVE/IMMOBILIZE
7	PNEUMATIC	SLURRY		TRUEX B	SALT/POLYMER	VITRIFICATION	GROUT FILL	IN SITU IMMOBILIZE	IMMOBILIZE
8	MECHANICAL/DECON	SLURRY		SLUDGE WASH B	CERAMIC/GROUT	HIP CERAMIC	DOME FILL	BARRIER ONLY	STABILIZE
9	PNEUMATIC/DECON	SLURRY		TRUEX A	GLASS/SULFUR	VITRIFICATION	DOME FILL	IN SITU WASH	DECON/STABILIZE
10	MECHANICAL	CASK		SLUDGE WASH A	GLASS/CONTAINER	VITRIFICATION	REMOVE/DECON	REMOVE/CHEMICAL	REMOVE/DECON
11	HYDRAULIC	SLURRY		TRUEX A	IN SITU VITRIFICATION	VITRIFICATION	IN SITU VITRIFICATION	IN SITU WASH	DECON/STABILIZE
12	MECHANICAL	CASK		NONE		NONE-SALT/CASK	REMOVE/LANDFILL	REMOVE/LANDFILL	REMOVE/LANDFILL
13	PNEUMATIC	CASK		NONE		VITRIFICATION	REMOVE/THERMAL	REMOVE/THERMAL	REMOVE/THERMAL
14	HYDRAULIC	SLURRY		NONE		CERAMIC PELLETS	REM/DECON/IMMOBILIZE	REM/DECON/IMMOBILIZE	REM/DECON/IMMOBILIZE
<u>SELECTIVE RETRIEVAL ALTERNATIVES</u>									
15	MECHANICAL	CASK	STABILIZE	TRUEX A	SALT/GROUT	VITRIFICATION	DOME FILL	BARRIER ONLY	STABILIZE
16	PNEUMATIC	SLURRY	IN SITU VITRIFICATION	TRUEX A	IN SITU VITRIFICATION	VITRIFICATION	IN SITU VITRIFICATION	IN SITU VITRIFICATION	DECON/STABILIZE

filling the tank voids with rock fill (dome fill) and installing infiltration and intrusion barriers. This alternative is the reference alternative in the HDW-EIS (DOE 1987).

4.1.2.2 Integrated Alternative 3. Integrated Alternative 3 treats the tank waste in place by immobilization. The immobilization solidifies the tank waste by mechanical mixing or injection of solidification agents that bind free liquids and reduce leachability. The remaining voids in the tanks and PPU's are filled with a grout or cementitious fill to prevent future dome collapse. Contaminated soils are immobilized by injection of solidification agents. Infiltration and intrusion barriers are installed to meet requirements for land disposal of hazardous wastes.

4.1.2.3 Integrated Alternative 4. Integrated Alternative 4 treats tank waste, tanks, contaminated soil, and PPU's by ISV. Tank wastes containing reactive compositions of ferrocyanide or organic salts and nitrate are blended to nonreactive compositions with glass formers or soil before vitrification. The resulting vitrified masses each encompass a whole tank farm and result in treated waste of Class C concentrations. The vitrified melts are covered with soil. No hazardous waste remains because all hazardous chemicals in the tank become fixed in the glass ceramic matrix, decompose, or volatilize during vitrification. Infiltration and intrusion barriers to meet DOE orders for LLW disposal are installed for final closure as a LLW radioactive disposal site.

4.1.3 Retrieval and Treatment Alternatives

Ten retrieval and treatment alternatives are defined that retrieve the tank waste and treat the waste for disposal. Three basic retrieval processes with two levels of waste retrieval are included. Seven cases partition the waste into HLW/TRU and LLW fractions before treatment in separate facilities. Three cases assume no partitioning of the retrieved waste with all waste being treated as HLW/TRU for offsite disposal.

The partitioning processes use two basic processes (sludge wash and TRUEX), with three variations of each (A, B, and C). The degree of radionuclide partitioning increases from A to B to C for each partitioning process. The seven integrated alternatives that partition retrieved waste have seven different LLW treatment processes with seven unique LLW forms and corresponding leachability characteristics. The seven partitioning/LLW treatment process combinations are matched so that partitioning processes with the greatest partitioning performance are combined with processes that have the least destruction of hazardous waste components and/or LLW forms that have the highest leach rates.

Closure of tank farms containing empty tanks, contaminated soils, and PPU's is represented by a variety of treatment processes ranging from stabilization or treatment in place to removal and treatment.

4.1.3.1 Integrated Alternative 5. Integrated Alternative 5 retrieves 99.9% of the waste with a hydraulic retrieval system using a freeze barrier to minimize tank leaks and transfers the waste, using slurry, to lag storage and partitioning. The partitioning process, TRUEX C, provides a very high degree

of radionuclide removal from the LLW stream. The LLW is treated for hazardous waste disposal by the baseline DST grout process, which solidifies mixed LLW salts and liquids with a grout formulation.

The HLW fraction is vitrified in the HWVP. Residual contamination on surfaces of the empty tanks is immobilized by a grout fill of the tank voids that prevents future dome collapse. Contaminated soils are washed in situ, and residual wastes are immobilized by in situ injection of solidification agents. The PPU's are decontaminated, and free liquids are removed. The tank farm site is closed as a mixed waste landfill with infiltration and intrusion barriers.

4.1.3.2 Integrated Alternative 6. Integrated Alternative 6 retrieves 99% of the waste with a mechanical retrieval system and then conditions and transfers the waste, using slurry, to lag storage and partitioning. The partitioning process, Sludge Wash C, provides a very high degree of radionuclide removal from the LLW stream. The LLW is calcined for destruction of nitrate, nitrite, and organic hazardous waste constituents. The resulting calcine with leachable metal oxides is solidified within a grout matrix.

The HLW fraction is vitrified in a new high-capacity vitrification facility. The empty tanks, contaminated soil, and PPU's are removed and disposed of in a mixed waste landfill with immobilization by mixing the removed debris with grout. The excavated tank farm site is closed with no restrictions by restoring the soil elevation to grade (e.g., clean closure).

4.1.3.3 Integrated Alternative 7. Integrated Alternative 7 retrieves 99% of the waste with a pneumatic retrieval system and then conditions and transfers the waste, using slurry, to lag storage and partitioning. The partitioning process, TRUEX B, provides a high degree of radionuclide removal from the LLW stream. The LLW is treated for hazardous waste disposal by evaporation of excess water and solidifying residual salts by encapsulation within a polyethylene matrix.

The HLW fraction is vitrified in the HWVP. Residual contamination on surfaces of the empty tanks is immobilized by a grout fill of tank voids that prevents future dome collapse. Contaminated soils and PPU's are immobilized by in situ injection of solidification agents. The tank farm site is closed as a mixed waste landfill by installing infiltration and intrusion barriers.

4.1.3.4 Integrated Alternative 8. Integrated Alternative 8 retrieves 99.9% of the waste with a mechanical retrieval system and then conditions and transfers the waste, using slurry, to lag storage and partitioning. The partitioning process, Sludge Wash B, provides an intermediate level of radionuclide removal from the LLW stream. The LLW is calcined and converted to a ceramic for destruction of nitrate, nitrite, and organic hazardous waste constituents. The resulting ceramic powder is solidified within a grout matrix.

The HLW fraction is converted to a ceramic log using HIP in a new high-capacity facility. The tank farms and PPU's with associated contaminated soil are closed as mixed waste landfills by filling the tank voids with rock fill (dome fill) and installing infiltration and intrusion barriers.

4.1.3.5 Integrated Alternative 9. Integrated Alternative 9 retrieves 99.9% of the waste with a pneumatic retrieval system and then conditions and transfers the waste, using slurry, to lag storage and partitioning. The partitioning process, TRUEX A, provides an intermediate level of radionuclide removal from the LLW stream and is sized to complete the partitioning in a 10-yr period. The LLW is vitrified to produce a glass cullet in a new high-capacity facility (220 MT per day) for destruction of nitrate, nitrite, and organic hazardous waste constituents. The resulting vitrified glass cullet is encapsulated within a sulfur matrix for bulk disposal in a vault as a nonhazardous radioactive LLW.

The HLW fraction is vitrified in the HWVP. The empty tank voids are filled with rock to prevent future dome collapse. Contaminated soils and PPU's are in situ washed and decontaminated, respectively. Final closure of the tank farm site as a mixed waste landfill is performed by installing infiltration and intrusion barriers.

4.1.3.6 Integrated Alternative 10. Integrated Alternative 10 retrieves 99% of the waste with a mechanical retrieval system and transfers the waste, using a cask, to a cask unloading station for lag storage and partitioning. The partitioning process, Sludge Wash A, provides a minimal level of radionuclide removal from the LLW stream. The LLW is vitrified with destruction of nitrate, nitrite, and organic hazardous waste constituents. The resulting LLW glass is cast in large canisters for placement in a nonhazardous LLW disposal site.

The HLW fraction is vitrified in a new, high-capacity vitrification facility that is sized to complete the HLW vitrification in 30 yr. The empty tanks, contaminated soil, and PPU's are removed and decontaminated in a new solid waste treatment facility. The decontamination solutions are transferred to LLW treatment. The decontaminated tank, soil, and PPU debris are disposed of in a mixed waste landfill. The excavated tank farm site is closed with no restrictions by restoring the soil elevation to grade (i.e., clean closure).

4.1.3.7 Integrated Alternative 11. Integrated Alternative 11 retrieves 99% of the waste with a hydraulic retrieval system and slurry transfers the waste to lag storage and partitioning. The partitioning process, TRUEX A, provides an intermediate level of radionuclide removal from the LLW stream. The LLW is treated for hazardous waste destruction and disposal with a liquid injected ISV process that vitrifies the LLW by injection in molten soil.

The HLW fraction is vitrified in the HWVP. Contaminated soils are washed in situ. PPU's are decontaminated, and free liquids are removed. The tank void is filled with soil and vitrified using a portable in situ vitrification process. Decontaminated soils between tanks and more than 60 ft below grade are not vitrified. The tank farm site is closed as a mixed waste landfill by installing infiltration and intrusion barriers.

4.1.3.8 Integrated Alternative 12. Integrated Alternative 12 retrieves 99% of the waste with a mechanical retrieval system and places the waste in a container. A cask transfers the containerized waste to a containerized waste

lag storage vault. The containerized waste lag storage area provides a Class A storage facility that is earthquake and aircraft-crash resistant. No partitioning or treatment is performed.

The lag storage facility provides storage until a new geologic disposal repository is designed and constructed. The new offsite geologic disposal repository is designed to accept the SST salt and sludge waste 'as retrieved' and without conversion to a vitrified form. The containerized waste is loaded into a shielded shipping cask for transport to the geologic disposal facility. The empty tanks, contaminated soil, and PPU are removed and disposed of in a mixed waste landfill. The excavated tank farm site is closed with no restrictions by restoring the soil elevation to grade (i.e., clean closure).

4.1.3.9 Integrated Alternative 13. Integrated Alternative 13 retrieves 99% of the waste with a pneumatic retrieval system and transfers the waste, using a cask, to a cask unloading station for lag storage and treatment. No partitioning of waste is performed. The retrieved tank waste is vitrified in a new vitrification facility with 24 parallel, high-capacity melter lines. The vitrified waste canisters are placed in lag storage and then shipped to a new offsite geologic disposal repository.

The empty tanks, contaminated soil, and PPUs are removed and thermally treated in a new solid waste treatment facility to destroy nitrates, nitrites and organics. The treated tank, soil, and PPU debris are disposed of in a mixed waste landfill. The excavated tank farm site is closed with no restrictions by restoring the soil elevation to grade (i.e., clean closure).

4.1.3.10 Integrated Alternative 14. Integrated Alternative 14 retrieves 99% of the waste with a hydraulic retrieval system and slurry transfers the waste to lag storage and treatment. No partitioning of waste is performed. The retrieved tank waste is converted to ceramic pellets in a new facility and loaded into large volume containers. The canisters, loaded with ceramic pellets, are placed in lag storage and then shipped to a new offsite geologic disposal repository.

The empty tanks, contaminated soil, and PPUs are removed and decontaminated in a new solid waste treatment facility. The decontamination solutions are transferred to LLW treatment. The decontaminated tank, soil, and PPU debris are disposed of in a mixed waste landfill. The treated tank, soil, and PPU debris are disposed of in a mixed waste landfill and are immobilized by mixing the decontaminated debris with grout. The excavated tank farm site is closed with no restrictions by restoring the soil elevation to grade (i.e., clean closure).

4.1.4 Selective Retrieval Alternatives

Selective retrieval alternatives use multiple concepts or technologies to optimize the closure of SSTs. The alternatives previously described treat all tanks and their contained wastes with the same technology. Selective retrieval alternatives retrieve wastes beyond a defined criterion for partitioning and treatment and use in situ treatment for wastes below the

defined cutoff criteria. The fraction of waste treated in situ requires an NRC ruling to establish if residual wastes are classified as LLW or HLW for licensing requirements.

4.1.4.1 Integrated Alternative 15. Integrated Alternative 15 retrieves waste from the 84 tanks in which the TRU concentration exceeds 100 nCi/g of tank wastes. This results in non-TRU Class C waste remaining in the tank farms at closure. A mechanical retrieval system retrieves 99% of the waste from the 84 TRU tanks and transfers the waste, using a cask, to lag storage and partitioning. The partitioning process, TRUEX A, provides an intermediate level of radionuclide removal from the LLW stream. The LLW is treated for hazardous waste disposal by the baseline DST grout process which solidifies mixed LLW salts and liquids with a grout formulation.

The HLW fraction is vitrified in the HWVP. The 65 tanks that have TRU concentrations less than 100 nCi/g of tank wastes are treated in situ with removal of all drainable liquids by drying. Tank voids remaining in all 149 retrieved and non-retrieved tanks are filled with rock to prevent future dome collapse. Final closure of the tank farm site as a mixed waste landfill is performed by installing infiltration and intrusion barriers.

4.1.4.2 Integrated Alternative 16. Integrated Alternative 16 retrieves waste from 18 tanks that have more than 1,000,000 Ci of ⁹⁰Sr in the year 2018 or have more than 1,000 Ci of TRU. A pneumatic retrieval system retrieves 99% of the waste from the 18 tanks and then conditions and transfers the waste, using a slurry, to lag storage and partitioning. The partitioning process, TRUEX A, provides an intermediate level of radionuclide removal from the LLW stream. The LLW is treated for hazardous waste destruction and disposal with a liquid injected in situ vitrification process that vitrifies the LLW by injection in molten soil.

The HLW fraction is vitrified in the HWVP. The 18 empty tanks, the other 131 tanks containing waste, tank farm soils, and PPU's are treated by in situ vitrification. Tank wastes containing reactive compositions of ferrocyanide or organic salts and nitrate are blended to nonreactive compositions with glass formers or soil before vitrification. The resulting vitrified tank farm monoliths are Class B LLW (less than 10 nCi/g) following the vitrification treatment of the hazardous waste constituents.

The ISV processes result in destruction of nitrate, nitrite, and organic hazardous waste constituents. Heavy metal oxides are combined in the melt limiting leachability and meeting the EP toxicity leachate test. The resulting vitrified masses are covered with soil. No hazardous waste remains because all hazardous chemicals in the tank become fixed in the glass ceramic matrix, decompose, or volatilize during vitrification. Infiltration and intrusion barriers to meet DOE orders for LLW disposal are installed for final closure as a LLW radioactive disposal site.

4.2 EVALUATION CRITERIA

The evaluation criteria are based on public acceptance, offsite and onsite safety, environmental releases, regulatory compliance, technical feasibility, compatibility with the Tri-Party Agreement (Ecology et al. 1990),

and costs as discussed in the following sections. Rating factors are provided for each of the evaluation criteria. The numerical ratings from 1 to 5 reflect the performance in meeting the evaluation criteria from the generic "very poor" to "excellent," respectively.

Rating factors for evaluation criteria	
<u>Rating</u>	<u>Criteria Performance</u>
5	Excellent
4	Good
3	Satisfactory
2	Poor
1	Very poor

4.2.1 Public Acceptance

This evaluation criterion relates to public acceptability of the integrated alternative. This rating of alternatives provides an overall rating reflecting perceived public acceptance. Public acceptance ultimately will be rated by the public participation plan described in Appendix A.1.

Rating factors for public acceptance	
<u>Rating</u>	<u>Criteria Performance definition</u>
5	Greater than 98% total radionuclide removal
4	Greater than 94% total radionuclide removal and Class C LLW
3	Greater than 70% total radionuclide removal and Class B LLW
2	No waste removal and in situ treated to Class C LLW
1	No waste removal and greater than Class C or not treated for geologic disposal

4.2.2 Environmental Releases

Environmental releases are evaluated, including long-term or postclosure releases from the final disposed waste forms and short-term or preclosure releases that result from treatment activities.

4.2.2.1 Long-Term (Postclosure)--Performance Assessment. The long-term environmental releases of both hazardous chemicals and radionuclides are developed by performance assessments of all disposal sites used in an integrated alternative. The evaluation is based on summing the fraction of groundwater limits from all radioactive, mixed, and hazardous disposal sites of an integrated alternative. The performance assessments are based on use of an infiltration barrier. The disposal sites include near surface, geologic, onsite, and offsite. This 60% draft sums the contributions from the limiting radionuclide and hazardous chemical, technetium and nitrate, respectively.

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Rating factors for performance assessment	
Rating	Summed fractions of groundwater concentration limit
5	Less than 0.001
4	0.001 to less than 0.01
3	0.01 to less than 0.1
2	0.1 to 1
1	Greater than 1

4.2.2.2 Short-Term (Preclosure)--Chronic. The short-term (preclosure) or chronic releases of chemicals and radionuclides to the environment that result from daily operations of the facility components and offsite shipping are developed for all functions of an integrated alternative. The evaluation is based on the total fraction of SST waste released to the atmosphere by all functions of an integrated alternative over their operating lives.

For the 100% draft of this document, the evaluation will be based on integrated population dose in man-rem for source terms from all functions of an integrated alternative. The integration interval is through completion of the closure mission using wind and population distributions. Man-rem calculations for the 100% draft will include decontamination and decommissioning (D&D) of new facilities required for the integrated alternative and transportation of radioactive waste to offsite geologic disposal. The 100% draft also will include higher atmospheric releases of semivolatile C-14 and I-129 isotopes relating to processing variations.

Rating factors for chronic releases	
Rating	Total atmospheric release, fraction of SST inventory
5	Less than 1E-9
4	1E-9 to less than 1E-8
3	1E-8 to less than 1E-7
2	1E-7 to less than 1E-6
1	Greater than 1E-6

4.2.2.3 Short-Term (Preclosure)--Acute. The short-term (preclosure) or acute environmental releases result from accidents. The short-term acute evaluation is based on the maximum offsite dose resulting from an accidental release in an integrated alternative including D&D. The maximum allowable offsite dose is 25 Rem.

The 100% draft of this document will rate acute releases based on the sum of the products of accident dose times operation life for all operations of an integrated alternative.

Rating factors for acute releases	
<u>Rating</u>	<u>Maximum offsite dose, rem</u>
5	Less than 0.015
4	0.015 to 0.15
3	0.15 to 1.5
2	1.5 to 15
1	15 to 25

4.2.3 Regulatory Compliance

The compliance of the integrated alternatives to applicable regulations is evaluated for both hazardous waste regulations and for radioactive waste regulations, as described in the following sections.

4.2.3.1 Hazardous Wastes. The ability to meet the RCRA land disposal restriction treatment standards of 40 CFR 268, *EPA Regulations on Land Disposal Restrictions* (EPA 1987), and WAC 173-303 *Dangerous Waste Regulations* (Ecology 1989) are evaluated for the integrated alternatives. The rating is based on the priorities of hazardous waste management practices as stated in Revised Code of Washington (RCW) 70.105.150 and WAC 173-303-140, *Land Disposal Restrictions* (Ecology 1989).

Rating factors for hazardous waste regulatory compliance	
<u>Rating</u>	<u>Waste management practice</u>
5	Recycling
4	Physical, chemical, and biological treatment
3	Incineration
2	Stabilization and solidification
1	Landfill or continued storage

4.2.3.2 Radioactive Wastes. The ability to meet NRC regulations on disposal of HLW and the suitability of classifying LLW as incidental wastes are evaluated for the integrated alternatives.

Rating factors for radioactive waste regulatory compliance	
<u>Rating</u>	<u>HLW and LLW disposal</u>
5	LLW is Class B and less than 5% of the SST inventory
4	LLW is Class B
3	LLW is Class C
2	Greater than Class C or requires NRC license for onsite HLW disposal
1	Continued storage

4.2.4 Occupational Safety

Occupational safety concerning reportable accidents and radiological dose to employees are evaluated for the integrated alternatives.

4.2.4.1 Industrial. The health effects on employees from industrial injuries are determined for all integrated alternatives. The industrial safety rating is based on reportable accident rates over the life of the mission for all functions including construction, operation, and D&D.

The 100% draft of this document will include the health effects of offsite waste transportation and offsite geologic disposal construction and operation.

Rating factors for industrial safety	
<u>Rating</u>	<u>Total reportable accidents</u>
5	Less than 5,000
4	5,000 to 10,000
3	10,000 to 15,000
2	15,000 to 20,000
1	Greater than 20,000

4.2.4.2 Radiological Safety. The total man-rem of occupational radiation doses are determined by summing the contributions from all functions of the integrated alternatives. The occupational dose is the integrated dose over the life of the mission including D&D of facilities required by an integrated alternative and is based on the current Hanford Site average of 10 mrem per month. The radiation dose of Hanford Site employees not directly involved in the SST closure mission are included in the short-term chronic release calculations.

The 100% draft of this document will include the occupational radiation dose for waste transportation and disposal operations in an offsite geologic repository. The 100% draft also will be based on projected dose rates for worker classification and activity.

Rating factors for occupational radiological safety	
<u>Rating</u>	<u>Total occupational dose, man-rem</u>
5	Less than 2,000
4	2,000 to 10,000
3	10,000 to 20,000
2	20,000 to 30,000
1	Greater than 30,000

4.2.5 Technical Feasibility

The technical feasibility assesses the status of the technology and corresponding risk of successful development for each of the integrated alternatives. The total technical risk is determined by an assessment of the risks in developing the required technologies for all functional operations required by an alternative. The risk will be based on technology level of demonstration (concept, laboratory demonstrated, pilot, prototype, industrial practice) and probability of successful development on a schedule to meet SST closure milestones for operations in all functions.

Rating factors for technical feasibility	
<u>Rating</u>	<u>Technical Risk</u>
5	Less than A (TBD)
4	Between A and B (TBD)
3	Between B and C (TBD)
2	Between C and D (TBD)
1	Greater than D (TBD)

4.2.6 Schedule Compatibility

The ability to meet the Tri-Party Agreement (Ecology et al. 1990) SST closure milestone is evaluated for all integrated alternatives. The assessments assume an accelerated SEIS with an ROD in 1996.

Rating factors for schedule compatibility	
<u>Rating</u>	<u>Schedule Compatibility</u>
5	SST closure by year 2018, waste treated by year 2018
4	SST closure by year 2018, waste treated by year 2030
3	SST closure by year 2018, waste treatment completed after year 2030
2	SST closure by year 2030, waste treatment completed after year 2030
1	Continued storage

4.2.7 Costs

Capital and operating costs, including transportation costs and geologic disposal fees, are determined and evaluated by summing costs for all functions of the integrated alternatives.

4.2.7.1 Capital. The capital costs of the integrated alternatives are based on summing the capital costs for all functions. Capital requirements by fiscal year will be developed for the 100% draft of this document and included in Appendix D.

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Rating factors for capital costs	
<u>Rating</u>	<u>Total capital costs, billions (1991 dollars)</u>
5	Less than 1.0
4	1 to 5
3	5 to 10
2	10 to 15
1	Greater than 15

4.2.7.2 Operating. The operating costs for the integrated alternatives are developed by summing the operating costs for all functions for the life of the mission. The costs include facility operations, equipment replacement, consumables, support services, interim storage, transportation, disposal fees, and D&D costs for all facilities constructed to support an integrated alternative. Integrated Alternative 1, no action, is based on 100 yr of continued surveillance. Operating costs by fiscal year will be developed for the 100% draft of this document in Appendix D.

Rating factors for operating costs	
<u>Rating</u>	<u>Total operating costs, billions (1991 dollars)</u>
5	Less than 2
4	2 to 10
3	10 to 20
2	20 to 50
1	Greater than 50

4.3 EVALUATION OF INTEGRATED ALTERNATIVES

The evaluation of the integrated alternatives described in Section 4.1 using the criteria and rating factors described in Section 4.2 is presented in the following sections, which discuss the methodology employed, present the numerical results and observations, and present the summary and conclusions.

4.3.1 Methodology

The evaluation and ranking of the 16 integrated alternatives is done with a numerical scoring for each integrated alternative as shown in Table 4-2.

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Each of the 12 identified criteria have been weighted at 0.5 or 1.0 as shown in Table 4-2. The resulting summed weights for the seven major evaluation areas are as follows:

<u>Evaluation Criteria</u>	<u>Weight</u>
Public acceptance	1
Environmental releases	2
Regulatory compliance	2
Occupational safety	1
Technical feasibility	1
Schedule compatibility	1
Costs	<u>2</u>
Total	10

Each of the 16 integrated alternatives are rated on a scale of 1 to 5 for each of the 12 evaluation criteria. The numerical scores of 1, 2, 3, 4, and 5 reflect the relative performance of meeting the evaluation criteria from very poor, poor, satisfactory, good, and excellent, respectively.

The overall ranking or scoring of multiple alternatives depends on the method used for weighing or combining scores of individual criteria. The overall score of each integrated SST closure alternative is determined using two techniques. The summation method adds the ratings for individual criteria. The product method multiplies the ratings for the individual criteria. The product method has the advantage because it shows differences between alternatives that attain equal or similar total scores with the summation method. The product method penalizes or differentiates alternatives that rate poor or very poor in one or a few criteria. A comparison of the two methods in differentiating between similar summation method overall scores is as follows.

Criteria					
Alternative	A	B	C	Sum	Product
First	4	3	3	10	36
Second	4	4	2	10	32
Third	5	4	1	10	20
Fourth	3	3	3	9	27
Fifth	4	3	2	9	24
Sixth	5	2	2	9	20
Seventh	4	4	1	9	16
Eighth	3	3	2	8	18
Ninth	4	2	2	8	16
Tenth	4	3	1	8	12

Table 4-2. Evaluation Matrix for Integrated Single-Shell Tank Closure Alternatives.

	EVALUATION CRITERIA												
	PUBLIC ACCEPTANCE	ENVIRONMENTAL RELEASES				REGULATORY COMPLIANCE		OCCUPATIONAL SAFETY		TECHNICAL FEASIBILITY	SCHEDULE COMPATIBILITY	COSTS	
		LONG TERM - PERFORMANCE ASSESSMENT	SHORT TERM		HAZARDOUS WASTE	RADIOACTIVE WASTES	INDUSTRIAL	RADIOLOGICAL	CAPITAL			OPERATING	
			CHRONIC	ACUTE									
WEIGHT FACTOR	1	1	0.5	0.5	1	1	0.5	0.5	1	1	1	1	
CRITERIA RATING													
EXCELLENT	5	5	5	5	5	5	5	5	5	5	5	5	
GOOD	4	4	4	4	4	4	4	4	4	4	4	4	
SATISFACTORY	3	3	3	3	3	3	3	3	3	3	3	3	
POOR	2	2	2	2	2	2	2	2	2	2	2	2	
VERY POOR	1	1	1	1	1	1	1	1	1	1	1	1	
WEIGHTED SCORE - SUMMATION METHOD													
EXCELLENT	5	5	3.0	2.5	5	5	2.5	2.5	5	5	5	5	
GOOD	4	4	2.0	2.0	4	4	2.0	2.0	4	4	4	4	
SATISFACTORY	3	3	1.5	1.5	3	3	1.5	1.5	3	3	3	3	
POOR	2	2	1.0	1.0	2	2	1.0	1.0	2	2	2	2	
VERY POOR	1	1	0.5	0.5	1	1	0.5	0.5	1	1	1	1	
WEIGHTED SCORE - PRODUCT METHOD													
EXCELLENT	5	5	2.2	2.2	5	5	2.2	2.2	5	5	5	5	
GOOD	4	4	2.0	2.0	4	4	2.0	2.0	4	4	4	4	
SATISFACTORY	3	3	1.7	1.7	3	3	1.7	1.7	3	3	3	3	
POOR	2	2	1.4	1.4	2	2	1.4	1.4	2	2	2	2	
VERY POOR	1	1	1	1	1	1	1	1	1	1	1	1	

For individual criteria that have a weight of 0.5, the numerical ratings are modified to maintain equivalent weighting as shown in Table 4-2. The modifications are one-half of the ratings 1 through 5 for the summation method or the square root of the ratings 1 through 5 for the product method. This results in the combined product or sum being 1 through 5 for two combined 0.5 weights in the overall evaluation.

The final score for an integrated alternative has a potential range of 10 to 50 for the summation method and 1 to about 10,000,000 for the product method as shown.

Ratings	Sum	Normalized sum	Product	Normalized product
5	50	125	10,000,000	1,000
4	40	100	1,000,000	100
3	30	75	60,000	6
2	20	50	1,000	0.1
1	10	25	1	0.0001

The final scores are normalized to 100 for all evaluation criteria being rated at 4 by dividing the final sum or product by 0.4 or 10,000, respectively.

4.3.2 Results

Input values used to determine ratings for selected evaluation criteria are presented in Table 4-3. The results of evaluating the 16 integrated alternatives are presented in Table 4-4 and Table 4-5. A discussion of the observations is provided in Section 4.3.3.

(Note - This 60% draft document provides ratings in Table 4-3 based on engineering data and engineering judgement on partially completed packages. Final ratings and overall scoring for the 100% draft of this document will be developed based on completion of engineering work.)

The ratings of the alternatives for each criterion are discussed in Appendix D. Evaluations of the individual functions and their technology options are provided in Chapters 5.0 through 11.0.

4.3.3 Observations

Analysis of the evaluation data reveals that two attributes are drivers in the overall ranking of integrated alternatives: (1) residual wastes left in the tanks after retrieval, soil contaminated from previous leaks, and residual wastes in PPU's, and (2) LLW form, including partitioned LLW, residual tank wastes, soil, and PPU's.

The residual waste in tanks after retrieval assumes either 1.0 or 0.1% of the initial tank inventory. The combined contaminated soil and PPU inventory

Table 4-3. Criteria Values for Integrated Single-Shell Tank Closure Alternatives.

ALTERNATIVE	ENVIRONMENTAL RELEASES								COSTS	
	LONG TERM - PERFORMANCE ASSESSMENT FRACTION OF GROUND WATER LIMIT			SHORT TERM		OCCUPATIONAL SAFETY		CAPITAL	OPERATING	
	TECHNETIUM	NITRATE	TOTAL	CHRONIC	ACUTE	INDUSTRIAL	RADIOLOGICAL	BILLIONS	BILLIONS	
				FRACTION SST WASTE INVENTORY RELEASED	MAXIMUM OFFSITE DOSE, REM	REPORTABLE ACCIDENTS	MAN REMS			
DEFERRED ACTION										
1	2.10	4.80	6.9	1.0E-07	15	3.758	13,500	0.0	5.8	
IN SITU ALTERNATIVES										
2	2.10	4.80	6.9	1.0E-09	15	2.100	1,039	0.8	1.4	
3	1.84	4.20	6.0	1.0E-09	1.5	2.823	1,890	1.8	2.1	
4	9E-07	0.0	9.0E-07	1.0E-08	0.3	2.823	1,890	2.1	1.8	
RETRIEVE AND TREAT ALTERNATIVES										
5	1E-02	1.30	1.3	3.1E-08	0.14	22,058	18,489	13.3	24.7	
6	3E-02	9E-02	1.1E-01	3.1E-08	1.5	18,884	17,745	12.0	29.7	
7	2E-02	9E-02	1.0E-01	3.1E-08	0.14	18,234	22,430	8.8	30.8	
8	1E-02	5E-02	6.0E-02	3.1E-08	1.5	14,489	15,451	8.8	17.7	
9	4E-03	1E-02	1.8E-02	3.1E-08	0.14	15,245	18,284	7.7	20.0	
10	2E-03	8E-03	1.0E-02	3.1E-08	0.14	18,895	21,591	13.3	26.8	
11	2E-03	1E-02	1.2E-02	3.1E-08	0.14	11,849	14,404	8.8	19.2	
12	2E-02	9E-02	1.1E-01	4.1E-08	1.5	11,076	9,828	14.7	18.5	
13	2E-02	5E-03	2.8E-02	2.1E-08	0.14	13,884	25,380	17.3	84.8	
14	4E-02	1E-02	5.1E-02	2.1E-08	0.14	16,408	23,258	10.2	112.0	
SELECTIVE RETRIEVAL ALTERNATIVES										
15	0.58	2.10	2.7	2.8E-08	15	9,380	10,948	7.8	17.5	
18	8.0E-07	0.00	8.0E-07	2.6E-08	0.3	10,823	9,311	5.2	8.0	

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Table 4-4. Evaluation Criteria Ratings of Integrated Single-Shell Tank Closure Alternatives.

Alternative	Evaluation criteria											
	Public acceptance	Environmental releases			Regulatory compliance		Occupational safety		Technical feasibility	Schedule compatibility	Costs	
		Long-term performance assessment	Short-term		Hazardous waste	Radioactive waste	Industrial	Radio-logical			Capital	Oper-ating
			Chronic	Acute								
Deferred action												
1	1	1	2	1	1	1	5	3	5	1	5	4
In situ alternatives												
2	1	1	4	1	2	2	5	5	4	5	5	5
3	1	1	4	2	2	2	5	5	5	5	4	5
4	2	5	3	3	4	2	5	5	3	5	4	5
Retrieve and treat alternatives												
5	5	1	3	4	2	5	1	3	3	3	2	2
6	5	2	3	2	3	5	2	3	3	3	2	2
7	5	2	3	4	2	5	2	2	4	3	3	2
8	5	3	3	2	4	5	3	3	2	3	3	3
9	5	3	3	4	4	5	2	3	3	3	3	3
10	5	3	3	4	4	5	2	2	4	3	2	2
11	5	3	3	4	4	5	3	3	3	3	3	3
12	1	2	3	2	2	5	3	4	2	3	2	3
13	5	3	3	4	4	5	1	2	4	3	1	1
14	5	3	3	4	4	5	2	2	2	3	2	1
Selective retrieval alternatives												
15	4	1	3	1	2	3	4	3	4	3	3	3
16	3	5	3	3	4	4	3	4	3	4	3	4

Table 4-5. Evaluation of Integrated Single-Shell Tank Closure Alternatives.

Alternative	Summation method		Product method	
	Sum	Normalized sum	Product	Normalized product
Deferred action				
1	24.5	61	548	0.1
In situ alternatives				
2	32.5	81	20,000	2.0
3	33.0	83	28,284	2.8
4	38.0	95	360,000	36.0
Retrieval and treatment alternatives				
5	28.5	71	10,800	1.1
6	30.0	75	32,400	3.2
7	31.5	79	49,883	5.0
8	33.5	84	119,045	11.9
9	35.0	88	206,192	20.6
10	33.5	84	99,766	10.0
11	35.5	89	252,533	25.3
12	26.0	65	6,109	0.6
13	31.0	78	17,636	1.8
14	30.5	76	24,942	2.5
Selective retrieval alternatives				
15	28.5	71	15,552	1.6
16	36.5	91	359,158	35.9

represents approximately 0.5% of the total SST waste inventory. Thus, the total waste in the tank farm after retrieval is 1.5 or 0.6% of the initial inventory. If retrieved waste is partitioned, approximately 1% of the radionuclides report to the LLW fraction for onsite disposal. The total onsite disposal for retrieval cases is 2.5 to 1.6% of the initial waste. Tank residues, soil, and PPU's represent approximately one-half the total onsite disposal and partitioned LLW represents one-half.

The waste forms for onsite disposal have a significant impact on the performance assessment as described in Chapter 7.0. The waste forms for partitioned LLW, tank residuals, soil, and PPU's have ranges of up to six orders of magnitude in impact on long-term performance assessment. Increasing partitioning performance by a factor of 10 from 99% to 99.9% of radionuclides reporting to HLW with no change in tank farm residues will reduce total radionuclides to the groundwater by less than 50%.

The net result of combining the two principal SST closure drivers is that reduction of releases from residual wastes, soil, and PPU's is more effective than increasing the partitioning performance on retrieved wastes. This is reflected in the evaluation of the 16 integrated alternatives to the point that retrieval of zero or 75% SST wastes in Alternatives 4 and 16, respectively, rate high because of the superior performance of low leach rate glass waste forms of tank farm residues and the partitioned LLW.

Analysis of the engineering data developed for the 60% draft reveals that a significant reduction in onsite disposal of technetium and long-term releases (performance assessment) with little increase in costs can be made by definition of an additional TRUEX option. The 100% draft of this document will include a TRUEX D option that substitutes anion exchange technetium recovery from alkaline supernatant for the uranium recovery and purification in TRUEX A. The TRUEX D option will be used in integrated Alternatives 9, 11, and 16. The TRUEX A alternative represents technology used in the current DST baseline and will be used in integrated Alternative 15.

Integrated Alternative 16 has available time in the SST waste processing schedule to allow processing of DST waste including NCAW supernatant, complexant concentrate (CC), and double-shell slurry feed (DSSF). The current DST baseline does not provide technetium removal from NCAW supernatant, CC, or DSSF and does not provide TRU or cesium removal from DSSF. The limiting radionuclide for DST grout disposal is technetium. Technetium distribution in DST tank wastes is currently estimated at 60 to 90% of the total site inventory. Processing of DST wastes through Alternative 16 with the proposed TRUEX D process reduces technetium in the total site LLW disposal by a factor of approximately 100. The improved LLW form, glass versus grout with vapor diffusion barrier, reduces concentrations in the groundwater by a factor of 100 or more. Use of integrated Alternative 16 to process DST wastes results in the following:

- Addition of 3 to 5 yr to the SST processing schedule
- Reduction of DST technetium concentration in the groundwater by a factor of approximately 10,000 or more

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- Elimination of organics, nitrate, and nitrite from onsite disposal of DST LLW
- Good schedule integration of DST and SST wastes processing with the DST rebaseline study proposal. The DST rebaseline proposes in-tank sludge wash of NCAW sludge and high silica 106-C and 241-AY-101 solids to provide HWVP feed through year 2008.

4.4 SUMMARY AND CONCLUSIONS

The summary and conclusions resulting from analysis of the integrated alternative evaluation are provided in the following sections.

4.4.1 Summary

The results of evaluating the integrated SST Closure Alternatives presented in Table 4-4 can be summarized (see Table 4-6) by discussing three groups of alternatives.

Group 1 alternatives defer or dispose of untreated SST wastes as a mixture of soluble salts and sludge. These alternatives are unattractive to the public for long-term closure. Alternative 1 is not proposed as a closure method but is included as a reference for comparison. Alternative 12 is likely to be unacceptable to the public because it merely transports the untreated waste to another state for disposal in a new geologic repository.

Group 2 alternatives represent the middle ground of alternatives with higher release-rate waste forms for onsite disposal and intensive retrieval and treatment operations resulting in higher chronic releases, higher personnel exposure, higher accident potential, higher technical development risk, and higher costs. The intermediate overall scores are even with the retrieved waste partitioning processes, which have superior performance.

Group 3 alternatives rate high as a result of maximum treatment of residual tank wastes, soils, and PPU's. Alternatives 4, 11, and 16 treat these waste forms using in situ vitrification to produce the maximum performing waste form. Alternative 9 provides maximum treatment of these waste forms by greater than 99.9% waste retrieval (effectively decontaminating the tank internal surfaces), in situ washing of soil to retrieve previous tank waste leaks, and decontamination of PPU's. All group three alternatives treat the bulk hazardous waste constituents by conversion to glass. This results in destruction of hazardous nitrates, nitrites, and organics, and converts heavy metals to low leach rate glass/ceramics. Alternatives 4, 11, and 16 use in situ vitrification. Alternative 9 uses a high-capacity glass melter and encapsulation of glass cullet in a sulfur cement matrix.

Process and operating schedule comparisons of Group 3 alternatives are summarized in Table 4-7. Alternatives 9, 11, and 16 use the TRUEX A partitioning process and the HWVP for HLW vitrification. Alternative 4 treats all waste with no partitioning and in situ vitrification. Alternatives 4 and

Table 4-6. Alternatives Grouping.

Group	Normalized sum	Normalized product	Integrated alternatives
1	<68	<1	1, 12
2	68 to 86	1 to 15	2, 3, 5, 6, 7, 8, 10, 13, 14, 15
3	>86	>15	4, 9, 11, 16

Table 4-7. Group 3 Integrated Alternatives Process Summary.

Alternative	Tanks retrieved	Process					Operating period, years
		Partition	LLW	HLW	Tank	Soil	
16	18	TRUEX A	ISV	HWVP	ISV	ISV	12
11	149	TRUEX A	ISV	HWVP	ISV	Wash	35
9	149	TRUEX A	Glass/S	HWVP	Decon	Wash	35
4	None	None	ISV	ISV	ISV	ISV	8

HWVP = Hanford Waste Vitrification Plant.

ISV = in situ vitrification.

LLW = low-level waste.

TRUEX = transuranic extraction.

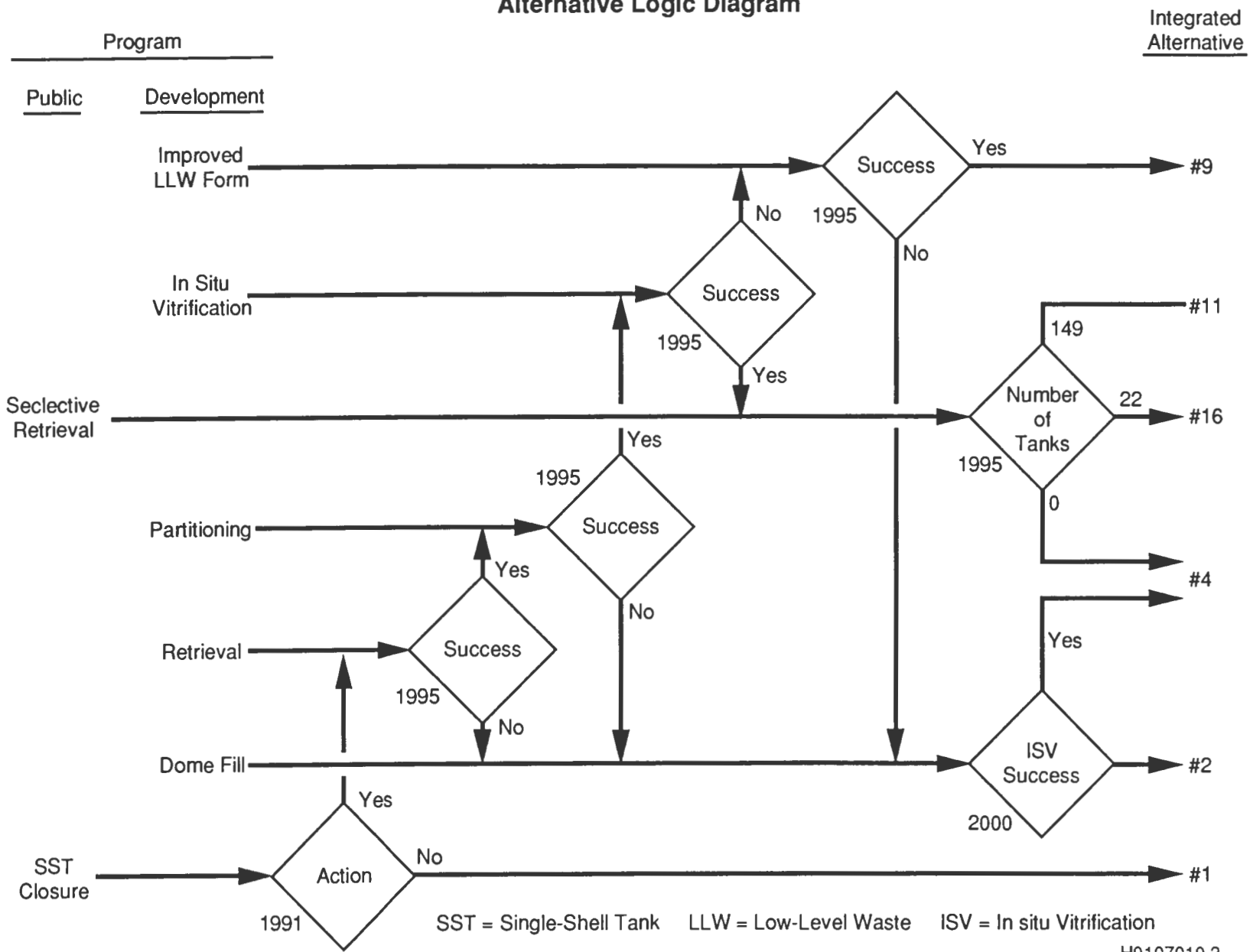
16 effectively complete the SST mission in an 8- to 12-yr operating period. Alternatives 9 and 11 require a 35-yr operating period. The programmatic risk of schedule impacts on operating periods or meeting Tri-Party Agreement milestones (Ecology et al. 1990) because of potential delays in formulating final agreement with the NRC and the public concerning radioactive waste regulations is not addressed in this study.

4.4.2 Conclusions

The recommended alternatives to be included in the SEIS for further evaluation (Figure 2-6) are the Group 3 alternatives (integrated Alternatives 4, 9, 11, and 16), the HDW-EIS (DOE 1987) reference alternative (Integrated Alternative 2) and the required no-action alternative (Integrated Alternative 1).

Figure 4-1 presents the alternatives available for SST closure based on programmatic success of public participation and technology development programs. Programmatic success includes timely provision of resources in addition to technical success. If the retrieval or partitioning programs fail, Alternatives 2 or 4 become the baseline SST closure based on failure or success of ISV, respectively. If retrieval and partitioning programs succeed

Supplemental Environmental Impact Statement Alternative Logic Diagram



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Figure 4-1. Supplemental Environmental Impact Statement Alternative Logic Diagram.

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and the ISV program fails, Alternative 9, with 149 tank retrieval, is the baseline SST closure assuming success of the improved LLW form program. If both the ISV and improved LLW form programs fail, Alternative 2 is the baseline SST closure method. If the retrieval, partitioning, and ISV programs are successful, the public participation program will be the primary factor in determining the number of tanks retrieved for treatment (0, 22, or 149 for Alternatives 4, 16, or 11 respectively).

For maximum programmatic flexibility, Alternative 16 and the onsite disposal technology option for Alternative 9 is the recommended technology development baseline for SST closure. Alternative 16 uses selective retrieval to retrieve 75% of the radionuclides, vitrifies all waste, meets Tri-Party Agreement milestones (Ecology et al. 1990), and provides significant improvements to the DST waste processing mission.

4.5 REFERENCES

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