TANK WASTE DISPOSAL PROGRAM REDEFINITION

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ABSTRACT

The record of decision[1] (ROD) (DOE 1988) on the Final Environmental Impact Statement, Hanford Defense High-Level, Transuranic and Tank Wastes, Hanford Site, Richland, Washington[2] identifies the method for disposal of double-shell tank waste and cesium and strontium capsules at the Hanford Site. The ROD also identifies the need for additional evaluations before a final decision is made on the disposal of single-shell tank waste. At the time of the ROD, the plan was to pretreat double-shell tank waste at B Plant, an existing Hanford Site facility. Recent developments in the regulatory area and increased public interest in the activities conducted on U.S. Department

[1]*DOE, 1988, "Final Environmental Impact Statement for the Disposal of Hanford Defense High-Level, Transuranic, and Tank Wastes, Hanford Site, Richland, Washington; Record of Decision," Federal Register, Vol. 53, No. 72, pp. 12449-12453, U.S. Department of Energy, Washington, D.C.*

[2]*DOE, 1987, Final Environmental Impact Statement, Disposal of Hanford Defense High-Level, Transuranic and Tank Wastes, Hanford Site, Richland, Washington, DOE/EIS-0113, Vol. 1 through 5, U.S. Department of Energy, Washington, D.C.*

of Energy sites have made it prudent to reevaluate the facilities, processes, and timing for pretreatment and disposal of all Hanford Site tank wastes.

This document presents the results of a systematic evaluation of the present technical circumstances, alternatives, and regulatory requirements in light of the values of the leaders and constituents of the program. It recommends a three-phased approach for disposing of tank wastes. This approach allows mature technologies to be applied to the treatment of well-understood waste forms in the near term, while providing time for the development and deployment of successively more advanced pretreatment technologies. The advanced technologies will accelerate disposal by reducing the volume of waste to be vitrified. This document also recommends integration of the double- and single-shell tank waste disposal programs, provides a target schedule for implementation of the selected approach, and describes the essential elements of a program to be baselined in 1992.

The methodology used to identify the selected approach incorporated the interests of several stakeholder groups beyond the immediate U.S. Department of Energy community. The values of the States of Washington and Oregon as well as the Yakima Indian Nation were considered. This process of stakeholder involvement, combined with a systematic multiattribute utility analysis, showed that the selected strategy satisfies a broad range of stakeholder values and interests. This process also identified further actions that would increase public support for the overall mission of Hanford Site cleanup.

EXECUTIVE SUMMARY

BACKGROUND

In accordance with the *National Environmental Policy Act of 1969*, an environmental impact statement, the *Final Environmental Impact Statement, Disposal of Hanford Defense High-Level, Transuranic and Tank Wastes, Hanford Site, Richland, Washington* (HDW-EIS) (DOE 1987), was prepared for the treatment and disposal of the tank wastes stored at the Hanford Site. The HDW-EIS was published in 1987, and the associated record of decision (ROD) (DOE 1988) was issued in 1988.

The ROD places the Hanford Site wastes addressed in this document into three categories: double-shell tank (DST) waste, single-shell tank (SST) waste, and cesium and strontium capsules. The following discussion is illustrated in Figure ES-1.

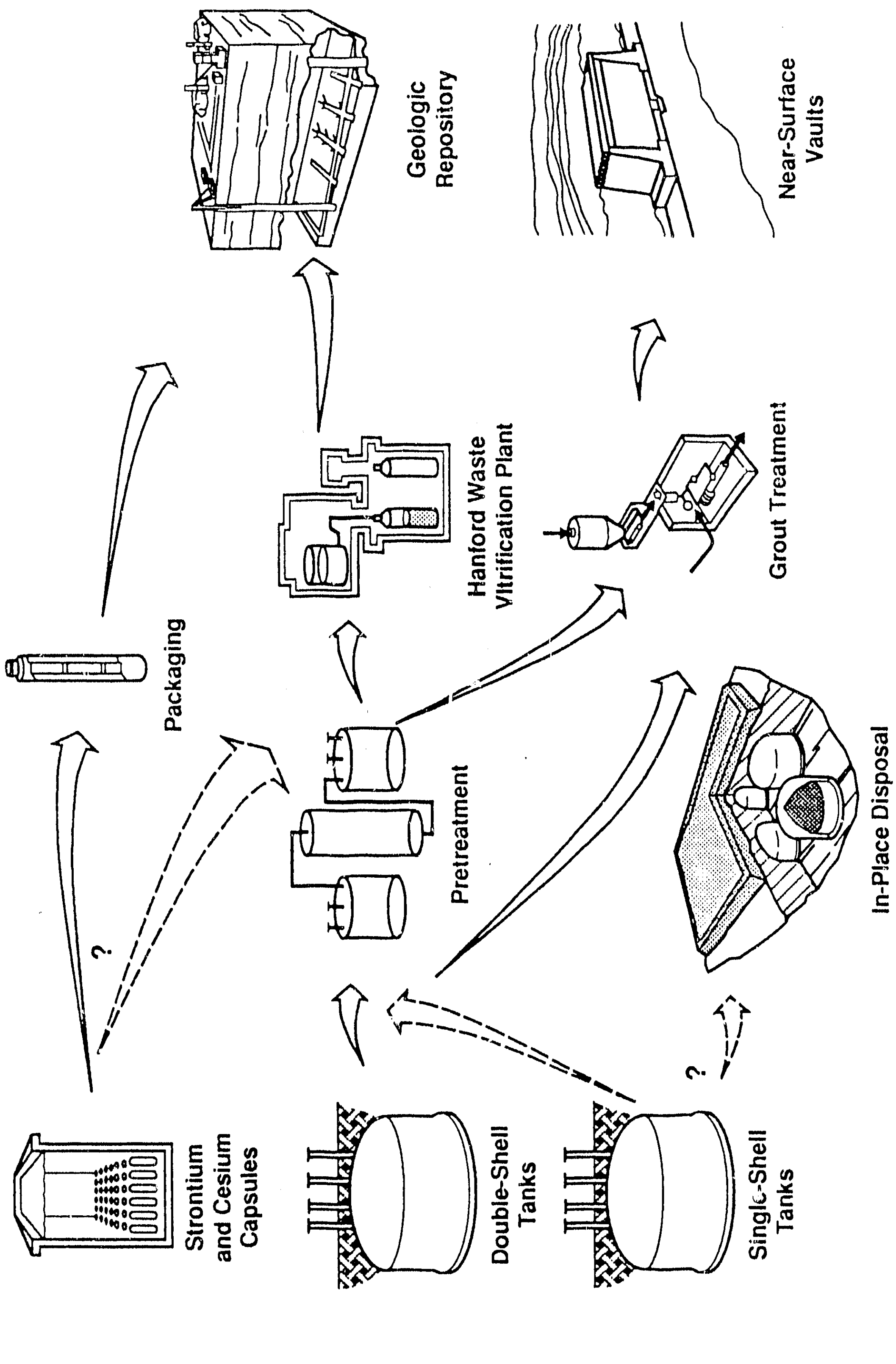
Under the provisions of the ROD, the first category, DST waste, will be pretreated to separate it into a high-level and transuranic (TRU) fraction and low-level waste (LLW) fraction. The high-level waste (HLW) fraction will be processed into a borosilicate glass waste form in the Hanford Waste Vitrification Plant (HWVP) and stored onsite until a geologic repository is built and ready to receive it. The LLW fraction will be solidified as a cement-based grout and disposed of in near-surface vaults. In the ROD, B Plant is mentioned as the current planning base for the pretreatment facility.

The ROD deferred a decision on the final disposal of the second category, SST waste, pending additional development and evaluation (DOE 1988). The results are to be analyzed and recorded in subsequent environmental documentation including a supplement to the HDW-EIS. While not specifically addressing final disposal of SST wastes, the ROD required that the HWVP be capable of processing Hanford Site SST wastes should a decision be made to vitrify these materials.

The third category is cesium and strontium capsules, which presently are stored at the Hanford Site in the Waste Encapsulation Storage Facility. The ROD recommended this waste be packaged in accordance with waste acceptance specifications before being shipped to a geologic repository. Regulatory requirements and recent information on repository waste acceptance specifications, however, have created the possibility that the capsules might have to be disassembled, and the cesium and strontium salts introduced into the high-level feed to the HWVP.

The *Hanford Federal Facility Agreement and Consent Order* (Tri-Party Agreement) (Ecology et al. 1990) established a timetable for implementing the ROD. Major milestones defined in the Tri-Party Agreement included completion of 14 grout campaigns (September 1994), initiation of B Plant pretreatment operations (October 1993), and initiation of HWVP operations (December 1999). A milestone was also established to complete closure of all 149 SSTs (June 2018).

Figure ES-1. Hanford Site Waste Management Program.



In preparation for disposing of waste in accordance with the ROD, modifications have been initiated in B Plant to bring it into compliance with current U.S. Department of Energy (DOE) orders, environmental regulations, and operational standards. In addition, the HWVP design has progressed to the point that construction activities can begin in April 1992.

NEED FOR PROGRAM REEVALUATION

The overall objective of the tank waste disposal program is the timely cleanup of tank waste. Since the original decision to proceed with the waste disposal mission, several new factors have altered the situation at the Hanford Site and within the DOE. These factors have made it prudent to reevaluate present plans for waste pretreatment and disposal. This report documents the reevaluation and the resulting recommendations.

When the original decision was made to use B Plant and other existing Hanford Site facilities to support the waste pretreatment mission, government facilities were not subject to hazardous waste laws, such as the *Resource Conservation and Recovery Act of 1976* (RCRA). As a result, possible shortcomings with existing facilities were thought to be manageable because compliance or equivalency could be demonstrated easily if modifications were made to address the then known problems. In addition, the decision on facility requirements, operating procedures, and timing was believed to rest primarily within the DOE and its congressional interfaces.

Recent developments have placed the DOE waste disposal program at the Hanford Site under closer public scrutiny and changed the regulatory environment in which the DOE and its contractors must function. In addition, budgetary limitations have increased competition for capital and operating funding at all of the DOE sites. Thus, the pretreatment (i.e., facility and process) of the tank waste disposal process has been questioned. Therefore, not only the facility configuration but also the timing of the entire disposal program at the Hanford Site is being reevaluated.

Other major factors affecting the reevaluation of the disposal activity are as follows.

- New construction and operating standards have been implemented for DOE facilities [e.g., DOE Order 6430.1A (DOE 1989)]. These standards significantly increase the cost of building, upgrading, staffing, and operating both new and existing facilities.

- Parties external to the DOE have legally entitled or historically vested interests in Hanford Site activities. The involvement of these stakeholders requires that a dialogue be established and maintained during both the decision-making and execution phases of the program.

- The low probability of bringing B Plant and other existing facilities into compliance with the new regulatory environment was highlighted during the *Hanford Waste Vitrification Systems Risk Assessment-Final Report* (Miller et al. 1991). This document showed that one of the most significant risks associated with the waste vitrification program was that existing facilities may not be permitable under the current Washington (State) Administrative Code.

OBJECTIVE AND DELIVERABLE ITEMS

Objective. The objective of this program redefinition is to develop a Hanford Site tank waste disposal strategy that accomplishes the following:

- Implements the HDW-EIS (DOE 1987) by producing terminal waste forms of borosilicate glass and grout
- Supports the December 1999 startup date for HWVP, if achievable
- Provides a cost-effective program, while minimizing technical and schedule risks
- Uses mature technology while maintaining flexibility to incorporate new technology when advantageous to do so
- Focuses the development of new technology to meet program requirements if existing technology cannot
- Provides a robust strategy that can accommodate all Hanford Site tank wastes and has sufficient technical and programmatic merit to survive future challenges
- Maximizes the satisfaction of stakeholders' values and provides continuing stakeholder involvement in future program evolution
- Provides high confidence in near-term activities while allowing sufficient time for development of future program needs.

Deliverable Items. The deliverable items from this activity include the following, which are contained in this document, together with sufficient backup material to support the conclusions:

- A recommended plan as well as a process and feed configuration to ensure the successful disposal of all Hanford Site tank wastes
- A summary program or target schedule that will be confirmed and baselined within one calendar year of a formal decision
- Cost estimates sufficient to distinguish between alternatives and to provide budgetary support to the fiscal year (FY) 1992 and 1993 budget submittals
- Development needs in the following areas:
  - Characterization
  - Retrieval
  - Pretreatment facilities

  - Pretreatment process technology
  - Low-level and high-level waste disposal technology.
- Identification of key constraints and decision points affecting the program.

METHODOLOGY

Alternatives Considered. The program redefinition focused on waste pretreatment concepts that embodied the previously stated objectives. Sixteen facility and process alternatives were developed that represent a broad range of options to accomplish disposal of Hanford Site tank wastes. The alternatives included the use of existing facilities [DSTs, B Plant, 244-AR Vault, Plutonium-Uranium Extraction (PUREX) Plant], expansion of the HWVP design to incorporate pretreatment elements, and construction of a new pretreatment facility (NPF). In conjunction with facility alternatives, pretreatment processes considered were sludge washing, filtration, ion exchange, intermediate processes (e.g., leaching of waste constituents critical to the waste loading in glass), transuranic extraction (TRUEX) process, and other advanced separation concepts (e.g., strontium extraction, technetium ion exchange). Candidate wastes for pretreatment included DST and SST wastes as well as encapsulated cesium and strontium salts. The potential application of pretreatment processes in the aforementioned facilities is shown in Figure ES-2. Disposal alternatives for SST and DST wastes were integrated to establish the scope of facilities and pretreatment processes. This is necessary to address the entire tank waste inventory at the Hanford Site. A more comprehensive description of the alternatives is provided in Section 6.6.

Evaluation of Alternatives. An integrated systems approach was used to evaluate facility and process alternatives for disposal of Hanford Site tank wastes. The basic steps in this evaluation process are identified in Figure ES-3. A unique aspect of this evaluation process was the involvement of stakeholders who are not in the immediate DOE community. This was deemed prudent because of the Tri-Party Agreement (Ecology et al. 1990), the increased awareness and concerns of the DOE activities around the country, and increased public involvement in Hanford Site activities. The stakeholder groups involved were the following:

- The States of Washington and Oregon
- U.S. Environmental Protection Agency
- Yakima Indian Nation
- Westinghouse Hanford Company and Pacific Northwest Laboratory
- U.S. Department of Energy-Headquarters
- U.S. Department of Energy Field Office, Richland.

While not an exhaustive representation of all regional entities who have an interest in Hanford Site activities, this group was felt to represent a

Figure ES-2. Waste Pretreatment Alternatives.

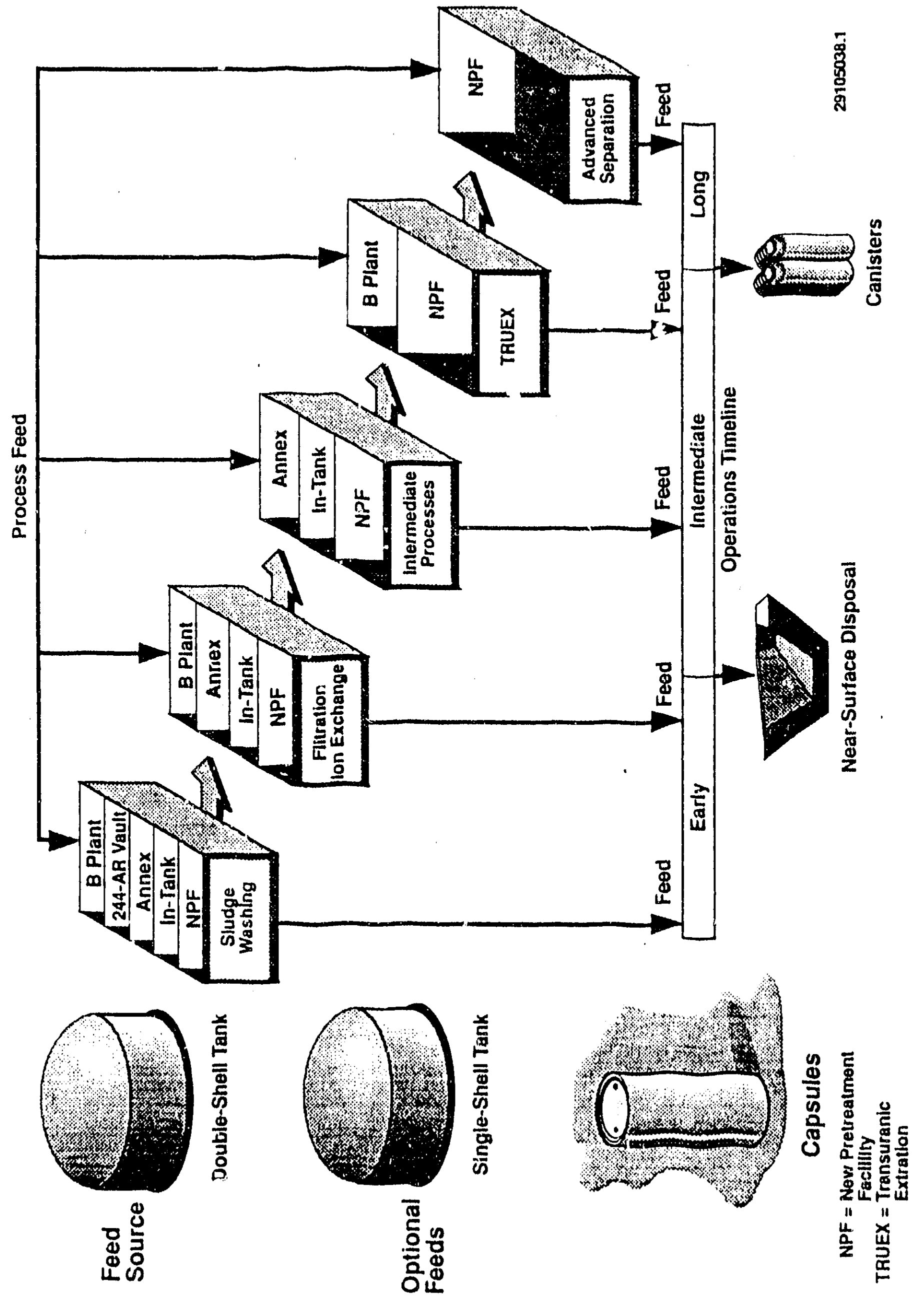
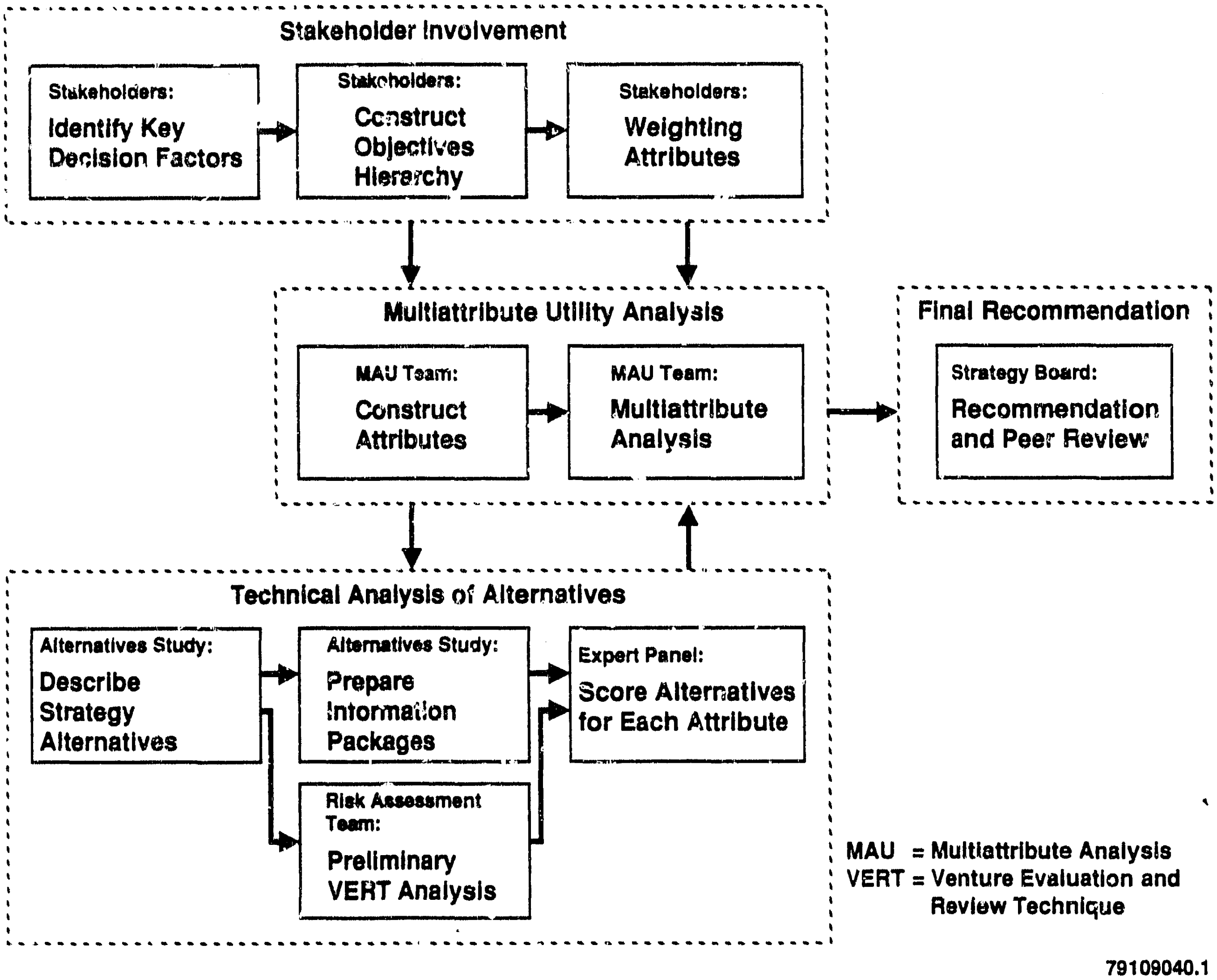


Figure ES-3. Decision Process for Program Redefinition.



diverse set of interests such that their values would represent a significant fraction of the region's interests. It is anticipated that future activities will involve a significantly expanded stakeholders group.

These six stakeholder groups established and confirmed a set of values that were used to compare the technical performance of the facility and process alternatives. These values fell into three general categories: (1) environmental, health, and safety; (2) technical integration; and (3) schedule and cost.

The facility and process alternatives were evaluated by a multiattribute utility analysis technique. This technique rates the alternative by strength as defined by the alternatives' performance score against the stakeholders' attributes and the relative importance of the value as determined by the stakeholder. A sensitivity analysis was also performed to determine which stakeholder values had the greatest effect on the resultant alternative ranking.

In conjunction with the multiattribute utility analysis, a venture evaluation and review technique was conducted for each alternative. The risk, including time and confidence level, to the successful application of the required program element (e.g., retrieval, pretreatment) was evaluated. The resultant ranking of alternatives showed a high correlation between those shown to satisfy stakeholders' values and those with a relatively low degree of risk to achieve successful tank waste disposal.

From these evaluations, a recommendation was formulated and reviewed by an independent peer review panel consisting of national and international experts in the field of radioactive waste management. The comments and concerns of the review panel have been embodied in the following conclusions and recommendations.

CONCLUSION

The results of the multiattribute utility analyses showed the stakeholders place high values on proceeding in a timely manner and being environmentally sound, safe, cost-effective, technically correct, and compliant with all applicable laws and regulations.

Technical and regulatory (i.e., programmatic) risks exist for such items as the development of intermediate and advanced pretreatment technologies, acceleration of an ROD on a supplemental environmental impact statement (SEIS), and availability of funding for major capital projects. These risks can be managed through the adoption of a time-phased approach, based upon development, demonstration, and deployment of more advanced technologies to accelerate disposal by reducing the volume of wastes to be vitrified. In the near term, well understood technologies applied for pretreatment and disposal of characterized wastes will be used.

RECOMMENDATIONS

The evaluation of facility and process alternatives using the attributes and values obtained from the stakeholders and subsequent validation by the independent review panel has produced the following recommended strategy for disposal of tank wastes. Continued involvement of stakeholder groups will build institutional support for the Hanford Site tank waste remediation program and this strategy.

The principal element of the recommended strategy is the time-sequenced disposal of tank wastes based on the implementation of pretreatment technology in three overlapping phases. Flexibility in the program is achieved by the ability to vary the overlap in adjacent phases consistent with the degree of success in technology development.

In the near term, mature technologies (i.e., sludge washing and cesium ion exchange) will be applied to alkaline PUREX Plant wastes to provide early feed to the HWVP. Early pretreatment will be accomplished in existing DSTs and/or in new facilities procured with a minimum impact to near-term capital and total program life-cycle costs. This phase uses proven technologies in which there is a high level of technical and programmatic confidence. With the use of these technologies, current research indicates sufficient feed exists to operate the HWVP without interruption until approximately the year 2010.

The overlapping intermediate phase can be initiated upon successful development and demonstration of more aggressive in-tank pretreatment processes. Intermediate-term pretreatment will be accomplished either by the implementation of process technologies for leaching of chemical constituents critical to the waste loading in glass, and/or by waste blending to reduce the impact of critical constituents on the number of canisters of vitrified waste produced. Other approaches to reduce glass canister requirements are under development. These intermediate processing technologies will be applied to waste in selected DSTs and will be accomplished primarily in-tank. The application of intermediate technologies provides the ability to maintain feed to the HWVP during the development of advanced pretreatment technologies and potentially the construction of a major NPF, if necessary.

In the long term, pretreatment of tank wastes will be accomplished in a new facility using advanced separation technologies, such as the TRUEX and strontium extraction processes, as well as technologies for the destruction of organic complexants.

The long-term phase overlaps the intermediate phase and has the goal of completing SST closure by 2018. If all SST waste is assumed to be retrieved, pretreated, and vitrified or grouted, as appropriate (the conservative case), the Tri-Party Agreement (Ecology et al. 1990) milestone for closure of SSTs by 2018 will be achieved if the following occur.

- The SEIS and ROD are accelerated and completed in 1996.
- The SST waste is disposed of selectively before the DST wastes.
- An NPF is online by the year 2007.

As a result of these uncertainties, the FY 2018 milestone is considered to be at risk under the current planning case. Additional work to mitigate this risk will be conducted during the detailed implementation planning.

Other major elements of the strategy are described as follows.

The B Plant, 244-AR Vault, and other existing Hanford Site processing plants are excluded from further consideration as waste pretreatment processing facilities because of the high risk in achieving environmental compliance. The B Plant continues to function in support of the Waste Encapsulation and Storage Facility for capsule storage and pilot-plant missions until these functions can be transferred to a replacement facility.

The tank waste disposal program will integrate the disposal of DST and SST wastes. Waste in SST 241-C-106 and possibly waste in other SSTs will be retrieved and pretreated as part of the near-term strategy with the goal of enhancing tank safety. Increased continuity of HWVP operations will be provided by treatment and vitrification of these wastes. In the long term, the NPF will have the capability to process both SST and DST wastes. Integration of the SST and DST waste disposal programs allows for optimization of the pretreatment process and more efficient disposal of both SST and DST wastes.

The capability to remove cesium from supernatant and sludge-washing solutions will be incorporated into the design of the HWVP and will be available concurrent with the start of HWVP operations. The neutralized current acid waste (NCAW) contains approximately 80 percent of the radioactive inventory (i.e., curies of radioactive elements) present in DSTs. The NCAW supernatant and sludge-washing solutions will contain approximately 40 percent of the radioactive inventory present in DSTs. Early cesium ion exchange is needed to complete the disposal of NCAW as opposed to the continued interim storage and handling of the waste.

The start of HWVP construction (site preparation activities) will proceed in accordance with the current Tri-Party Agreement (Ecology et al. 1990) milestone, April 1992. The HWVP radioactive operations will be delayed a minimum of 15 months to allow incorporation of cesium ion exchange capability and to fully implement lessons learned during the startup and operation of the Defense Waste Processing Facility.

Major capital expenditures for an NPF will be deferred until HWVP construction is complete, tank farm operational safety issues have been resolved, and a decision as to the number of SSTs to be retrieved has been made.

The tank waste disposal program will continue with grout as the LLW form as directed in the HDW-EIS. Technology programs to develop alternative LLW forms, which could reduce costs or improve waste form performance, will continue to be evaluated.

The schedule and cost implications of this recommendation are described in Section 8.0. The major features are described in the following text.

- The start of the HWVP radioactive operations is delayed a minimum of 15 months because of additional design work needed to incorporate cesium ion exchange capability. Construction start remains in April 1992. The construction schedule for the HWVP will be reviewed as part of the 1992 baseline program planning effort.

- Total cost of the HWVP increases by approximately $200 million (1991 dollars) because of the added scope.

- The delayed start of HWVP radioactive operations alleviates the near-term concerns centered around lack of pretreated wastes for continuous operation.

- Long-term Tri-Party Agreement (Ecology et al. 1990) objectives are retained, but the milestone date for start of the radioactive HWVP operations will have to be renegotiated.

- Flexibility is retained in the use of future facilities and implementation of processes. In addition, considerable fallback flexibility is retained if process development or facility construction objectives are not achieved.

- Incorporation of SST 241-C-106 as an early source of feed to HWVP represents an enhancement to the DST waste disposal, SST closure, and tank safety programs.

- The early ability to pretreat wastes by in-tank sludge washing and by cesium ion exchange, and the capability to solidify the high-level and/or TRU waste fraction as glass and the LLW in grout, provide the basic processes needed to dispose of tank wastes. The addition of other technologies, facilities, and processes provides significant economic benefits and shortens the overall time required to dispose of tank wastes. In providing these early capabilities, the selected strategy affords considerable tolerance in allowing tank waste disposal to proceed despite funding or technology development delays. Waste disposal will be able to proceed while recovery approaches are developed.

The selected strategy will be implemented and managed through issuance of a program plan to be baselined in 1992.

FUTURE ACTIONS AND DECISIONS

The recommended strategy implements a time-phased approach that allows for work to proceed based upon existing mature technologies while developing intermediate and advanced technologies for reducing the volume of wastes for vitrification. The recommended strategy embodies actions needed to begin processing wastes through HWVP upon its startup. It also allows time for additional development and characterization work to support future activities. This strategy represents a balanced schedule approach for remediation of Hanford Site tank waste. Aggressive budget profiles can be alleviated by providing a balance between technology development and construction of vitrification systems (i.e., retrieval, pretreatment, and HWVP). Higher emphasis on waste characterization and technology development in support of vitrification systems must be placed during the near term. Section 8.0 describes such an approach.

The technology needs for implementation of the selected strategy are described in Section 9.0. A technology plan will be prepared and form the foundation for a comprehensive demonstration of existing treatment concepts and development of intermediate and long-term pretreatment processes. The technology plan will embody the following:

- Additional characterization of all wastes (this will both confirm present planning of near-term waste remediation and provide data to develop future facility and process designs)
- Retrieval technology development and testing for DST and SST wastes
- In-tank sludge-washing demonstration
- Intermediate processing development and demonstration
- Pilot-scale testing and confirmation of the TRUEX process
- Organic destruction process evaluation and testing
- Evaluation of alternate LLW forms and treatment concepts to enhance long-term performance
- Evaluation of productivity enhancements to the vitrification system.

Decisions on layout and process configuration of future plants can be delayed until additional information is available concerning the previously mentioned issues without adverse impact on schedule. Specific decisions to be made include the following.

- The extent and timing of the recovery of SST wastes is critical to the future configuration of the program. While sufficient information exists to proceed now with the disposal of DST wastes, it will be important to accelerate the SEIS preparation and decision process for SSTs and to clarify the documentation necessary to allow the early recovery and processing of SST wastes being considered for early HWVP feed.
- The extent to which TRUEX or an alternative actinide partitioning process will be used and when it will be used depends in part on the performance exhibited by the intermediate processing capability being developed.
- The configuration and need date for an NPF must be finalized.
- The number of additional DSTs to be constructed will be determined in part by the pretreatment processes used and the quantity of SST waste to be retrieved, pretreated, and vitrified as well as SST closure milestone commitments.

Pretreatment decisions will also be affected by data from the tank safety program. While these decisions cannot be defined until additional information is available, they will be critical to continued success. This area will be monitored and closely integrated with the tank waste remediation program.

REFERENCES

DOE, 1987, *Final Environmental Impact Statement, Disposal of Hanford Defense High-Level, Transuranic and Tank Wastes, Hanford Site, Richland, Washington*, DOE/EIS-0113, Vol. 1 through 5, U.S. Department of Energy, Washington, D.C.

DOE, 1988, "Final Environmental Impact Statement for the Disposal of Hanford Defense High-Level, Transuranic, and Tank Wastes, Hanford Site, Richland, Washington; Record of Decision," *Federal Register*, Vol. 53, No. 72, pp. 12449-12453, U.S. Department of Energy, Washington, D.C.

DOE, 1989, *General Design Criteria*, DOE Order 6430.1A, U.S. Department of Energy, Washington, D.C.

Ecology, EPA, and DOE, 1990, *Hanford Federal Facility Agreement and Consent Order*, Vol. 1 and 2, Washington State Department of Ecology, U.S. Environmental Protection Agency, and U.S. Department of Energy, Olympia, Washington.

Miller, W. C., D. W. Hamilton, L. K. Holton, and J. W. Bailey, 1991, *Hanford Waste Vitrification Systems Risk Assessment-Final Report*, WHC-EP-0421, Rev. 0, Westinghouse Hanford Company, Richland, Washington.

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

Resource Conservation and Recovery Act of 1976, 42 USC 6901, et seq.

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ACRONYMS

$BiPO_4$	bismuth phosphate
CC	complexant concentrate
CERCLA	*Comprehensive Environmental Response, Compensation and Liability Act of 1980*
DN	dilute noncomplexed
DOE	U.S. Department of Energy
DSS	double-shell slurry
DSSF	double-shell slurry feed
DST	double-shell tank
Ecology	Washington State Department of Ecology
EPA	U.S. Environmental Protection Agency
FY	fiscal year
HDW-EIS	*Final Environmental Impact Statement, Disposal of Hanford Defense High-Level, Transuranic and Tank Wastes, Hanford Site, Richland, Washington*
HWVP	Hanford Waste Vitrification Plant
Na_2CO_3	sodium carbonate
$NaNO_2$	sodium nitrite
$NaNO_3$	sodium nitrate
NaOH	sodium hydroxide
NH_4F	ammonium fluoride
NH_4NO_3	ammonium nitrate
NCAW	neutralized current acid waste
NCRW	neutralized cladding removal waste
PFP	Plutonium Finishing Plant
PUREX	Plutonium-Uranium Extraction
RCRA	*Resource Conservation and Recovery Act of 1976*
REDOX	reduction-oxidation
ROD	record of decision
SST	single-shell tank
Tri-Party Agreement	*Hanford Federal Facility Agreement and Consent Order*
TRU	transuranic

1.0 INTRODUCTION

1.1 OBJECTIVES AND REPORT ORGANIZATION

This document describes the methodology and results of a recently completed comprehensive engineering study to develop a revised strategy for pretreatment of Hanford Site tank wastes for final disposal. Pretreatment involves those processes that convert the waste into two fractions:

- A relatively small volume high-level waste fraction requiring vitrification and disposal in a geologic repository
- A larger volume low-level waste fraction suitable for incorporation into a solid grout form, which can be disposed of in onsite near-surface facilities.

Previously, the strategy for disposal of double-shell tank (DST) waste assumed that all pretreatment processes would be conducted in the 244-AR Vault and B Plant. Increased regulatory and operational requirements led to concerns about conducting an extended campaign in an aging facility such as B Plant. These concerns coupled with several other factors identified during the *Hanford Waste Vitrification Systems Risk Assessment-Final Report* (Miller et al. 1991) [e.g., budgetary constraints, the immaturity of the proposed pretreatment technology, the potential for discontinuous operation of the Hanford Waste Vitrification Plant (HWVP), and the need and desire to accomplish the strategic objectives (Section 1.4) of the overall Hanford Site tank waste disposal program, including single-shell tanks (SST)] provided incentive to reexamine and revise, if necessary, the current strategy for pretreating DST wastes.

Section 1.0 includes a synopsis of relevant historical information relating to types and compositions of DST and SST wastes and the evolution of strategies for pretreating DST wastes. The need for a revised program strategy is further discussed in Section 1.3, and important objectives of a revised strategy are listed in Section 1.4.

Section 2.0 provides summary-level description of the work performed and the conclusions reached.

Section 3.0 provides the recommended strategy.

The remaining sections provide a detailed discussion of study methodology in selecting and evaluating alternatives as well as plans for implementing the revised tank waste disposal program.

Section 4.0 outlines the methodology followed in developing and evaluating a revised strategy for pretreatment of DST waste.

In Section 5.0, those entities and organizations, i.e., U.S. Department of Energy (DOE), U.S. Environmental Protection Agency (EPA), Washington State Department of Ecology (Ecology), and members of the public who have a stake in a revised DST waste pretreatment strategy are identified. Section 5.0 also lists and discusses various stakeholder values.

Section 6.0 lists and describes alternate reference pretreatment processes including solid-liquid separation, sludge washing, removal of ^{137}Cs from some liquid wastes, destruction of organic compounds in some liquid wastes, acid dissolution of solid wastes, and removal of transuranic (TRU) elements from dissolved solid waste. Relevant features and characteristics of six candidate facilities -- DSTs, 244-AR Vault, B Plant, Plutonium-Uranium Extraction (PUREX) Plant, an expansion of the HWVP, and a new pretreatment facility -- for performing some or all of the reference pretreatment processes are also described in Section 6.0.

In Section 7.0, systematic multiattribute utility analysis methodology is rigorously followed to evaluate and compare 16 pretreatment facility and process alternatives. These comparisons include costs, schedules, pretreatment technology availability and maturity, and accommodation of any retrieved SST wastes. The procedures lead to the recommendation of the preferred pretreatment facility and process alternatives. The preferred alternative identifies constraints and decision points that must be achieved for successful completion of the disposal strategy.

In Section 8.0, schedules for implementing the selected pretreatment facility and process strategy are shown. Cost data presented in Section 8.0 also include projected budgetary needs for fiscal year (FY) 1992 and FY 1993. A level 0 schedule is presented in this document; a baseline schedule will be provided within one calendar year of a formal decision.

Section 9.0 describes the technology needed to implement the program objectives and the approach to be used in technology development.

Section 10.0 describes the architecture for the program plan to be used in managing the redefined program.

Appendix A describes related correspondence. Appendix B describes history and background. Appendix C describes the defense waste remediation strategy revision attributes. Appendix D describes the calculation of environment, safety, and health attributes for DST remediation alternatives. Appendix E contains the *Hanford Site Tank Waste Disposal Program Redefinition Peer Review Final Draft*. Appendix F contains the life-cycle costs for pretreatment alternatives. Appendix G contains the facility descriptions.

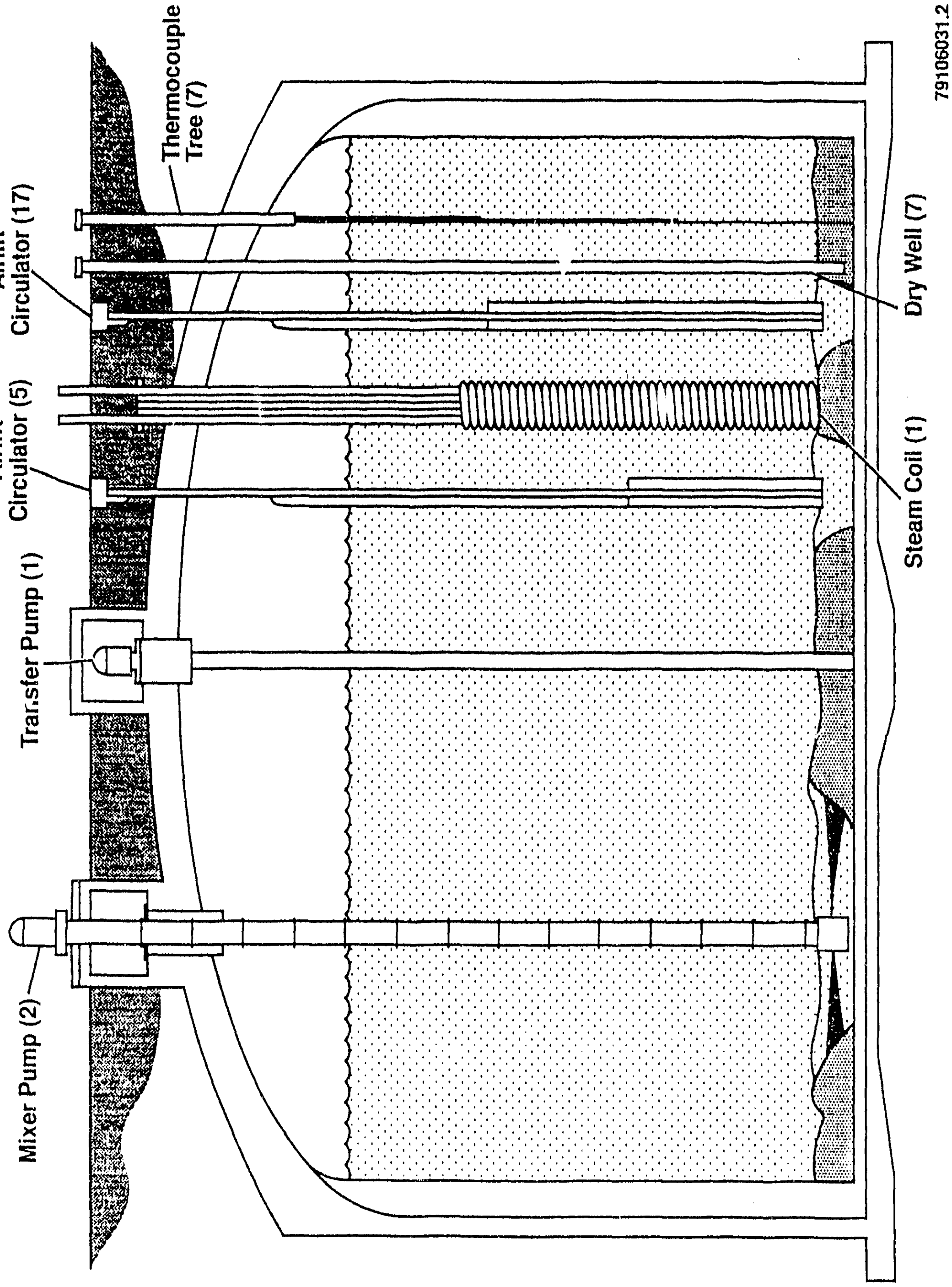
1.2 HISTORICAL BACKGROUND

1.2.1 Waste Tank Systems and Contents

Radioactive waste from previous (1944 to 1988) reprocessing of irradiated uranium fuel from plutonium production reactors at the Hanford Site is currently stored in 28 DSTs and 149 SSTs. These tanks, all buried at least 2 m belowgrade, are located in the tank farms in the 200 East and 200 West Areas of the Hanford Site.

The DSTs (tank-within-a-tank) (Figure 1-1) were constructed from 1970 to 1985; all of the DSTs are designed to contain 3,800 m^3 of waste. The older SSTs include tanks designed to contain 200 m^3 (16 tanks), 2,000 m^3 (60 tanks),

Figure 1-1. Double-Shell Tank.



2,900 m^3 (48 tanks), and 3,800 m^3 (25 tanks) of waste. All the DSTs and SSTs are constructed of mild steel (high carbon content). The sides and bottoms of all tanks are supported by concrete structures. Openings in the unsupported tank domes allow limited access for sampling wastes and for measuring waste temperatures and liquid levels. An extensive network of buried piping is provided for transfer of liquid wastes and waste slurries within and between tank farms.

The total present and future inventory of waste in the DSTs is classified into five types:

- Neutralized current acid waste (NCAW)--5,300 m^3
- Neutralized cladding removal waste (NCRW)--3,300 m^3 of sludge
- Plutonium Finishing Plant (PFP) waste--970 m^3 of sludge
- Complexant concentrate (CC) waste--18,200 m^3
- Double-shell slurry (DSS), double-shell slurry feed (DSSF) and dilute noncomplexed (DN) saltwell wastes--75,700 m^3 (including the future addition of 35,300 m^3 DN waste to be evaporated down to 5,300 m^3 DSSF).

All the DST wastes consist of a liquid portion and a solid portion. The NCAW is the waste that was produced when concentrated acidic PUREX process high-level waste generated between 1983 and 1988 was made alkaline and stored in DSTs. An NH_4NO_3 - NH_4F solution was used in the PUREX Plant during 1983 to 1988 to dissolve Zircaloy cladding from N Reactor fuel. The NCRW resulted when the spent cladding waste was made alkaline and stored in DSTs. The PFP waste resulted when composite acidic waste from the PFP was made alkaline and stored in a DST. The CC waste has a very high concentration of organic chelating agents and their degradation products. The CC waste is the concentrated aqueous raffinate from ^{90}Sr liquid-liquid extraction operations performed in the 1960's and 1970's. The DSS and DSSF waste is a viscous, highly alkaline liquid waste containing high concentrations of sodium salts generated from evaporation of dilute low-level waste solutions. The DSS differs from DSSF in that DSS has been evaporated past the aluminate phase boundary and does not normally separate into sludge and supernatant layers.

The solid portion of NCAW, NCRW, CC waste, and PFP waste all contain $\geq$100 nCi/g of TRU elements. The NCAW solids also contain >99 percent of the ^{90}Sr present in the PUREX process high-level waste; other DST solid wastes do not contain large concentrations of ^{90}Sr. The NCAW and CC alkaline waste solutions contain relatively high concentrations of ^{137}Cs. Because of the large amounts of organic chelators, alkaline CC liquid waste also contains >100 nCi/g of TRU elements.

Approximately 141,000 m^3 of wastes are presently distributed among the 149 SSTs. These wastes consist mainly of two types of solids, sludge and salt cake. A small amount (2,300 m^3) of interstitial liquid is also present. Sludges consist principally of heavy metal (e.g., iron, chromium, nickel) oxides and hydroxides. These precipitated when the acidic liquid wastes from the bismuth phosphate ($BiPO_4$), reduction-oxidation (REDOX), and PUREX processes were made alkaline before routing to the SSTs. Many of the SST sludges also contain significant amounts of aluminum. Salt cake is mainly composed of water-soluble sodium salts (e.g., $NaNO_3$, Na_2CO_3, $NaNO_2$, NaOH) that crystallized when the original highly alkaline liquid wastes were evaporated. Of the SST radionuclide inventory, over 99 percent of the uranium, plutonium, other TRU elements, ^{90}Sr and some of the ^{99}Tc are in the sludge, while the salt cake contains over 99 percent of the ^{137}Cs and the rest of the ^{99}Tc.

Appendix B provides further detailed information on the origins of DST and SST waste.

1.2.2 Evolution of Strategy for Disposal of Tank Wastes

Plans and strategies for final disposal of DST and SST wastes have evolved over the last 15 yr. Table 1-1 lists some important chronological studies, reports, and highlights. Detailed information concerning each of the items listed in Table 1-1 is provided in Appendix B. The following discussion is limited to a summary of the significant strategic considerations that derive from previous engineering studies and reports.

- **Incentive for Waste Pretreatment**--Early on, it was recognized that there was a strong economic incentive to separate tank wastes into a relatively small volume requiring expensive geologic repository disposal and a larger volume qualified for disposal in relatively inexpensive near-surface facilities. All following studies have confirmed and continued to emphasize the need and desirability for such waste partitioning.

- **Scope of Waste Pretreatment Processes**--Over time, waste separations became known as waste pretreatment. Initially, pretreatment involved only separation (and washing) of solid wastes (sludges) from alkaline supernatants. removal of ^{137}Cs from NCAW supernatant, and destruction of organic complexants in CC waste. Washed sludges containing TRU elements and, in some cases, ^{90}Sr along with ^{137}Cs from the NCAW were to be immobilized and disposed of in a geologic repository. Later engineering studies showed that large reductions in disposal costs could be realized by dissolution of the sludges and separation of TRU elements from large amounts of associated nonradioactive constituents. Even later engineering studies have addressed the need for technology to remove long-lived ^{99}Tc from some wastes and to remove ^{137}Cs from other liquid wastes.

- **Final Waste Forms**--From the outset, borosilicate glass, because of its favorable history in nuclear waste disposal operations, was chosen as the final form for geologic disposal of undissolved sludges and concentrated radionuclide fractions. A report documenting results of an exhaustive evaluation and comparison of various waste forms for immobilizing Hanford Site tank wastes was published in Schulz (1980). This work was further supported by: (1) an environmental assessment for waste form selection for Savannah River Plant HLW; (2) the final Defense Waste Production

Table 1-1. Significant Events in Evolving Strategy for Disposal of Double-Shell Tank Wastes.

Date	Event	Reference
1977	First technical report on alternatives for long-term management of Hanford Site high-level radioactive waste	ERDA 1977
1980	Follow-on reports on alternatives for disposal of Hanford Site high-level wastes	RHO 1980a RHO 1980b RHO 1980c
1983	Definitive engineering study on disposal of DST wastes	Schulz et al. 1983
1985	*Hanford Defense Waste Disposal Alternatives: Engineering Support Data for the Hanford Defense Waste Environmental Impact Statement*	RHO 1985
1987	*Final Environmental Impact Statement, Disposal of Hanford Defense High-Level, Transuranic and Tank Wastes, Hanford Site, Richland, Washington*	DOE 1987
1988	Record of decision on final environmental impact statement	DOE 1988
1988	Updated assessment of processes and facilities for pretreating DST waste	Kupfer et al. 1989
1989	*Hanford Federal Facility Agreement and Consent Order* signed by DOE, EPA, and Ecology	Ecology et al. 1990
1989	Further updated assessment of DST waste pretreatment alternatives	WHC 1990
1991	*Hanford Waste Vitrification Systems Risk Assessment-Final Report* evaluated risks to the DST waste disposal baseline and to the integration of DST and SST programs	Miller et al. 1991

DOE = U.S. Department of Energy
DST = Double-shell tank
Ecology = Washington State Department of Ecology
EPA = U.S. Environmental Protection Agency
SST = Single-shell tank.

Facility environmental impact statement for the Savannah River Plant; and (3) an analysis of the terminal waste form selection for the West Valley Demonstration Project. For very much the same reasons, cementitious grout was quickly accepted as the form for onsite, near-surface disposal of low-level waste fractions of DST waste.

- **Selection of Pretreatment Facilities**--The B Plant was equipped and used in the 1960's and 1970's for separation of some liquid and solid tank wastes, for ion exchange separation and purification of ^{137}Cs from liquid wastes, and for liquid-liquid extraction of ^{90}Sr from dissolved sludge. B Plant's availability and history of pretreatment operations made it the first choice for future pretreatment of retrieved DST wastes. Eventually, it was recognized that some simple pretreatment operations, e.g., solid-liquid separation and sludge washing could be done in the 244-AR Vault or directly in the DSTs. Performance of initial waste pretreatment operations in the 244-AR Vault or DSTs is advantageous because it allows B Plant cell space to be used for other pretreatment process unit operations (e.g., TRUEX extraction process, sludge dissolution). The use of larger vessels available in 244-AR Vault or DSTs reduces the time required to accomplish solid-liquid separation and sludge washing.

- **Environmental Impact Statement and Record of Decision**--The record of decision (ROD) (DOE 1988) on the *Final Environmental Impact Statement, Disposal of Hanford Defense High-Level, Transuranic and Tank Wastes, Hanford Site, Richland, Washington* (HDW-EIS) (DOE 1987) was published in April 1988. With regard to DST wastes, the ROD, substantiating results of many previous engineering studies, calls for the following:

  - Retrieval and pretreatment of all existing and future DST wastes

  - Processing of the radioactive high-level waste fraction into a borosilicate glass in the HWVP

  - Solidification of the low activity waste as a cement-based grout and disposal in near-surface vaults at the Hanford Site.

  The ROD (DOE 1988) remains the controlling policy for disposal of DST waste.

  With regard to the SSTs, the ROD did not define a baseline disposal strategy, but rather required that additional studies and evaluations be conducted and that a supplemental environmental impact statement be prepared at a later date.

- **Evolution of EPA and DOE Jurisdiction**--The EPA is responsible for administering the provisions of the *Resource Conservation and Recovery Act of 1976* (RCRA) and the *Comprehensive Environmental Response, Compensation and Liability Act of 1980* (CERCLA). Wastes falling under the jurisdiction of the EPA include both hazardous chemical and mixed wastes (i.e., those containing both radioactive and hazardous chemicals).

In 1986, the DOE agreed that all mixed wastes on DOE sites are subject to RCRA regulations. In June 1986, in a letter to all its Hanford Site contractors, the DOE Field Office, Richland reemphasized the need to comply with RCRA regulations and the need to characterize all wastes for EPA-listed hazardous chemicals.

In 1987, Region 10 EPA officials delegated authority to Washington State for management of all mixed wastes on the Hanford Site. In February 1988, serious negotiations began among the DOE, EPA, and Ecology on a mutual agreement on cleanup of the Hanford Site waste.

- **Hanford Federal Facility Agreement and Consent Order**--In May 1989, the DOE, EPA, and Ecology signed the *Hanford Federal Facility Agreement and Consent Order* (Tri-Party Agreement) (Ecology et al. 1990) which establishes enforceable milestones for specific cleanup actions identified in the ROD (DOE 1988). One of these milestones, "Initiate HWVP Operation by December, 1999," is of great importance and impact in formulating a revised strategy for pretreatment of DST wastes.

1.3 NEED FOR REVISED DOUBLE-SHELL TANK WASTE PRETREATMENT STRATEGY

The current strategy (Section 1.2) for pretreatment of DST wastes involves performance of the reference set of pretreatment operations in B Plant and, in some cases, in the 244-AR Vault on a schedule consistent with a December 1999 start of radioactive operations in the HWVP. Several separate forces have now converged in a manner to require development of a revised strategy for pretreatment of DST wastes.

1.3.1 B Plant Viability Issues

The questionable viability of B Plant for a long-term waste pretreatment mission is a principal force behind a revised DST waste pretreatment strategy. Even with planned upgrades, the 40-yr-old B Plant may not meet current Washington State standards for facilities for treating mixed wastes and, therefore, may not receive the necessary operating permits and approvals. Thus, alternative facilities to conduct DST waste pretreatment operations must be identified and evaluated.

1.3.2 December 1999 Hanford Waste Vitrification Plant Startup Date and Feed Continuity

If technically and economically justifiable, the Tri-Party Agreement (Ecology et al. 1990) milestone for a December 1999 startup of the HWVP still must be met. Any revised strategy for DST waste pretreatment must provide for an adequate supply of feed to allow the HWVP to start in December 1999 and to continue operating without excessive interruptions caused by a lack of pretreated wastes.

1.3.3 New Stakeholder Interests and Concerns

The current strategy for pretreatment of DST waste was formulated and adopted before the signing of the Tri-Party Agreement. There is a need for a revised strategy that addresses all interests and concerns of the original stakeholders and of those groups who through either recent legal action or unchanneled public interest now have a legitimate involvement in the development and execution of plans at the Hanford Site.

1.3.4 Integrated Double-Shell Tank and Single-Shell Tank Waste Pretreatment Operations

In the future, it may be necessary to retrieve wastes from at least some of the SSTs and pretreat them for final disposal. A revised strategy for pretreating DST wastes needs to take into account the economic and technical advantages of facility and process alternatives that allow for pretreatment of DST wastes and all or part of the SST wastes.

1.3.5 Pretreatment of Double-Shell Slurry and Double-Shell Slurry Feed Waste

In the current strategy for pretreatment of DST wastes, DSS and DSSF will be disposed of in cementitious grout form without undergoing any pretreatment. A revised DST waste pretreatment strategy must address the needs and benefits of additional radionuclide removal from DSS and DSSF before disposal.

1.3.6 Budgetary Realities and Constraints

For many years, requests for financial resources, particularly funds for capital projects, have far exceeded the amounts available in the DOE fiscal budgets. This situation is expected to continue into the foreseeable future. These budget constraints and realities are key input to the evaluation of facility and process alternatives for pretreating DST waste.

1.4 PROGRAM REDEFINITION OBJECTIVES

A revised strategy for DST waste pretreatment must address, as a first priority, concerns about the viability of B Plant for long-term continued use. The redefined program should also retain and/or incorporate other strategic elements and objectives, the basis and importance of which are well recognized from previous studies and experience. These other strategic elements and objectives are addressed in the following sections.

1.4.1 Provisions of the Final Environmental Impact Statement

The HDW-EIS (DOE 1987) and the accompanying ROD (DOE 1988) still represent official DOE policy and plans for disposal of DST wastes. The redefined program for pretreatment of DST waste still must specify production of borosilicate glass and cementitious grout as final waste forms.

Composition, amounts, and other features of SST waste were noted in the HDW-EIS. But, an ROD concerning final disposal of waste in each of the 149 SSTs was not made. Instead, the HDW-EIS stated that decisions relating to disposal of the SST waste would be made in a supplemental environmental impact statement. The Tri-Party Agreement (Ecology et al. 1990) requires that a draft of the supplemental environmental impact statement be available for review in June 2002 and a closure plan be approved in December 2003. Issues related to facility and process alternatives for pretreatment of both DST and SST waste were noted in Section 1.1.

1.4.2 December 1999 Hanford Waste Vitrification Plant Startup

Startup of the HWVP in December 1999 is a highly visible and important milestone identified in the Tri-Party Agreement (Ecology et al. 1990). A revised DST waste disposal program must determine if the December 1999 startup date can still be justified and, if so, how to meet it. The key issue is to ensure an adequate and reliable supply of feed to the HWVP both for startup and continuous operation, thereby effectively using the facility and reducing overall program expenditures.

1.4.3 Cost Effectiveness

A revised strategy for pretreatment of DST wastes should be cost-effective. To be cost-effective, a revised strategy should, wherever possible, employ mature and proven pretreatment technologies and yet also be flexible enough to adopt and incorporate new technology where required or appropriate. Where existing pretreatment technology is inadequate, development of new technology should be directed to processes that contribute significantly to reduced costs and improved efficiency and safety.

As expected, economic analyses clearly show that it is highly cost-effective to use the same facility to pretreat DST wastes and any retrieved SST wastes. This economic factor must be included in the program redefinition for pretreatment of DST wastes. In addition, pretreatment and disposal strategies must ensure that the resultant inventory of glass canisters is kept to the minimum allowed by applicable and planned technology.

1.4.4 Survivability

Because of the long time to implement and complete them, all plans and strategies for pretreatment and disposal of DST wastes are vulnerable to changes in regulatory, social, and financial conditions and assumptions. Regulatory and financial changes in planning bases are inevitable and must be recognized at the outset.

A desirable and worthwhile goal is to devise a program for pretreatment of DST waste that will be sufficiently robust on its own merits to survive over long periods of time, even though minor adjustments to accommodate various changes will likely be necessary from time to time.

1.4.5 Stakeholder Confidence

Technical and financial considerations not withstanding, the most important aspect of a redefined tank waste disposal program is that, to the maximum extent possible, the stakeholders contribute to it, believe in it, and support it.

1.5 REFERENCES

Comprehensive Environmental Response, Compensation and Liability Act of 1980, 42 USC 6901, et seq.

DOE, 1987, *Final Environmental Impact Statement, Disposal of Hanford Defense High-Level, Transuranic and Tank Wastes, Hanford Site, Richland, Washington*, DOE/EIS-0113, Vol. 1 through 5, U.S. Department of Energy, Washington, D.C.

DOE, 1988, "Final Environmental Impact Statement for the Disposal of Hanford Defense High-Level, Transuranic, and Tank Wastes, Hanford Site, Richland, Washington; Record of Decision," *Federal Register*, Vol. 53, No. 72, pp. 12449-12453, U.S. Department of Energy, Washington, D.C.

Ecology, EPA, and DOE, 1990, *Hanford Facility Agreement and Consent Order*, Vol. 1 and 2, Washington State Department of Ecology, U.S. Environmental Protection Agency, and U.S. Department of Energy, Olympia, Washington.

ERDA, 1977, *Alternatives for Long-Term Management of Defense High-Level Radioactive Waste*, ERDA 77-44, Energy Research and Development Administration, Richland, Washington.

Kupfer, M. J., A. L. Boldt, and J. L. Buelt, 1989, *Process and Facility Options for Pretreatment of Hanford Tank Waste*, SD-WM-TA-015, Westinghouse Hanford Company, Richland, Washington.

Miller, W. C., D. W. Hamilton, L. K. Holton, and J. W. Bailey, 1991, *Hanford Waste Vitrification Systems Risk Assessment-Final Report*, WHC-EP-0421, Rev. 0, Westinghouse Hanford Company, Richland, Washington.

Resource Conservation and Recovery Act of 1976, 42 USC 6901, et seq.

RHO, 1980a, *Technical Status Report On Environmental Aspects of Long-Term Management of High-Level Defense Waste at the Hanford Site*, RHO-LD-139, Rockwell Hanford Operations, Richland, Washington.

RHO, 1980b, *Environmental Aspects of Long-Term Management Alternatives for High-Level Defense Waste at the Hanford Site*, RHO-LD-140, Rockwell Hanford Operations, Richland, Washington.

RHO, 1980c, *Technical Aspects of Long-Term Management Alternatives for High-Level Defense Waste At the Hanford Site*, RHO-LD-141, Rockwell Hanford Operations, Richland, Washington.

RHO, 1985, *Hanford Defense Waste Disposal Alternatives: Engineering Support Data for the Hanford Defense Waste-Environmental Impact Statement*, RHO-RE-ST-30P, Rockwell Hanford Operations, Richland, Washington.

Schulz, W. W., 1980, *Preliminary Evaluation of Alternative Forms for Immobilization of Hanford High-Level Defense Waste*, RHO-ST-32, Rockwell Hanford Operations, Richland, Washington.

Schulz, W. W., M. J. Kupfer, and J. P. Sloughter, 1983, *Evaluation of Process and Facility Options for Treatment of Double-Shell Tank Wastes*, SD-WM-ES-023, Rockwell Hanford Operations, Richland, Washington.

WHC, 1990, *Assessment of Double-Shell Tank Waste Pretreatment Options*, WHC-SP-0464, Westinghouse Hanford Company, Richland, Washington.

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ACRONYMS

CC	complexant concentrate
DOE	U.S. Department of Energy
DST	double-shell tank
Ecology	Washington State Department of Ecology
ES&H	environmental, safety, and health
FY	fiscal year
HDW-EIS	*Final Environmental Impact Statement, Hanford Defense High-Level, Transuranic and Tank Wastes, Hanford Site, Richland, Washington*
HWVP	Hanford Waste Vitrification Plant
MAU	multiattribute utility
NPF	new pretreatment facility
PUREX	Plutonium-Uranium Extraction
RCRA	*Resource Conservation and Recovery Act of 1976*
ROD	record of decision
SEIS	supplemental environmental impact statement
SST	single-shell tank
Tri-Party Agreement	*Hanford Federal Facility Agreement and Consent Order*
TRUEX	transuranic extraction
WESF	Waste Encapsulation and Storage Facility

2.0 SUMMARY OF ALTERNATIVES ANALYSIS

2.1 PROGRAM NEEDS AND ALTERNATIVES

Since 1988, U.S. Department of Energy (DOE) sites and facilities have come under the jurisdiction of the *Resource Conservation and Recovery Act of 1976* (RCRA). The use of existing facilities, such as B Plant, is being questioned because of the potential inability to comply with the design and operational requirements of this law and DOE orders.

To address these concerns and other concerns raised in the recent *Hanford Waste Vitrification Systems Program Risk Assessment-Final Report* (Miller et al. 1991), 16 facility and process alternatives for the pretreatment of tank wastes at the Hanford Site were developed and assessed. These alternatives were evaluated based on their perceived likelihood for meeting all or most of the objectives for a revised program strategy as discussed in Section 1.0. The specific areas of concern together with associated mitigating actions are discussed in Section 7.9.

The record of decision (ROD) (DOE 1988), resulting from the *Final Environmental Impact Statement, Hanford Defense High-Level, Transuranic and Tank Wastes, Hanford Site, Richland, Washington* (HDW-EIS) (DOE 1987), required that additional development and evaluation be conducted to determine whether single-shell tank (SST) wastes would be disposed of in-place or whether some (or all) SST wastes would be retrieved and processed. Decisions relating to the disposal of SST waste would be documented in a draft supplemental environmental impact statement (SEIS) to be issued before June 2002. Assuming that the ROD will be to retrieve and process some or all of SST wastes, pretreatment alternatives for both SST and double-shell tank (DST) wastes were integrated into the 16 facility and process alternatives. The SST wastes consist of 89,000 m^3 (24 Mgal) of salt cake, and 48,000 m^3 (13 Mgal) of sludge.

Two reference processing alternatives were considered for DST wastes:

- Separation of solids or sludges from supernatants and washing the solids with water to remove soluble salts
- Solid-liquid separations followed by sludge dissolution and removal of transuranic components from acidic waste solutions using the transuranic extraction (TRUEX) process or a comparable actinide partitioning process.

  NOTE: Throughout this report, the term TRUEX process should be understood to mean either the TRUEX process or equivalent actinide partitioning capability.

In addition, organic complexants in complexant concentrate (CC) waste supernatant must be decomposed (e.g., complexant destruction) and ^{137}Cs must be removed from neutralized current acid waste supernatant and CC supernatant for the solid washing and TRUEX process alternatives.

Intermediate processing methods for DST and select SST wastes were also considered. These processes represent an intermediate position between simple water washing of sludges, and sludge dissolution followed by TRUEX process operation. Candidate intermediate processes include selective leaching of chemical constituents critical to the waste loading in glass and blending of wastes. Other intermediate processes were also addressed.

Because of the large volume of glass and the resulting adverse economic impact that would result from pretreating all SST waste using the sludge-washing process, the TRUEX process was evaluated as the reference alternative for SST waste pretreatment.

The pretreatment facility alternatives considered include those already existing at the Hanford Site, specifically B Plant, the 244-AR Vault, the Plutonium-Uranium Extraction (PUREX) Plant, and existing DSTs. Potential new facilities are also considered including an expansion of the Hanford Waste Vitrification Plant (HWVP) and a new pretreatment facility (NPF).

The 16 facility and process alternatives are shown in Table 2-1. Each alternative is described in detail in Section 6.0, and the comparative analysis of alternatives is discussed in Section 7.0.

2.2 METHODOLOGY

To evaluate the complex data involved with the analysis of alternatives and to ensure that parties having legally entitled interests in waste disposal and restoration of the Hanford Site (i.e., stakeholders) were involved, processes that have not been used extensively in the DOE community before were used. The methodology employed is shown in Figure 2-1 and involves six basic steps.

Step 1 Alternative solutions were developed and described in uniform terms for comparison.

Step 2 Decision attributes (i.e., essential criteria on which the decision will be based) were developed. The attributes were developed jointly with the parties that have legally entitled interests (i.e., stakeholders).

Step 3 Each alternative was scored against the decision attributes by a panel of experts knowledgeable on the various program issues.

Step 4 Independent of the scoring process, the stakeholders ranked the attributes from most to least important and a weight was assigned to each attribute.

Table 2-1. Process and Facility Alternatives. (sheet 1 of 2)

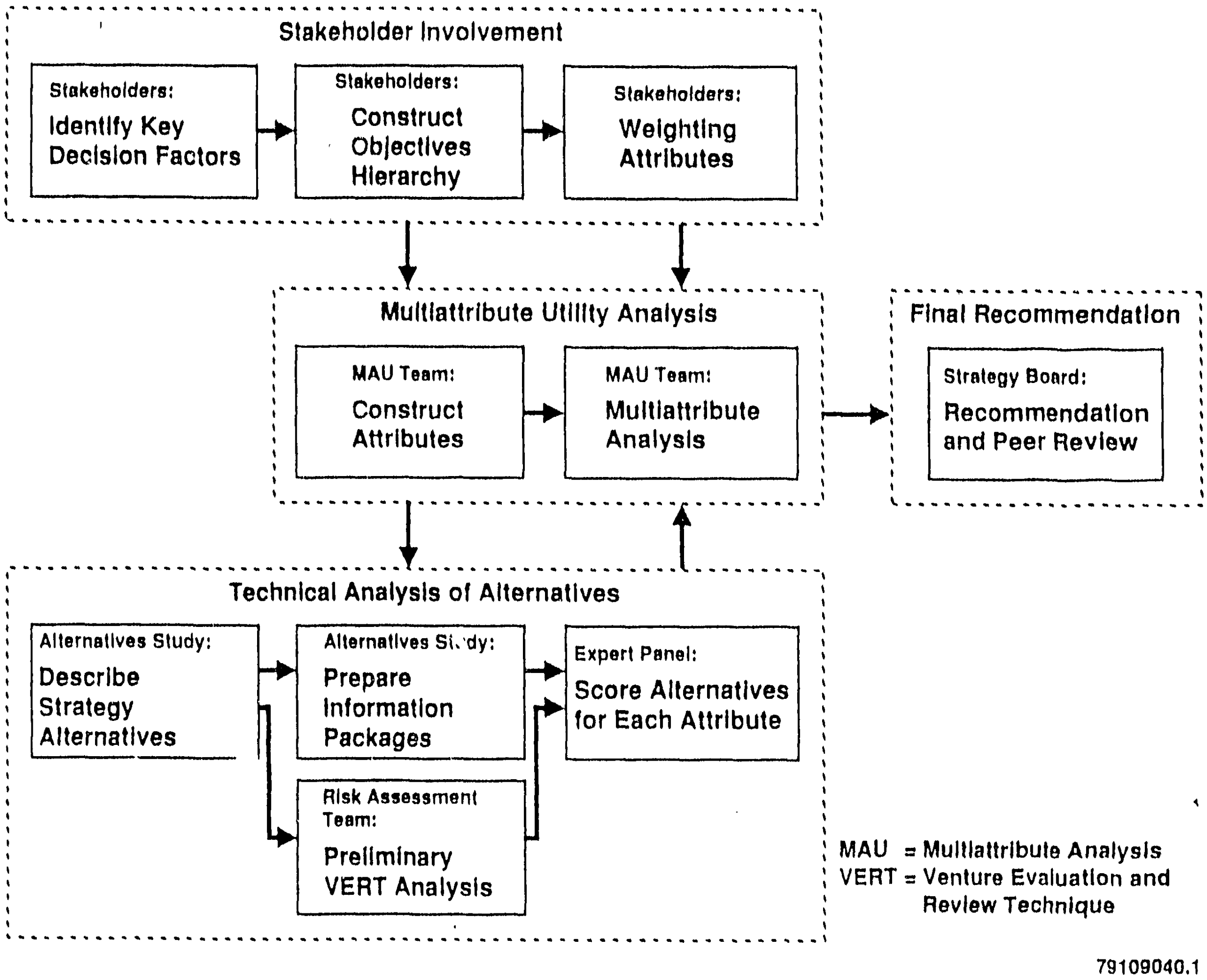
Number	Short-form description	Description	Glass canisters from DST wastes
1	244-AR Vault/ B Plant with TRUEX (risk assessment baseline)	Neutralized current acid waste sludge washing in 244-AR Vault, cesium ion exchange and filtration in B Plant, TRUEX process and organic destruction in B Plant	1,340
2	DST/B Plant with TRUEX	Neutralized current acid waste sludge washing in DST, cesium ion exchange and filtration in B Plant; TRUEX process, and organic destruction in B Plant	1,340
3	DST/B Plant without TRUEX	Neutralized current acid waste and Plutonium Finishing Plant sludge washing in DST, cesium ion exchange and filtration in B Plant, neutralized cladding removal waste sludge washing, and CC waste cesium ion exchange and organic destruction in B Plant	10,380
4	DST/NPF with TRUEX	Neutralized current acid waste sludge washing in DST (supernatant stored) cesium ion exchange and filtration in an NPF, TRUEX process and organic destruction in an NPF	1,340
5	DST/Intermediate processing/NPF with TRUEX	Neutralized current acid waste and limited CC sludge washing in DST (supernatant stored), Plutonium Finishing Plant chrome leaching in DST, cesium ion exchange and filtration in NPF, TRUEX process, and organic destruction in NPF	2,090
6	DST/NPF without TRUEX	Neutralized current acid waste and Plutonium Finishing Plant sludge washing in DST (neutralized current acid waste supernatant stored), cesium ion exchange and filtration in NPF, neutralized cladding removal waste sludge washing and CC waste cesium ion exchange and organic destruction in NPF	10,380
7	DST/Intermediate processing/NPF without TRUEX	Neutralized current acid waste sludge washing in DST (supernatant stored), Plutonium Finishing Plant chrome leaching in DST, cesium ion exchange and filtration in NPF, neutralized cladding removal waste and CC sludge washing in NPF, CC chrome leaching and organic destruction in NPF	4,080
8	DST/PUREX Plant with TRUEX	Neutralized cu'rent acid waste sludge washing in DST, cesium ion exchange and filtration in PUREX Plant, TRUEX process and organic destruction in PUREX Plant	1,340
9	DST/PUREX Plant without TRUEX	Neutralized current acid waste and Plutonium Finishing Plant sludge washing in DST, cesium ion exchange and filtration in PUREX Plant, neutralized cladding removal waste sludge washing and CC cesium ion exchange and organic destruction in PUREX Plant	10,380
10	DST/HWVP without TRUEX	Neutralized current acid waste and Plutonium Finishing Plant sludge washing in DST, cesium ion exchange and filtration in HWVP, neutralized cladding removal waste sludge washing and CC waste cesium ion exchange and organic destruction in HWVP	10,380
11	DST/B Plant/NPF with TRUEX	Neutralized current acid waste sludge washing in DST, cesium ion exchange and filtration in B Plant, TRUEX process and organic destruction in NPF, CC waste cesium ion exchange in NPF	1,340
12	DST/B Plant/NPF without TRUEX	Neutralized current acid waste and Plutonium Finishing Plant sludge washing in DST, cesium ion exchange and filtration in B Plant, neutralized cladding removal waste sludge washing and CC waste cesium ion exchange and organic destruction in NPF	10,380

Table 2-1. Process and Facility Alternatives. (sheet 2 of 2)

Number	Short-form description	Description	Glass canisters from DST wastes
13	DST/HWVP/NPF with TRUEX	Neutralized current acid waste sludge washing in DST, cesium ion exchange and filtration in HWVP, TRUEX process and organic destruction in NPF	1,340
14	DST/Intermediate processing/HWVP/ NPF with TRUEX	Neutralized current acid waste sludge washing in DST, cesium ion exchange and filtration in HWVP, Plutonium Finishing Plant chrome leaching and limited CC sludge washing in DST, TRUEX process and organic destruction in NPF	1,770
15	DST/HWVP/NPF without TRUEX	Neutralized current acid waste and Plutonium Finishing Plant sludge washing in DST, cesium ion exchange and filtration in HWVP, neutralized cladding removal waste sludge washing and CC cesium ion exchange and organic destruction in NPF	10,380
16	NPF with TRUEX	All pretreatments in NPF	905

CC = Complexant concentrate
DST = Double-shell tank
HWVP = Hanford Waste Vitrification Plant
NCAW = Neutralized current acid waste
NCRW = Neutralized cladding removal waste
NPF = New pretreatment facility
PFP = Plutonium Finishing Plant
PUREX = Plutonium-Uranium Extraction
TRUEX = Transuranic extraction.

Figure 2-1. Decision Process for Program Redefinition.



Step 5 The alternatives were then evaluated using a multiattribute utility (MAU) analysis technique that produced an overall ranking of the alternatives. This ranking was according to alternative attribute scores and the relative importance weight assigned to each attribute. A sensitivity analysis was also performed in this step by varying the weights of the attributes to determine over which ranges various alternatives were dominant.

Step 6 From the information in Step 5, the parties responsible for the decision formulated a recommendation, which was evaluated by a peer review team for validation or modification.

2.3 ASSESSMENT OF STAKEHOLDER VALUES

Because several parties were involved in the *Hanford Federal Facility Agreement and Consent Order* (Tri-Party Agreement) (Ecology et al. 1990) and also because of heightened public awareness, a decision was made to involve the major parties in the decisions concerning the program redefinition for Hanford Site tank wastes. Several stakeholders outside of the DOE were involved in the decision-making process. While this is not an extensive set of the possible stakeholder groups, it is believed that the divergent values held by this group are reflective of the range of values held by the majority of possible stakeholder organizations. The stakeholder groups involved were as follows:

- The States of Washington and Oregon
- U.S. Environmental Protection Agency
- Yakima Indian Nation
- Westinghouse Hanford Company and Pacific Northwest Laboratory
- U.S. Department of Energy-Headquarters
- U.S. Department of Energy Field Office, Richland.

Stakeholder values and decision attributes were solicited through a series of informal meetings. The detailed development of the stakeholder values is discussed in Section 5.0. The resultant set of decision attributes is shown in Table 2-2 along with the relative weights that each stakeholder group assigned to each attribute. This table shows how important each group feels an attribute is relative to the group's values. This information, together with the analysis of the performance of each facility and process alternative relative to each attribute, was evaluated in the MAU analysis model. Thus, the strength of the alternatives was assessed to provide the decision-making team the information needed to understand the impacts of differing stakeholder group preferences on the overall desirability of the alternatives. Note that the Washington State Department of Ecology (Ecology) data have not been reviewed and confirmed by Ecology. The Ecology's data are preliminary and are used for comparison only.

Table 2-2. Decision Attributes.

Stakeholder Weights

Attribute Description		WEIGHTS WHC/PNL	WDOE	Yakima	DOE-RL	Swing Weight Range Best	Worst
CONTRIBUTION TO MISSIONS							
Stored Irradiated Fuel	:	0.09%	0.00%	0.00%	0.46%	100	0
Contribution to SST Mission	:	8.61%	12.20%	6.08%	4.56%	100	0
Cs & Sr Capsules	:	0.00%	0.00%	0.00%	0.00%	NA	NA
TECHNOLOGY ASSURANCE							
Maturity	:	2.87%	4.39%	9.12%	3.19%	100	0
Adaptability	:	2.87%	4.88%	4.56%	3.19%	100	0
Reliability	:	2.87%	2.44%	0.91%	3.19%	100	0
HWVP Downtime (months)	:	4.10%	0.49%	0.91%	1.28%	0	144
PUBLIC HEALTH AND SAFETY							
Rad Accident-Public	:	1.15%	1.06%	0.01%	0.36%	0	1
Nonrad Accident-Public	:	0.23%	1.06%	0.01%	0.36%	0	1
Transport Rad Routine-Public	:	1.15%	1.06%	0.00%	0.37%	0	1
Transport Rad Accident-Public	:	3.44%	3.18%	0.04%	1.08%	0	3
Transport Nonrad Accident-Public	:	0.23%	1.06%	0.01%	0.36%	0	1
WORKER HEALTH AND SAFETY							
Rad Routine-Worker	:	0.57%	1.06%	0.05%	0.72%	0	1
Nonrad Chem Accident-Worker	:	0.06%	1.06%	0.03%	0.36%	0	1
Rad Accident-Worker (Rem)	:	0.29%	2.12%	0.03%	0.36%	0	2
Nonrad Ind Accident-Worker	:	0.69%	12.73%	0.30%	4.33%	0	12
ENVIRONMENT							
Routine & Nonroutine Effluents	:	5.74%	8.71%	1.52%	4.10%	100	0
Solid Waste	:	1.15%	6.10%	30.39%	4.10%	20	200
Number of Grout Vaults	:	1.15%	4.36%	30.39%	0.04%	35	50
Number of Glass Canisters	:	11.48%	4.36%	3.04%	4.10%	500	11000
Land Use	:	0.11%	0.87%	3.04%	0.04%	0	35
SCHEDULE AND COMPLIANCE							
Compliance	:	5.74%	4.28%	5.47%	15.96%	100	0
HWVP Start Date	:	11.48%	4.28%	0.03%	3.19%	Dec-99	Oct-2008
SST Closure Date	:	5.74%	4.28%	2.74%	0.32%	2018	2021
DST Completion Date	:	5.74%	2.14%	0.27%	0.32%	2010	2034
SST Completion Date	:	5.74%	2.14%	0.27%	0.32%	2041	2065
COST							
DST $93 (billions)	:	5.74%	5.31%	0.30%	20.52%	10	20
COST PROFILE							
Average Annual % Increase	:	7.18%	1.06%	0.30%	0.00%	25.00%	45.00%
Max. Ann. Site Budget Increase	:	2.87%	2.13%	0.02%	20.52%	5.00%	15.00%
COMMUNITY AND ECONOMY							
Community Economic Impact	:	0.92%	1.20%	0.15%	2.28%	0	4000
TOTAL SCORE		100.00%	100.01%	99.99%	99.98%		
HEALTH AND SAFETY		7.81%	24.39%	0.48%	8.30%		
ENVIRONMENT		19.63%	24.40%	68.38%	12.38%		
COMMUNITY AND ECONOMY		0.92%	1.20%	0.15%	2.28%		
SCHEDULE & COMPLIANCE		34.44%	17.12%	8.78%	20.11%		
CONTRIBUTION TO MISSIONS		8.70%	12.20%	6.08%	5.02%		
TECHNOLOGY ASSURANCE		12.71%	12.20%	15.50%	10.85%		
COST		5.74%	5.31%	0.30%	20.52%		
COST PROFILE		10.05%	3.19%	0.32%	20.52%		

The final step of the stakeholder involvement process derived weights for the decision attributes. Not all of the original stakeholder groups participated in this final step. Representatives from Ecology; the Hanford Site contractors; DOE Field Office, Richland; and the Yakima Indian Nation participated in this effort.

2.4 ANALYSIS OF FACILITY AND PROCESS ALTERNATIVES

The decision attributes for evaluating the alternatives were divided into three categories. The categories were environmental, safety, and health (ES&H); technical integration; and cost and schedule. The performance of the alternatives in these areas is summarized in the following text.

2.4.1 Environmental, Safety, and Health

The ES&H impacts portion of the evaluation consisted of measuring four individual attributes: public health, environmental impacts, worker safety, and compliance with regulations. The first attribute, public health, was used to measure the impact of the facility and process alternatives on the general population. The second attribute, environmental impacts, was used to measure the impacts to the environment on the following:

- Routine and nonroutine effluents
- Amount of solid waste generated
- Number of grout vaults required for disposal of low-level waste
- Number of glass canisters required
- Incremental land use
- Potential incremental SST leakage.

The third attribute, worker safety, measured the occupational health and safety impacts to the work force. The fourth attribute, compliance with regulations, measured the probability of obtaining compliance for each of the alternatives. The following are the results of the ES&H impacts assessment.

Public Health (First Attribute)--Traffic accidents resulting from transporting high-level waste glass canisters had the most impact on the number of fatalities. Because alternatives using the TRUEX process resulted in the least number of canisters, these alternatives were more favorable.

Environmental Impacts (Second Attribute)--Regardless of the process selected, the minimum number of grout vaults (38) occurs when using new facilities for processing DST waste. The number of grout vaults and new facilities were the most significant factors in measuring incremental land use.

The alternatives using the TRUEX process result in only 13 percent as many glass canisters as alternatives that do not use the TRUEX process. Alternatives using new facilities would delay the start of SST pretreatment by 5 yr, increasing the potential for additional leakage from SSTs.

There was significant change in actinide levels across the various processing alternatives. During the dissolution cycle in TRUEX processing, some radionuclides in the sludge (e.g., strontium) will dissolve and become part of the TRUEX feedstream. These radionuclides are not removed by the TRUEX process and become part of the low-level wastestream to be disposed of in grout. As a result, alternatives using the TRUEX process result in 3.5 times more strontium in the low-level wastestream. However, the grout waste form will meet criteria for Class C low-level waste as defined in 10 CFR 61 (NRC 1990). Strontium extraction has been demonstrated in laboratory tests and could possibly be included in a new pretreatment facility to compensate for this fact.

Worker Safety (Third Attribute)--The most significant impact to worker safety results from industrial accidents during construction, operation, and transportation. These dominate all other types of worker fatalities. The total number of potential fatalities ranged from 6.5 to 11.7, with the greatest number of potential fatalities resulting from the construction of new facilities.

Compliance with Regulations (Fourth Attribute)--This attribute measures the difficulty and uncertainty in obtaining compliance with Federal, State, local, and contractor requirements. A scale was constructed to measure the difficulty and uncertainty in obtaining compliance. Although the DSTs are thought to be compliant, there is some risk that the support systems will need upgrades to comply with the RCRA. The use of newer facilities increases the likelihood of obtaining compliance.

2.4.2 Technical Integration

The technical integration portion of the expert evaluation process evaluated seven individual attributes that were collected into two major groups. The first group, contribution to other programs, consisted of four attributes:

- Ability of the alternative to process fuel currently stored at the Hanford Site
- Ability of the alternative to process and blend the cesium and the strontium capsules with other high-level waste for vitrification in the HWVP
- Contribution of the alternative to the SST disposal program
- Ability of the alternative to contribute to the near-term resolution of the tank safety problems.

The second group, technical assurance, consisted of three attributes:

- Maturity
- Adaptability
- Reliability.

The following significant points were found as part of the technical integration expert evaluation.

Process Stored Fuels--All the alternatives can process the stored irradiated fuel except those that use the PUREX Plant for pretreatment processing. The installation of pretreatment processing into the PUREX Plant will remove all or part of the fuel processing capability. The other alternatives will not preclude the use of the PUREX Plant for N Reactor fuel processing.

Process Cesium and Strontium Capsule Wastes--The alternatives that upgrade B Plant and use it for pretreatment processing were judged as being fully capable of incorporating the cesium and strontium capsules into the HWVP feedstream. The alternatives that did not retain B Plant as an operating facility were judged to require a new Waste Encapsulation and Storage Facility (WESF) support facility for incorporating the cesium and strontium capsules into the HWVP feedstream.

Contribution to SST Waste Disposal--Because an advanced pretreatment, such as the TRUEX process, was deemed essential for the SST waste disposal mission to keep cost and schedule within practical limits, all non-TRUEX process alternatives were judged as not contributing to the SST mission. The B Plant and PUREX Plant alternatives with the TRUEX process were judged as contributing in a limited manner to the SST mission because these facilities are capable of processing a limited quantity of SST wastes. All alternatives with the TRUEX process in a new facility fully contributed to the SST mission.

Contribution to Resolution of Tank Safety Issues--Although none of the alternatives make an immediate and direct impact on tank safety, all of the alternatives will potentially make secondary longer term impacts, such as processing sludge from high heat tanks and making tank space available for remediation of tanks having safety concerns and storage of SST waste.

Technical Maturity--All of the alternatives possess a mixture of mature and relatively immature technologies with immature technologies having sufficient time available for development. Thus, from the technical maturity attribute point of view, no significant differences are experienced among all of the alternatives.

Adaptability--The alternatives employing new facilities trended higher than those alternatives employing existing facilities in the adaptability attribute. This is caused by the ability to design new facilities to accommodate changing technology and requirements.

Reliability--Alternatives employing new facilities are more reliable than those making use of existing facilities.

2.4.3 Cost and Schedule Summary

A comparison of the alternatives with respect to schedule and cost attributes was performed. The schedule attributes were as follows:

- Ability to meet scheduled vitrification start date
- Ability to meet the SST closure date
- DST mission completion
- SST vitrification completion
- HWVP continuity of operations.

The cost attributes were as follows:

- Life-cycle costs for DST mission
- Life-cycle costs for combined DST and SST mission
- Peak annual cost
- Annual percent operating funds increase and annual increase in Site budget
- Community economic impacts.

Note, to properly evaluate the alternatives, a consistent set of assumptions was developed to define both cost and schedule constraints. These assumptions are discussed in detail in Section 7.3. Results of the schedule and cost comparisons are as follows.

Ability to Meet Scheduled Vitrification Start Date (December 1999), Tri-Party Agreement Milestone M-03-00--Only alternatives that implement in-tank (DST) sludge washing in fiscal year (FY) 1997 can provide feed to support December 1999 vitrification. Thus with the following exceptions, the majority of the alternatives will support December 1999 vitrification:

- Alternative 1 (baseline) delays vitrification startup approximately 3 yr because of extensive requirements for upgrading 244-AR Vault to perform sludge washing of neutralized current acid waste
- Alternatives 10, 13, 14, and 15, which use HWVP for pretreatment, delay vitrification startup because of impacts of design changes required to implement pretreatment in HWVP
- Alternative 16 delays vitrification 9 yr because in-tank sludge washing and intermediate processing are not used. Therefore, vitrification feed is not available for this alternative until after startup of the NPF.

Ability to Meet SST Closure Date (2018) - Tri-Party Agreement Milestone M-09-00--If a draft SEIS results in an ROD in 2003 which recommends retrieval and processing of SST wastes, the earliest SST closure date is 2025. This assumes that the TRUEX process in an NPF is used to pretreat SST waste. Accelerating the ROD to FY 1996 could allow closure by 2018 because an NPF startup could occur in 2007. However, SST closure by the 2018 Tri-Party Agreement milestone date requires that disposal of SST wastes be accomplished before disposal of some DST wastes. These assumptions also minimize the number of new DSTs required to support tank waste disposal.

DST Mission Completion--Alternatives that use the TRUEX process result in the earliest DST vitrification completion dates (2010 - 2015) since use of the TRUEX process results in a relatively small volume of glass to be vitrified. Alternatives that use all sludge washing will result in the latest completion of vitrification (2032 - 2034) due to the large number of canisters of glass produced. Approximately 80 percent of the projected design life for HWVP is used for alternatives that use only sludge washing. Alternatives that combine intermediate processes with sludge washing complete vitrification significantly earlier than those that use sludge washing alone. Alternatives that combine intermediate processes with TRUEX processing complete vitrification only slightly earlier than those using only TRUEX processes.

SST Vitrification Completion--Assuming that an ROD is completed in 2003 and recommends retrieval and processing of SST waste, the date for completion of SST waste vitrification depends on the chosen pretreatment process for DST waste. If the TRUEX process is selected for DST waste, the SST waste pretreatment and vitrification mission will be complete in approximately 2045 - 2050. If sludge washing is selected for DST waste, SST vitrification would not be completed until approximately 2065, which is far beyond the design life of the HWVP.

A 1996 ROD to retrieve and process SST waste would likely result in using an NPF with TRUEX process capabilities for all DST and SST waste. For this scenario, vitrification of SST waste would be complete by approximately 2045.

HWVP Continuity of Operation--The DST pretreatment alternatives that use only sludge washing provide continuous HWVP feed (i.e., no down time) because of the substantial volume of waste to be vitrified. Significant vitrification down time occurs for alternatives that use the TRUEX process (approximately 70 - 120 months) since TRUEX operations do not commence until FY 2007 in an NPF, and FY 2004 in B Plant or PUREX Plant. However, strategies can be employed for increasing vitrification continuity for the TRUEX process alternatives by vitrification of washed sludge wastes that are not good candidates for the TRUEX process (e.g., DST 241-AY-101) and selected SST wastes (e.g., sludge in SST 241-C-106). Some penalty would result however, from increased vitrification and disposal costs. Alternatives that combine intermediate processing with an NPF that uses the TRUEX process will result in less vitrification down time than alternatives that use the TRUEX process alone.

Life-Cycle Costs for DST Mission--Cost estimates are preliminary and are presented for comparison only. The DST mission costs for alternatives that use the TRUEX process range from $9 to $12 billion dollars and are $2 to $6 billion less than alternatives that use sludge washing due to increased costs associated with extended vitrification operations and glass canister disposal for the sludge washing alternatives. Costs for alternatives that use existing facilities are $2 to $3 billion less than those using a new TRUEX facility. Use of intermediate processing in combination with sludge washing can potentially reduce disposal mission costs up to $4 billion dollars compared to sludge washing alone. The costs for alternatives using intermediate processing in combination with a TRUEX NPF are slightly higher than for those using the TRUEX process alone.

Life-Cycle Costs for Combined DST and SST Mission--Cost estimates are preliminary and are presented for comparison only. Life-cycle costs for a combined DST and SST mission range from approximately $38 to $48 billion dollars. Use of the TRUEX process in an NPF is assumed for pretreating the SST waste. The lowest costs are achieved ($38 to $40 billion) if both DST and SST wastes are treated in an NPF with the TRUEX process. The highest costs for a combined DST and SST mission (up to $48 billion) would result if the DST wastes were processed using sludge washing rather than the TRUEX process.

If the SST ROD is accelerated to 1996 and retrieval (as opposed to in situ disposal) is recommended, the total DST and SST mission costs would be approximately $40 billion because both DST and SST wastes would be pretreated in a TRUEX NPF.

Peak Annual Cost--Comparison of peak annual cost for 16 facility and process alternatives provides a measure of the relative achievability of the alternatives. The concern is that concurrent construction of the HWVP and pretreatment facilities would demand annual budgets exceeding reasonable limits for the Hanford Site. The alternatives that include an NPF show two annual funding peaks, one in the near term during construction of the HWVP and a second during construction of an NPF. The near-term funding peak for alternatives that include an NPF is nominally the same as for the present baseline (B Plant and the 244-AR Vault), showing that the NPF construction can be accomplished subsequent to completion of the HWVP construction without penalty to other optimal attributes.

Annual Percent Operating Funds Increase and Maximum Annual Increase in Site Budget--These cost attributes are another measure of achievability for the 16 alternatives. Operating or expense funds are a reflection of staff levels. Large increases in operating funds may indicate that the required staffing increases may be unachievable. Increases in operating funds in the range of 20 percent to 40 percent are considered to be achievable if not sustained over several years. Increases in both operating and total budget requirements in the range of 5 percent to 15 percent are more reasonable and favorable.

In all alternatives the most significant growth occurs between FY 1992 and FY 1993. This is due, in part, to the presidential budget (RL 1991) for FY 1992 being lower than the required case and the need for recovery in FY 1993, resulting in a "bow wave" effect. Other areas of growth in the FY 1992 to FY 1993 timeframe are the HWVP project, the grout program, which is entirely expense funded, and expense funded pretreatment pilot-plant projects. Alternative 1, using B Plant and the 244-AR Vault, showed peak annual increases in excess of 60 percent, while alternatives using the PUREX Plant or putting non-TRUEX pretreatment processes in the HWVP showed peak annual increases of about 30 percent. Alternatives employing an NPF had peak annual increases of about 40 percent. The most significant aspect in evaluating this attribute is the need to acquire funding and to manage program scope in the near term.

Community Economic Impact--This attribute measures the impact of plant construction and operation on the local and regional economy. Positive benefits can result from increased revenues and employment for the region. Adverse impacts such as boom-bust cycles can result from large and sudden swings in employment levels. Large steady flows of business to the community would be most beneficial.

The specific measure chosen for this attribute is the difference between the peak construction employment and the average employment during operations. The latter is measured by the average employment from 2005 to the completion of the DST pretreatment mission.

The alternatives tend to fall into several groups. Alternatives 6 and 12 (Table 2-1) show the smallest drop in employment, about 2,100 workers. Alternatives 1, 2, 3, 7, 9, and 10 are slightly worse with a difference of between 2,400 and 2,800 workers. Alternatives 4, 5, 8, 11, 13, and 14 all have slightly higher employment drops ranging from about 3,100 to 3,400 workers. Option 16 shows the largest drop in employment, 4,030 workers.

Recent employment fluctuations at the Hanford Site have shown comparable changes and in some cases greater changes. Between 1981 and 1986 there was a decline of nearly 10,000 workers at the Washington Public Power Supply System reactor construction sites. Nearly half of this decline occurred from 1981 to 1983. Between 1987 and 1989, Hanford Site employment fell by 2,300 workers. To fully assess the impact of these changes, one would ideally need to know the changes that are occurring in other sectors of the regional economy at the same time. If the drop in employment coincides with declines in other sectors, the overall impact would be much more severe than if other sectors were growing at that time.

2.4.4 Multiattribute Utility Analysis

An MAU analysis approach was used to combine the technical analysis of the alternatives with the stakeholder weights. The MAU analysis provides an overall measure of the relative value of each option given each stakeholder's expressed preferences. This analysis approach highlights differences in the preferences for alternatives due to variation in stakeholder values. It also provides insight into those factors that are most important in the selection of a preferred alternative.

In general, the stakeholder weights drove the preference for alternatives to a set with the following features in common:

- Early in-tank sludge washing
- An NPF containing the TRUEX process.

These features are common to alternatives 4, 5, 11, 13, and 14. Early in-tank washing contributes significant value by supporting the earliest possible startup of HWVP. This supports the Tri-Party Agreement (Ecology et al. 1990) milestone and the need to establish real progress. This combination of characteristics also performs the bulk of the waste processing in newly constructed facilities, thus alleviating potential environmental compliance problems that can arise with the use of existing facilities. Also, the potential for unplanned environmental releases or other adverse environmental impacts is perceived to be lower with the use of new facilities. Finally, use of the TRUEX process in an NPF supports timely and efficient completion of the SST mission. Clearly, all of the stakeholder groups placed a high value on the accomplishment of the entire tank waste disposal mission. Consequently, the ranking of the alternatives tends to be driven by this factor: TRUEX-based alternatives are clearly preferred over non-TRUEX-based alternatives because of the long-term potential to complete the entire tank waste disposal effort. Also, implementation of the TRUEX process in B Plant or PUREX Plant is less desirable, in part, because of the inability to size the process systems to pretreat the additional waste from the SST mission.

Two additional features showed potential for improving this base strategy:

- Early cesium ion exchange

- Intermediate processing.

Early cesium ion exchange is included in alternatives 11, 13, and 14. Alternative 14 contains both early cesium ion exchange (in HWVP) and intermediate processing. This capability enhances DST waste pretreatment progress, reduces the quantity of radionuclides for disposal in grout, and can alleviate potential tank space constraints by allowing supernatant and wash solution to be processed at the grout facility following ion exchange processing. The additional processing capability protects against failure or delay in other system components, e.g., deployment of the NPF.

Intermediate processing, in combination with an NPF that uses the TRUEX process, is included in alternatives 5 and 14. It provides the capability to pretreat some additional wastes before deployment of an NPF. This feature helps to accelerate progress and strengthens the bridge to the NPF. Incorporating this capability also would allow advances in in-tank processing capability to be adopted. Finally, intermediate processing can mitigate the effects of potential delays in an NPF or failures in other treatment processes. In summary, intermediate processing appears to offer many potential benefits and very few risks. If it does not work, the strategy reverts back to the base plan using in-tank sludge washing.

The final result from the MAU analysis is the impact of the stakeholder groups' widely differing concern over the suitability of onsite disposal of low-level waste. This concern and the associated high weight placed on the number of grout vaults highlights the need to develop processing steps that will further reduce the mobile constituents in grout. For example, use of early cesium ion exchange would provide some additional processing capability. Including this capability in the final strategy would reduce the differences seen in stakeholder preferences.

2.5 CONCLUSIONS

The conclusions gained from comparing the alternatives to a set of established attributes using the MAU analysis, along with input from an external peer review panel, led to a recommendation of a preferred alternative. A detailed discussion of the evaluations, conclusions, recommendations, and a plan for implementation of a preferred alternative are provided in Sections 7.0 through 10.0 and are summarized in Section 3.0, "Conclusions and Recommendations."

2.6 REFERENCES

DOE, 1987, *Final Environmental Impact Statement, Disposal of Hanford Defense High-Level, Transuranic and Tank Wastes, Hanford Site, Richland, Washington*, DOE/EIS-0113, Vol. 1 through 5, U.S. Department of Energy, Washington, D.C.

DOE, 1988, "Final Environmental Impact Statement for the Disposal of Hanford Defense, High-Level, Transuranic and Tank Wastes, Hanford Site, Richland, Washington; Record of Decision," *Federal Register*, Vol. 53, No. 72, pp. 12449-12453, U.S. Department of Energy, Washington, D.C.

Ecology, EPA, and DOE, 1990, *Hanford Federal Facility Agreement and Consent Order*, Vol. 1 and 2, Washington State Department of Ecology, U.S. Environmental Protection Agency, and U.S. Department of Energy, Olympia, Washington.

Miller, W. C., D. W. Hamilton, L. K. Holton, and J. W. Bailey, 1991, *Hanford Waste Vitrification Systems Risk Assessment-Final Report*, WHC-EP-0421, Rev. 0, Westinghouse Hanford Company, Richland, Washington.

NRC, 1990, "Licensing Requirements for Land Disposal of Radioactive Waste," *Code of Federal Regulations*, 10 CFR 61, U.S. Nuclear Regulatory Commission, Washington, D.C.

Resource Conservation and Recovery Act of 1976, 42 USC 6901, et seq.

RL, 1991, *Environmental Restoration and Waste Management Site Specific Plan for the Richland Operations Office - Hanford Site Five-Year Plan FY 1993 - 1997*, DOE/RL-91-25, U.S. Department of Energy Field Office, Richland, Richland, Washington.

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ACRONYMS

DST	double-shell tank
FY	fiscal year
HWVP	Hanford Waste Vitrification Plant
LLW	low-level waste
NCAW	neutralized current acid waste
NEPA	*National Environmental Policy Act of 1969*
NPF	new pretreatment facility
ROD	record of decision
SST	single-shell tank
TRUEX	transuranic extraction

3.0 CONCLUSIONS AND RECOMMENDATIONS

3.1 CONCLUSIONS

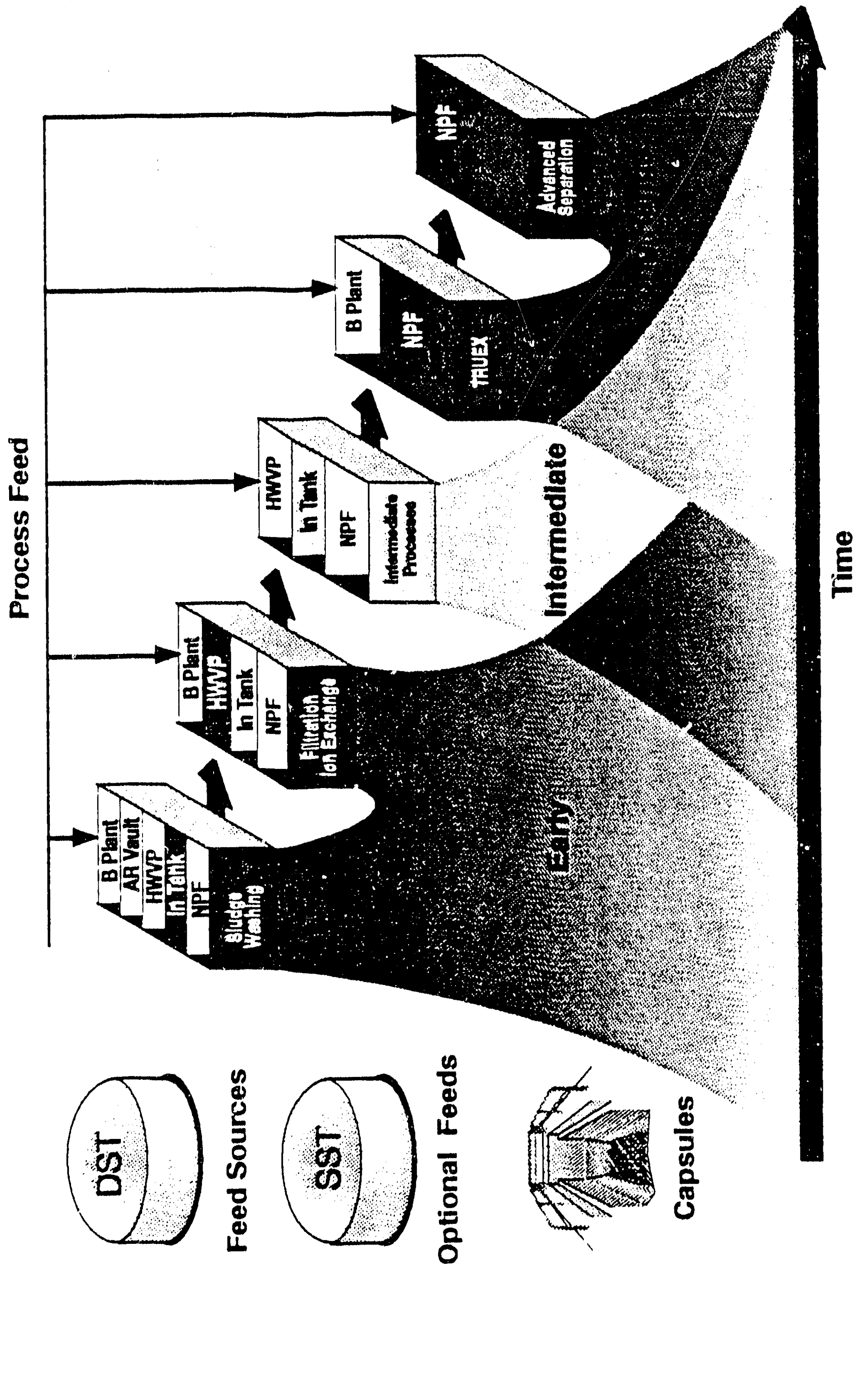
The comparative analysis of the key decision attributes for the 16 facility and process alternatives presented in other sections and summarized in Section 2.0 resulted in several important conclusions.

- The preferred alternatives use sludge washing in an existing or new double-shell tank (DST) to provide early feed for vitrification in the Hanford Waste Vitrification Plant (HWVP).
- Alternatives that use the transuranic extraction (TRUEX) process result in fewer canisters of glass, reduce disposal costs, and complete the disposal mission earlier than alternatives that use sludge washing alone.
- A new pretreatment facility (NPF) that includes the TRUEX process is preferred to the use of existing facilities. An NPF eliminates environmental compliance issues resulting from the use of existing facilities and supports the capability to process single-shell tank (SST) wastes.
- Intermediate processes provide flexibility to the pretreatment strategy by adding the potential to accelerate processing of some wastes before construction of an NPF. Also, intermediate processes can potentially reduce the requirements for processes to be installed in the NPF.
- The capability to process neutralized current acid waste (NCAW) supernatant and wash solutions at an early date to remove ^{137}Cs by ion exchange accelerates complete disposal of a DST waste type and alleviates tank space constraints.
- The remediation of SST 241-C-106 through waste retrieval and transfer not only resolves a priority tank safety issue but also complements this strategy. Pretreatment and vitrification of this high-heat waste will eliminate concern over continued storage and provide enhanced continuity to vitrification operations in the HWVP.

3.2 RECOMMENDED STRATEGY

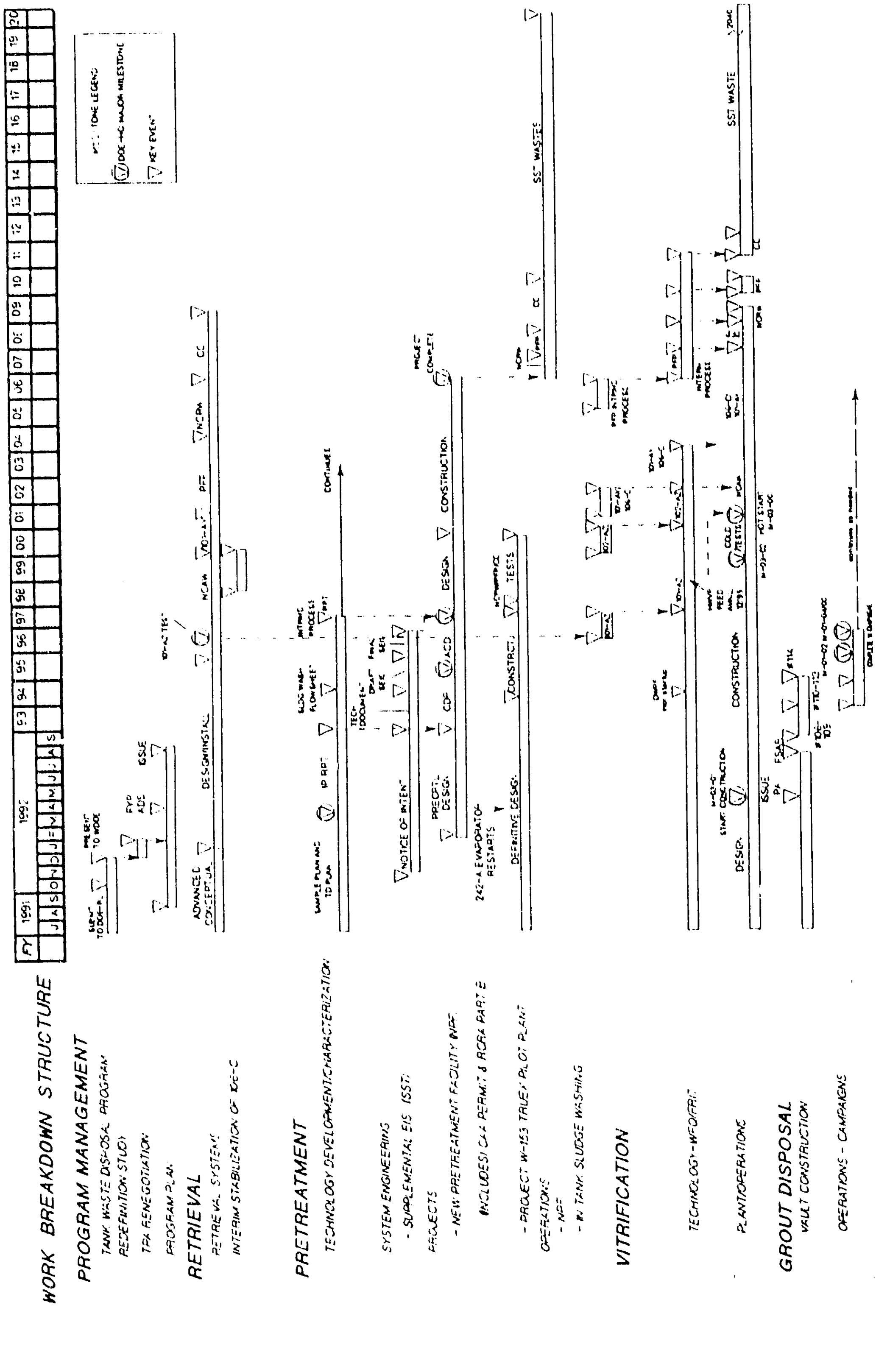
The recommended alternative that best supports the conclusions listed in Section 3.1 is alternative 14 (Table 2-1, Section 2.0). Alternative 14 provides flexibility in the disposal of Hanford Site tank wastes by using a time-phased approach for implementation of pretreatment technologies. Figure 3-1 shows a three-phase strategy for implementing alternative 14. Figure 3-2 shows a target schedule for implementing alternative 14. The three phases of the recommended strategy are as follows.

Figure 3-1. Phased Implementation of Waste Pretreatment.



AR Vault = 244-AR-Vault
DST = Double-shell tank
HWVP = Hanford Waste Vitrification Plant
NPF = New pretreatment facility
SST = Single-shell tank
TRUEX = Transuranic extraction.

Figure 3-2. Target Schedule for Implementing Alternative 14.



ACD = Advanced conceptual design
CAA = Clean Air Act of 1977
CDR = Conceptual design report
FSAR = Final safety analysis report
FYPADS = Five Year Plan Activity Data Sheet
PA = Preliminary assessment
TPA = Hanford Federal Facility Agreement and Consent Order (Tri-Party Agreement)
WDOE = Washington State Department of Ecology
WFQ = Waste form qualification.

In the near term, mature technologies (i.e., sludge washing and cesium ion exchange) will be applied to NCAW, waste from tank 241-C-106, and possibly other chemically and physically similar wastes to provide initial feed to the HWVP. Initial pretreatment will be accomplished in existing DSTs and/or in new facilities procured at a minimum impact to near-term capital and total program life-cycle costs. This phase uses proven technologies in which there is a high level of technical and programmatic confidence; with the use of these technologies, sufficient feed exists to operate HWVP for approximately 9 yr, assuming full throughput capacity and melter replacement every 3 yr.

An overlapping intermediate phase can be started after successful development and demonstration of more aggressive in-tank pretreatment processes. Intermediate-term pretreatment will be accomplished either by implementing process technologies for leaching chemical constituents critical to the waste loading in glass and/or by blending the waste to reduce the impact of critical components on the number of glass canisters produced, along with other approaches that may emerge during the development process. These intermediate processing technologies will be applied to waste in selected DSTs and primarily accomplished in-tank. The application of intermediate technologies would maintain feed to the HWVP if the development of advanced pretreatment technologies or construction of an NPF is delayed.

In the long term, pretreatment of tank wastes will be accomplished in a new facility using advanced separation technologies, such as the TRUEX process and organic complexant destruction. Advanced processing will be conducted in an NPF that could be operational as early as fiscal year (FY) 2007. The final configuration of this facility does not have to be determined for several years. The size and configuration of the NPF will depend on several factors that have to be determined, including the following:

- The extent and timing of SST waste retrieval, to be defined in a record of decision (ROD) following submittal of a supplemental environmental impact statement
- Further characterization of both SST and DST wastes
- The success of intermediate process development.

Other major elements of the strategy are described in the following paragraphs.

Because of the high risk of achieving compliance with environmental regulations and U.S. Department of Energy orders, the existing B Plant and 244-AR Vault are excluded from further consideration as waste pretreatment processing facilities. The B Plant continues to function in support of the Waste Encapsulation and Storage Facility for capsule storage and pilot-plant missions until these functions can be transferred to a replacement support facility.

The tank waste disposal program will integrate the remediation of SST and DST wastes. Waste in tank 241-C-106 and possibly other SST wastes will be retrieved and pretreated as part of the near-term strategy with the goal of enhancing tank safety. In the long term, an NPF will have the capability to process both SST and DST wastes. Integration of the SST and DST waste disposal program allows for optimization of the pretreatment process.

The capability to remove cesium from supernatant and sludge washing solutions will be incorporated into the design of the HWVP and will be available concurrently with the start of HWVP radioactive operations. This capability reduces tank space concerns, reduces the quantity of radionuclides for disposal in grout, provides operational flexibility in the near- and intermediate-terms, and allows earlier final disposal of NCAW. Early disposal of NCAW remediates approximately 80 percent of the total radioactivity in DST waste. If NCAW supernatant is stored until the NPF is available for removing cesium, approximately 40 percent of the total radioactivity in DST waste would be disposed of in the early timeframe.

The start of HWVP construction (site preparations) will proceed in accordance with the current *Hanford Federal Facility Agreement and Consent Order* (Ecology et al. 1990) milestone, April 1992. The start of HWVP hot operations will be delayed a minimum of 15 months to incorporate cesium ion exchange capability and incorporate lessons learned during startup and operation of the Defense Waste Processing Facility. The HWVP construction and startup schedule will be revised as part of the baseline program planning effort scheduled for 1992.

Major capital expenditures for an NPF will be deferred until HWVP construction is complete, tank farm operational safety issues have been resolved, and a decision as to the number of SSTs to be retrieved has been made.

The tank waste disposal program will continue with grout, as directed in the *Final Environmental Impact Statement, Disposal of Hanford High-Level, Transuranic and Tank Wastes, Hanford Site, Richland, Washington* (DOE 1987), as the low-level waste (LLW) form. Technology programs to develop alternative LLW forms that could reduce costs or improve waste form performance will continue to be evaluated.

The participation of stakeholders outside the immediate U.S. Department of Energy community, who contributed to the development of this strategy, will be continued. Future decisions will be made with the assistance of stakeholders.

In summary, a recommended strategy based on alternative 14 implements stakeholders' values for accomplishing the objectives of tank waste disposal. First, the integration of SST and DST waste disposal missions demonstrates responsible environmental stewardship and full commitment to environmental restoration by ensuring that the entire inventory of tank wastes are addressed and considered in a systematic manner. Second, the use of in-tank sludge washing supports the need to get started, supports startup of the HWVP, and is cost-effective. Third, the use of advanced processes, such as the TRUEX process, in an NPF supports timely completion of the entire mission, disposal of both SST and DST wastes, and also ensures an efficient and cost-effective approach. These features and use of the HWVP for cesium ion exchange processing support the environmental and regulatory compliance objectives by performing the bulk of the processing operations in new facilities that fully meet regulatory requirements. Fourth, the inclusion of intermediate processing and early cesium ion exchange provides the flexibility to accelerate the processing of some wastes (e.g., alkaline wastes with high cesium concentration) to further minimize risk to the environment. Finally, the primary difference among the stakeholder groups is driven by the concern over the hazardous chemical and radionuclide inventory in the grout vaults. The selected strategy implements the ROD by proceeding with the disposal of LLW in grout. This strategy also continues work on the evaluation of methods to further remove mobile constituents from the grout feedstream and develop alternative LLW forms with better long-term performance characteristics than the current grout. The ion exchange process installed in the HWVP reduces the quantity of radionuclides for disposal in grout and could be used to remove cesium from double-shell slurry and double-shell slurry feed (LLWs), should that be required. A major impact on the disposal program would occur if the HWVP ion exchange process was required to be used to treat all of these LLWs.

3.3 FUTURE DECISIONS AND ACTIONS

Inherent in the strategic plan are future decisions and actions. These future decisions represent a retention of flexibility in the program because the ability to incorporate new technology, the addition of operating experience from the Defense Waste Processing Facility, and the accommodation of budgetary uncertainty is maximized. The key future decisions are as follows:

- Acceptance of this strategy
- Location and extent of future pilot-scale work
- Scope and timing of the supplemental environmental impact statement for SST wastes
- Timing and extent of SST waste retrieval (as noted in Section 2.4.3, acceleration of the supplemental environmental impact statement and ROD for SSTs will allow better integration of the DST and SST disposal missions)
- Extent of intermediate processing to be deployed and the preferred facility location
- Process requirements and physical configuration of an NPF
- Determination of additional viable candidate tanks for sludge washing.

The key future actions are as follows:

- Establish program baseline
- Perform additional characterization of waste in DSTs and SSTs
- Complete retrieval development for DST and SST wastes

- Confirm the viability of in-tank sludge washing
- Continue development of intermediate processing
- Complete the TRUEX development plan and evaluate alternative (to TRUEX) processes
- Continue development of the TRUEX process and the required pilot-scale plants and preparation of regulatory permits (i.e., *Clean Air Act of 1977* and research and development permits)
- Develop process details, facility modifications, process control hardware, and *National Environmental Policy Act of 1969* (NEPA) documentation to support in-tank sludge washing
- Develop the conceptual design of the NPF and conduct NEPA assessment
- Integrate this strategy with other programs
- Perform a detailed risk assessment of the selected strategy
- Perform an assessment of NEPA actions and timing for the selected strategy
- Continue development of the LLW disposal strategy
- Ensure waste management and tank farm systems will be capable of supporting pretreatment and disposal activities
- Continue glass feed specification enhancement work as well as other vitrification systems enhancement process developments.

3.4 REFERENCES

Clean Air Act of 1977, 42 USC 7401, et seq.

DOE, 1987, *Final Environmental Impact Statement, Disposal of Hanford Defense High-Level, Transuranic and Tank Wastes, Hanford Site, Richland, Washington*, DOE/EIS-0113, Vol. 1 through 5, U.S. Department of Energy, Washington, D.C.

Ecology, EPA, and DOE, 1990, *Hanford Federal Facility Agreement and Consent Order*, Vol. 1 and 2, Washington State Department of Ecology, U.S. Environmental Protection Agency, and U.S. Department of Energy, Olympia, Washington.

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

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ACRONYMS

DOE	U.S. Department of Energy
DST	double-shell tank
HWVP	Hanford Waste Vitrification Plant
MAU	multiattribute utility
risk assessment	*Hanford Waste Vitrification Systems Risk Assessment-Final Report*
VERT	venture evaluation and review technique

4.0 METHODOLOGY

4.1 INTRODUCTION

4.1.1 Characterization of the Problem

The disposal of Hanford Site tank waste represents a complex problem that involves many technical, institutional, and public issues. For the most part, the wastes are not characterized in detail. There are, however, sufficient characterization data and knowledge of the waste generation processes to safely describe a broad range of treatment and disposal methods with a high confidence of success. The regulatory environment for the tanks, their contents, and the organizations that deal with them is complex and continuing to evolve. In addition, a newly heightened public and regional awareness of all Hanford Site activities, including remediation of the tank wastes, exists.

There are also competing technical considerations that will influence the remediation of the tank wastes. The need to move quickly and knowledgeably results from the following:

- Concern over existing and potential tank leaks
- Operational safety considerations such as the generation of hydrogen in some tanks and the possibility of reactant chemicals in others
- Decreasing tank space to store wastes that are currently being generated by ongoing nonproduction activities.

On the other hand, proper development and demonstration of treatment methodologies and supporting equipment will take time. Facilities to house future processing operations will take time to construct. Also, continuous and efficient feed to the Hanford Waste Vitrification Plant (HWVP) should be provided in a timeframe that supports the scheduled startup.

4.1.2 Factors Affecting the Decision

Because of the considerations discussed previously, there are a number of factors that will affect the decisions being made on disposal of the Hanford Site tank wastes. These are as follows.

- The decision must provide a technically viable method for disposing of both double-shell tank (DST) and single-shell tank wastes. It must strike an optimum balance between the short-term needs and the long-term requirements in such a way as to minimize risks to the program.
- The decision must provide a plan that remediates the waste in a safe manner and that protects the public, environment, and Hanford Site workers.

- The disposal process must be conducted in compliance with all applicable environmental and hazardous waste requirements. Where it is not possible to comply with the letter of the requirements, a fully acceptable mitigating strategy must be in place that is satisfactory to the regulatory agencies.

- The remediation plan must account for the realities of the Federal budget situation. It cannot place unreasonable demands on the U.S. Department of Energy (DOE) budget in terms of total funding or unrealistic rates of growth in resource requirements.

- The tank waste disposal program must be integrated with the overall Hanford Site waste disposal program to ensure the most efficient use of the available resources. It must also ensure that the safety and operational requirements of other programs are fully considered, preferably complemented and enhanced.

- Program development and execution must involve the stakeholders who have interests in the activities at the Hanford Site, either through their legal involvement as regulators or because they live and work in the immediate area.

4.1.3 Need for a Robust Strategy

The activities at the Hanford Site and other Federal facilities are conducted in an environment of rapidly changing national priorities. Because of the frequent changes in Federal management, program management also is subject to change. Thus, programs are in a constant state of reevaluation and redirection. For the tank waste disposal program to succeed, two conditions are necessary. First, the program must possess the technical robustness to justify itself on its own merits in the face of changing priorities. Therefore, it must be well thought out, accomplish the mission efficiently, and be sufficiently flexible to incorporate new technology and endure the impacts of new information or future problems. Second, the program must also have an organization charged with guiding it through the challenges of the future. This organization must be sufficiently knowledgeable and experienced to ensure that the program needs are presented with enough weight behind them to compete with future priorities. The organization also should communicate with the non-DOE stakeholders who have an interest in the disposal of wastes at the Hanford Site.

4.2 ORGANIZATION

To manage the program redefinition project and to ensure that supporting activities received sufficient resources to achieve success, a functional organization responsible to the Westinghouse Hanford Company management team was formed. This functional organization oversaw the supporting activities, ensured proper review of the program redefinition process and resultant recommendation, and ensured that the effort was properly documented and submitted to the DOE in a timely manner.

4.2.1 Supporting Studies and Evaluations

At the beginning of the program redefinition project, there were a number of questions from the *Hanford Vitrification Systems Risk Assessment-Final Report* (risk assessment) (Miller et al. 1991) as well as from previous studies of the pretreatment process. These questions were addressed in a series of study tasks that were performed in support of the program redefinition effort. The topics addressed included the following:

- B Plant seismic evaluation
- B Plant secondary containment
- Compatibility of B Plant piping with the transuranic extraction process solutions
- Feasibility of replacing piping in B Plant
- Glass canister costs
- Double-shell tank retrieval
- Grout performance.

As the project developed, it became obvious that additional areas of study would be beneficial and in some cases necessary. These additional areas of concern are as follows:

- Incorporation of single-shell tank mission considerations
- Consideration of tank operational safety concerns
- Alternate low-level waste forms
- Risk and uncertainty analysis of pretreatment facility and process alternatives
- Characterization and retrieval technology development
- Increased emphasis on alternate noncanyon facility configuration
- Intermediate processing.

4.2.2 Organization

To support the actions listed previously, the functional organization shown in Figure 4-1 was formed. In this configuration, each task or logical grouping of tasks was assigned to an activity manager or lead engineer. These activity managers or lead engineers reported to the project manager. In addition, separate teams were formed to conduct the decision-making process and support the writing and publishing of the document associated with the program. The overall organization functioned under the oversight of a board of directors, which contained the personnel shown in Table 4-1. This board of

Figure 4-1. Functional Organization.

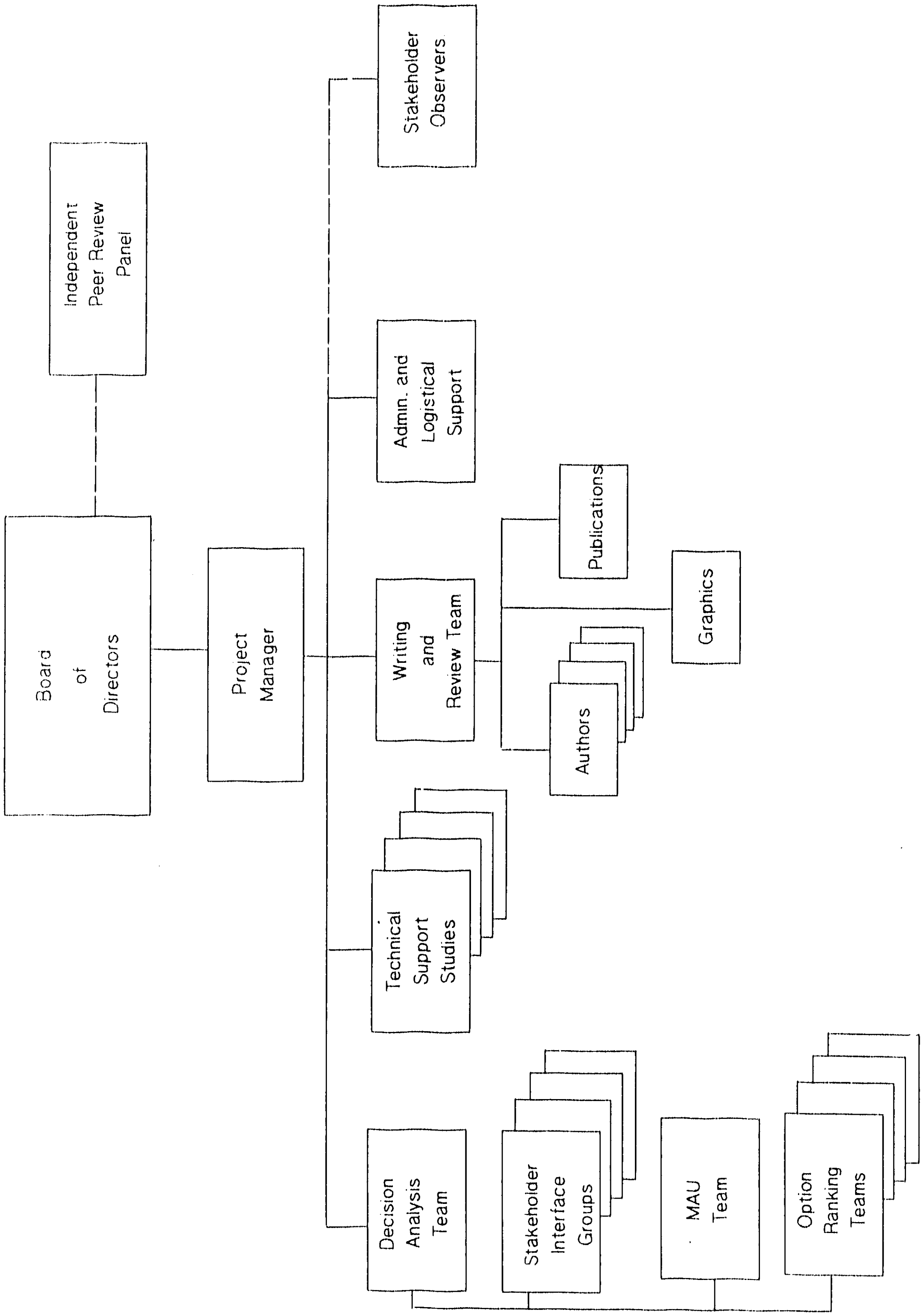

Table 4-1. Board of Directors Personnel.

Name	Organization	Title
M. A. Cahill	Defense Waste Remediation	Manager, Waste Pretreatment Engineering and Project
A. J. Fisher	Environmental, Safety, Health and Quality Assurance	Manager, Quality Assurance
J. S. Garfield	Resource Planning and Program Integration	Manager, Strategic Systems Engineering
K. A. Gasper	Waste Tank Safety Programs	Manager, Program Planning
E. W. Gerber	Engineered Applications	Manager, Nuclear Process Engineering
M. L. Grygiel	Defense Waste Remediation	Manager, B Plant
W. F. Heine	Restoration and Remediation	Staff Manager, Environmental Division
J. J. Holmes	Nuclear Process Engineering	Manager, Alternatives Analysis
J. O. Honeyman	Resource Planning and Program Integration	Manager, Strategic Planning and System Integration
J. L. McElroy	Pacific Northwest Laboratory	Manager, Waste Technology Center
W. C. Miller	Defense Waste Remediation	Manager, Hanford Waste Vitrification System Risk Assessment
G. A. Meyer	Defense Waste Remediation	Manager, Waste Vitrification Program
D. J. Newland	Restoration and Remediation	Manager, Defense Waste Remediation Division
R. C. Roal	PUREX/UO_3 Plant	Manager, PUREX Engineering
J. H. Roecker	Restoration and Remediation	Assistant Manager, Defense Waste Remediation
J. L. Straalsund	Pacific Northwest Laboratory	Director, Office of Waste Minimization
J. C. Wiborg	Environmental, Safety, Health and Quality Assurance	Manager, Health, and Safety Assurance
D. D. Wodrich	Waste Tank Safety, Operations and Remediation	Manager, Technical

PUREX = Plutonium-Uranium Extraction

directors consisted of senior management of concerned organizations within Westinghouse Hanford Company and Pacific Northwest Laboratory. Its purpose was to provide guidance based on the aggregate experience of its members and to build consensus among the Hanford Site contractor team. The project manager reported formally to the board of directors weekly on topics of special interest and kept the members apprised of progress.

4.2.3 External Participation

Representatives of the Washington State Department of Ecology, the Yakima Indian Nation, and the DOE observed and participated in weekly meetings and in key decision-making meetings. In addition, as described in Section 5.0, the values and opinions of the external parties (i.e., stakeholders) were actively solicited and incorporated into the decision-making process.

4.3 DECISION-MAKING METHODOLOGY

The basic elements of the decision-making methodology used to support the redefinition of the tank waste disposal program included the following:

- A stakeholder involvement process, which ensured that stakeholders' viewpoints and values are considered
- Technical analyses of the pretreatment alternatives, which provided a complete and consistent basis for comparing the alternatives
- A multiattribute utility (MAU) analysis, which systematically linked stakeholder values with the technical performance measures to assess the overall merits of the alternatives
- A final recommendation and peer review, which ensured that any additional relevant factors are considered in formulating a final recommendation.

An assessment of the relative merits of the alternatives that supported the formulation of a revised strategy was provided by the MAU analysis. This analysis did not, however, make the final decision. The purpose of this analysis was to gain insight into (1) how the various stakeholder positions affect the preferences for the alternative and (2) how uncertainties in alternative performance can affect the overall preferences. The MAU analysis supports the development of a recommendation, but it is not a substitute for judgment.

Key decision factors were identified through interviews with various stakeholders. These decision factors were organized into objective hierarchies that provided the basis for defining attributes. The attributes define how the alternatives are evaluated. As part of the technical analysis, a consistent set of facility and process alternative descriptions were prepared. These are summarized in Section 6.0 and include deployment and operating schedules, cell layouts, and process descriptions. To supplement the analysis, each alternative was modeled using the venture evaluation and review technique (VERT). The VERT model examined the probable behavior of the alternatives, e.g., schedule variability, cost variability, and the likelihood of technical completion of a mission. The final step in analyzing the alternatives was the scoring of each alternative for each of the attributes. Each attribute included a rating scale, and each alternative was given a score on that scale.

In parallel with the scoring of the alternatives, the stakeholders were asked to provide weights for the attributes. These weights reflected the relative importance of each attribute and were useful in generating a measure of the overall value or utility of the alternatives. The weight elicitation process and results are described in Section 5.0. Attribute scores and weights were combined using the MAU analysis. This analysis provided an overall measure of the relative merit of each alternative. In addition, the analysis was used to assess the sensitivity of the final ranking of alternatives to variations in stakeholder weights and technical performance measures, e.g., total cost or expected schedule performance. These results are described in Section 7.4.

The MAU analysis, VERT model, and peer review combined all aspects of the problem to formulate a final recommendation. An essential aspect of this step was a final review of the MAU analysis by peers not working on the Hanford Site and a technical analysis of the alternatives. The final recommendation balanced the results of the MAU analysis and related sensitivity studies, along with the input from the peer review activity.

4.4 REFERENCES

Miller, W. C., D. W. Hamilton, L. K. Holton, and J. W. Bailey, *Hanford Waste Vitrification Systems Risk Assessment-Final Report*, WHC-EP-0421, Rev. 0, Westinghouse Hanford Company, Richland, Washington.

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ACRONYMS

DST	double-shell tank
HWVP	Hanford Waste Vitrification Plant
SST	single-shell tank
Tri-Party Agreement	*Hanford Federal Facility Agreement and Consent Order*
USC	University of Southern California

5.0 DEVELOPMENT OF STAKEHOLDER VALUES

Redefining the tank waste disposal strategy involves a far-reaching set of decisions and actions. These decisions and actions affect numerous interest groups, within the U.S. Department of Energy and outside of it. A critical part of the redefinition was to identify the values and concerns of the various stakeholders that were pertinent to the evaluation of the tank waste disposal alternatives. The stakeholders' values and concerns were first translated into objectives hierarchies and then into measurable attributes. The attributes defined the dimensions along which the alternatives were evaluated. The intent of the stakeholder involvement process was to ensure that when the alternatives for tank waste disposal were assessed the factors or aspects of performance that were of concern to the stakeholders were included.

This section describes how the stakeholders were identified, the process used to elicit their objectives, and the aggregate results. The aggregate results are shown in a combined objectives hierarchy (see Figure 5-1) that includes the relevant factors from each of the individual hierarchies. The combined hierarchy was used to derive the performance attributes. Also, this section summarizes the results of the meetings in which weights were derived for the attributes. These weights represented the relative importance of the individual attributes to each stakeholder.

5.1 IDENTIFICATION OF STAKEHOLDERS

Stakeholders, previously identified in Section 2.3, are defined as those interest groups that are affected by the outcome of the decision and have a strong desire to ensure that their concerns are addressed in the development of a revised strategy.

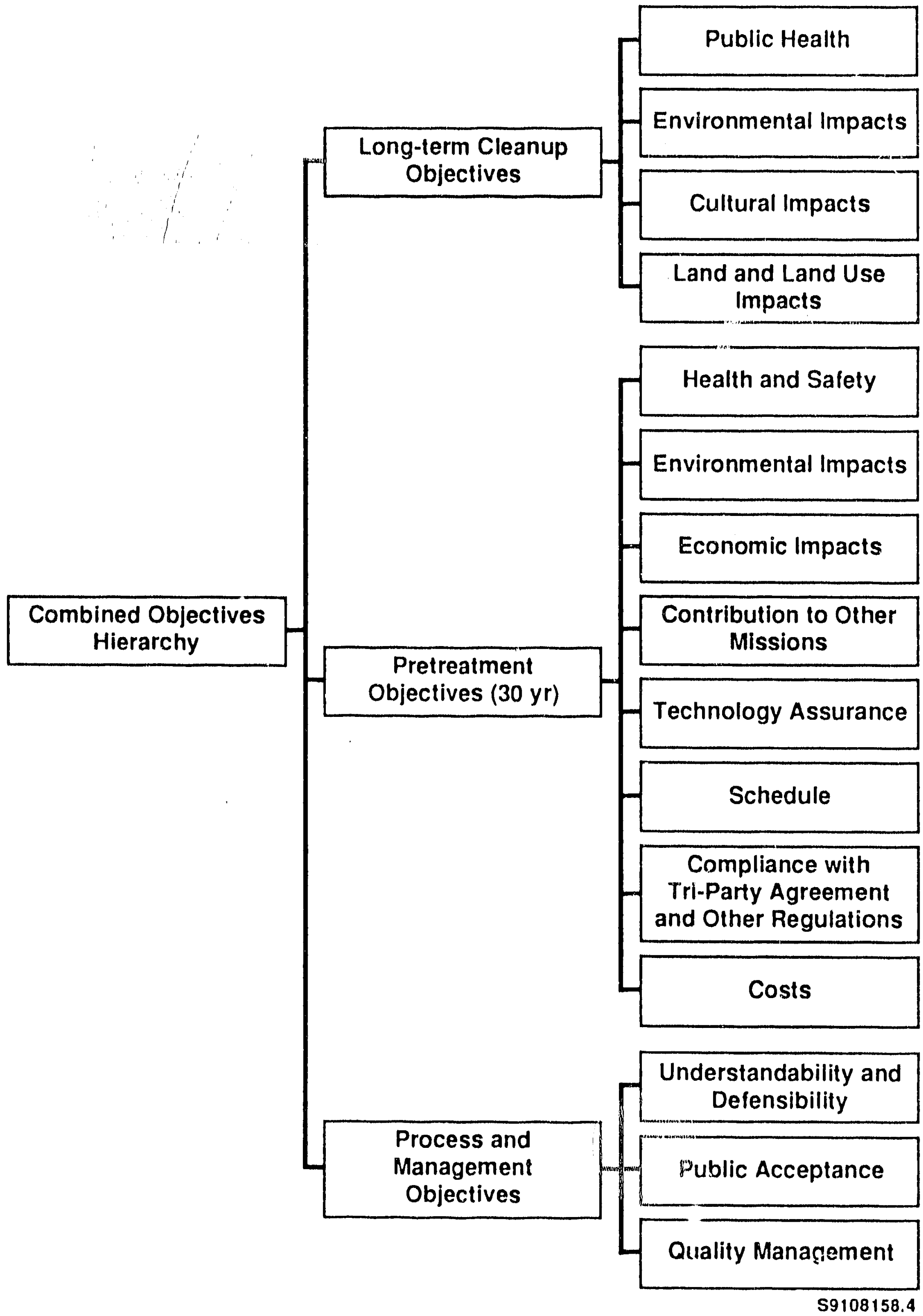
Meetings were held with each stakeholder group. The number of meetings with different stakeholders does not reflect the relative weight or importance that is placed on a particular group's input. Rather, additional meetings were held with some stakeholders to ensure complete coverage of the possible issues of concern.

5.2 ELICITATION OF STAKEHOLDER OBJECTIVES

The initial series of stakeholder meetings[1] generated a set of objectives and possible criteria for assessing the relative merits of the 16 facility and process alternatives. These objectives were elicited from each of the meeting participants and were clarified through discussions and

[1]These meetings were conducted by Dr. Detlof von Winterfeldt from the University of Southern California (USC). He was assisted in these meetings by Dr. Ralph Keeney from USC and Dr. Robin Gregory from Decision Research.

Figure 5-1. Combined Objectives Hierarchy.



combined with similar objectives, as appropriate. Finally, an initial hierarchy was developed that represented the structure of the group's objectives. Meeting participants were given an opportunity to review and revise the initial hierarchy.

5.3 DERIVATION OF THE COMBINED OBJECTIVES HIERARCHY

The individual hierarchies were combined into a single hierarchy, as shown in Figure 5-1. This hierarchy has three basic elements: (1) long-term cleanup objectives, (2) pretreatment objectives, and (3) process and management objectives. Long-term cleanup objectives were separated from the shorter term (30 yr) pretreatment objectives because it was believed that the pretreatment alternatives would not differ significantly along these dimensions. The process and management objectives were also placed in a separate group. This was done because these objectives were believed to apply to all pretreatment alternatives and could be viewed as "critical success factors" affecting the implementation of the alternatives.

5.3.1 Long-Term Cleanup Objectives

The long-term cleanup objectives are shown in more detail in Figure 5-2. These objectives included factors that are more relevant to the analysis of alternatives for the ultimate disposition of the Hanford Site, such as those being addressed in the development of Hanford Site's future use strategy. These objectives took into account the long-term public health, environmental, and cultural impacts, especially as they related to Native American rights. In addition, the general issue of impact on land and land use was included.

These objectives were placed in a separate category because the pretreatment strategies were expected to show little variation along these dimensions. Within the context of the *Final Environmental Impact Statement, Disposal of Hanford Defense, High-Level Transuranic and Tank Wastes, Hanford Site, Richland, Washington* (DOE 1987) record of decision (DOE 1988) that this strategy is implementing, these long-term impacts were relatively stable. Other Hanford Site cleanup actions or strategies could differ along these dimensions.

In particular, future Hanford Site use strategies will examine alternative end uses for various regions within the Site. These factors will be especially important to evaluate as future Hanford Site uses are examined through the Hanford Site's integrated planning process.

5.3.2 Pretreatment Objectives (30 yr)

These objectives represented the primary values that were relevant to the evaluation of the pretreatment alternatives. Figure 5-3 illustrates the complete hierarchy of these objectives.

Figure 5-2. Long-Term Cleanup Objectives.

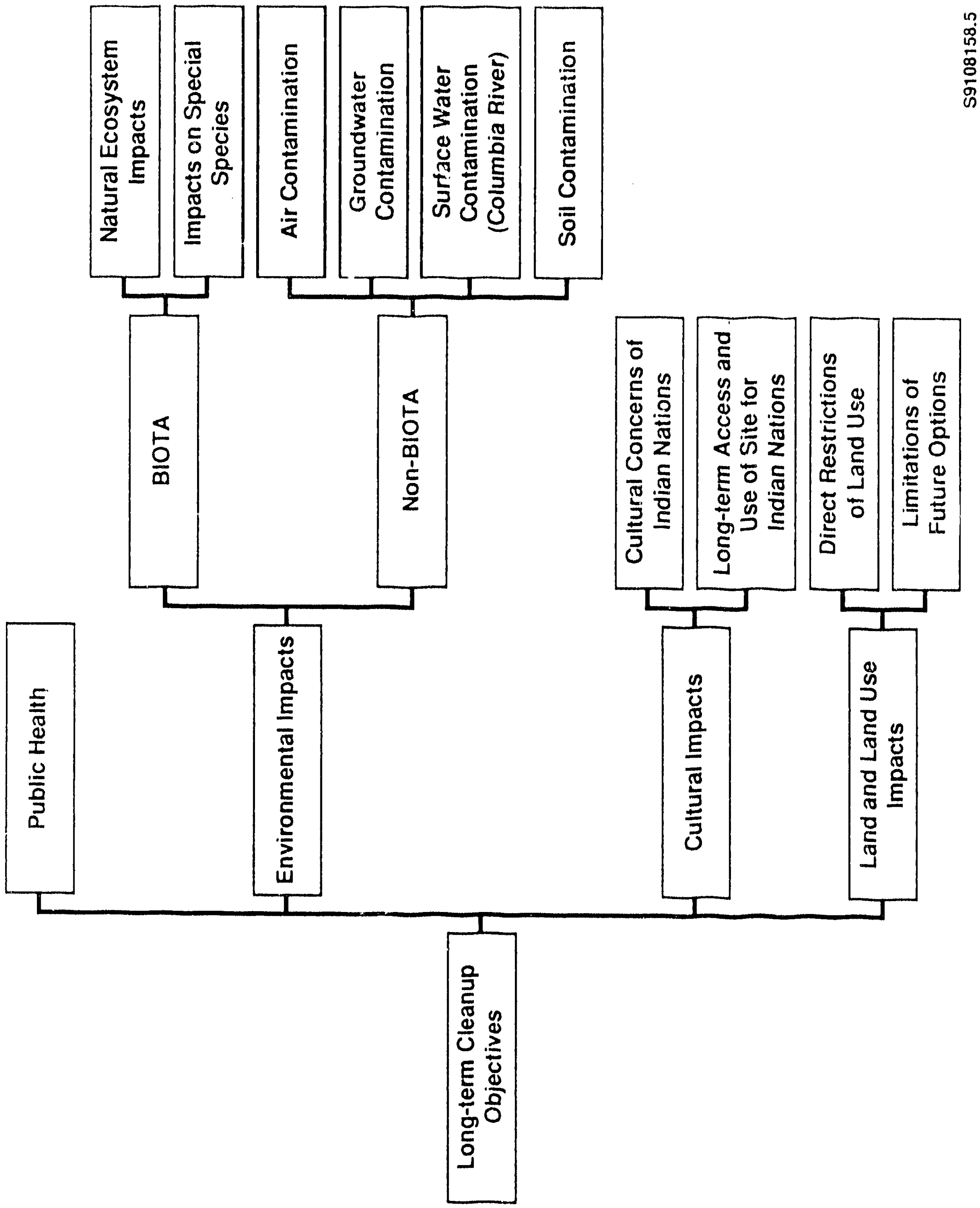
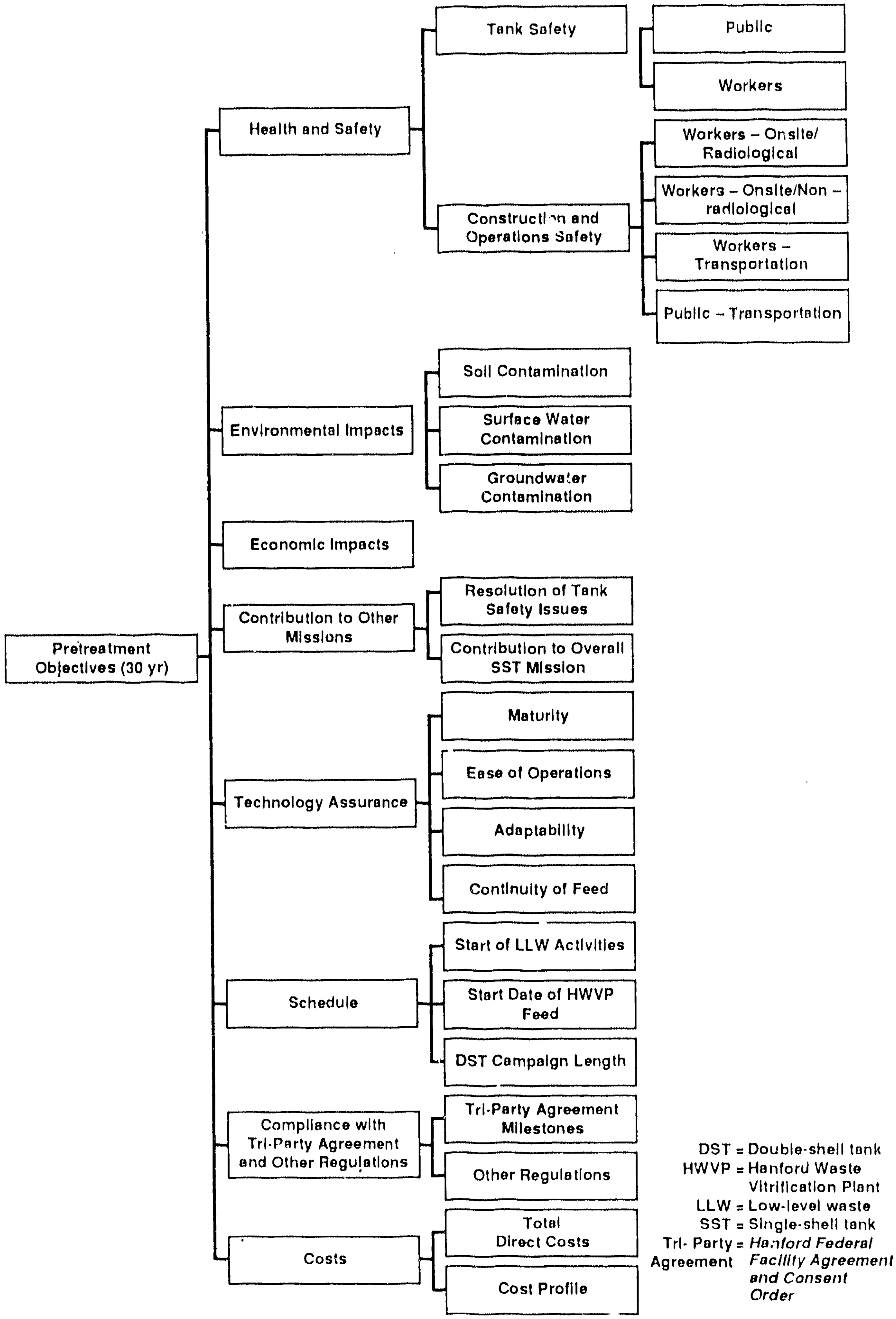


Figure 5-3. Complete Hierarchy.



The health and safety objectives (see Figure 5-3) showed concern for the public and Hanford Site workers. Construction and operational safety issues included radiological and nonradiological risks. In addition, near-term tank safety risks to both the public and Hanford Site workers are included. Environmental impacts included measures for potential contamination of the soil, surface water, and groundwater. Economic impacts addressed the regional and local economic impacts from the development and operation of the pretreatment system. These impacts can result from revenues entering the region and also from variations in employment levels.

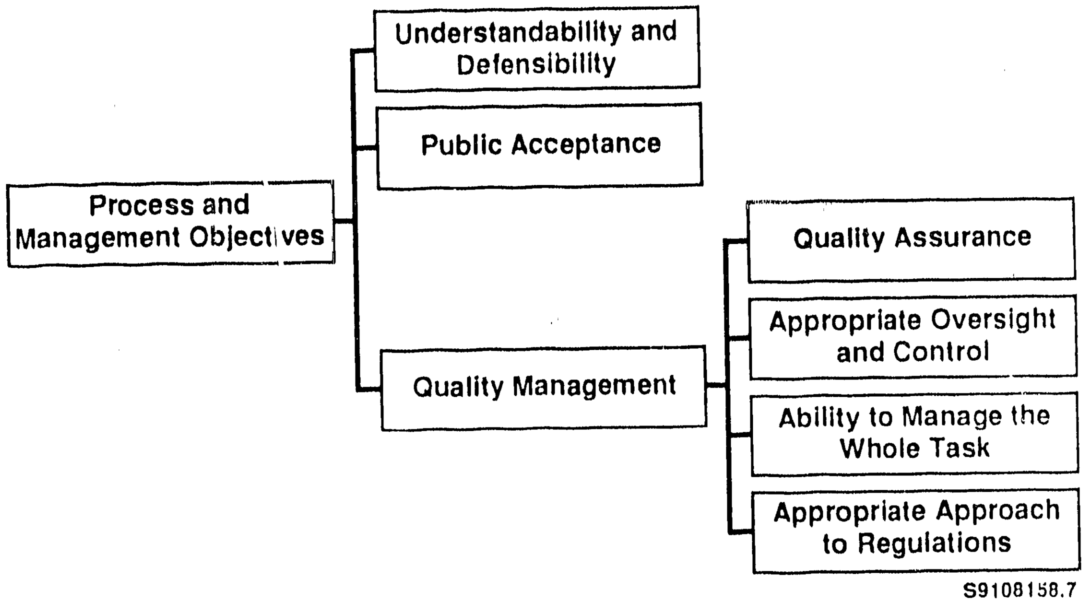
Contributions to other missions reflected the desire to provide benefits to other missions in addition to the double-shell tank (DST) mission, especially single-shell tank (SST) remediation and tank safety. Technology assurance reflected the desire to implement appropriate technology in the pretreatment strategy. Appropriate technology would be mature (i.e., well-developed and demonstrated), reliable, and adaptable (i.e., able to accommodate changes in requirements or improvements in technological capabilities). The overall pretreatment strategy would also need to provide relatively continuous feed to the Hanford Waste Vitrification Plant (HWVP) to ensure full use of multimillion-dollar facilities.

Schedule objectives reflected the desire to start the job and complete it in a reasonable timeframe. Among the subobjectives were initiation of low-level waste (LLW) disposal operations (grout), start of feed to HWVP, and total DST campaign length. A related set of objectives, compliance with *Hanford Federal Facility Agreement and Consent Order* (Tri-Party Agreement) (Ecology et al. 1990) and other regulations, reflected the importance of the Tri-Party Agreement as a controlling mechanism for cleanup at the Hanford Site. Finally, cost objectives were included. There were two separate objectives represented. The first objective was total direct or life-cycle cost. The second objective was the cost profile, which represented the difficulty of simultaneously funding several large capital projects, technology development, and continued operation of facilities.

5.3.3 Process and Management Objectives

The process and management objectives were separated from the other objectives because these objectives could be achieved regardless of which alternative was chosen. Figure 5-4 illustrates these objectives in greater detail. These objectives showed critical "success factors" to the implementation of any of the alternatives. Included in these success factors was the need for tank waste disposal strategy to be understandable and defensible to a broad audience. Overall, public involvement must be continued to develop and maintain public acceptance for the strategy. Quality management reflects the need to implement the strategy in an appropriate manner consistent with U.S. Department of Energy orders and regulatory requirements. These objectives highlight important considerations in the formulation of a success-oriented strategy, but were not discriminators for the selection of which pretreatment alternative to pursue.

Figure 5-4. Process and Management Objectives.



5.4 ELICITATION OF STAKEHOLDER WEIGHTS

A set of measurable attributes were defined to correspond with the objectives in the pretreatment hierarchy. The attributes are listed and defined in Appendix C. The attributes provided the dimensions along which the alternatives were compared. Not all attributes were of equal importance or weight. To determine the relative importance or weight that should be placed on each attribute, a systematic process to elicit separate sets of weights from each stakeholder group was conducted. Separate sets of weights were carried through the analysis for each stakeholder group. No attempt was made to derive a consolidated consensus or "average" set of weights. The sets of weights were used to determine the impact on the relative ranking of the alternatives caused by variations in the values, or weights, expressed by each stakeholder group.

Attribute weights were obtained from four separate stakeholder groups:

- Hanford Site contractor management staff (Westinghouse Hanford Company and Pacific Northwest Laboratory)
- U.S. Department of Energy Field Office, Richland
- Washington State Department of Ecology
- The Yakima Indian Nation.

These weights were elicited in separate sessions with one or more representatives from each organization. These four stakeholder groups represent a broad and diverse spectrum of organizations with a legal interest in waste disposal activities. The technique used to estimate weights for the attributes is known as "swing" weighting. This process calibrates the relative importance to the stakeholder of the expected "swings" or ranges in the attributes. For example,

- The four stakeholder groups' values were judged to provide a range of viewpoints comparable to that of the six stakeholder groups.
- Should a swing of $1 billion between two alternatives be considered more important than a swing of 5 yr in the expected start date of HWVP?
- Would you be willing to absorb a $1 billion increase for an alternative that starts 5 yr earlier?

A series of comparisons were made of this sort with each stakeholder group. Comparisons were first done within a group of similar attributes (e.g., technical assurance attributes). Then, once these initial importance comparisons were done, comparisons were made across groups of attributes. Comparisons were expressed in terms of ratios of importance. Weights were computed for each attribute so that the weights totalled 1.0 and the ratio of any two weights was consistent with the ratios expressed by the stakeholders.

5.5 RESULTS OF STAKEHOLDER WEIGHT ELICITATION

Table 5-1 summarizes the weights derived from the initial stakeholder meetings. The weights are listed for each attribute and for each stakeholder group. At the bottom of the table, the sum of weights for each of the major attribute categories are provided. These provide a quick way to view differences in weights.

The last two columns in Table 5-1 indicate the attribute ranges that were used to derive the weights. The weights should be interpreted as the relative importance, compared to the other attributes, of changing the attribute value from "worst" to "best." The weights show the relative importance of the "swings" of ranges in attribute values.

A wide range of variation in some attribute weights was apparent. For example, the weight on the number of grout vaults varied from 0.04 percent to 30.39 percent. The high weight on grout reflected the Yakima Indian Nation's concern over the inventory of mobile constituents in grout. If this inventory can be reduced, it was indicated that the concern over grout, and its weight, would diminish greatly.

There were some important commonalities in the stakeholder weights. The importance of schedule is clear. The stakeholders showed a strong consensus that the decision needs to be made and a final and complete solution needs to be developed. Also, there appeared to be a consensus on the importance of technology assurance. All of the stakeholders recognized the key role that technology played in accomplishing this mission. Contributing to the SST mission was also highly weighted for all of the stakeholder groups. There was clearly a strong signal from the stakeholders to adopt a strategy that was capable of accomplishing the entire mission.

5.6 REFERENCES

DOE, 1987, *Final Environmental Impact Statement, Disposal of Hanford Defense High-Level, Transuranic and Tank Wastes, Hanford Site, Richland, Washington*, DOE/EIS-0113, Vol. 1 through 5, U.S. Department of Energy, Washington, D.C.

DOE, 1988, "Final Environmental Impact Statement for the Disposal of Hanford Defense, High-Level, Transuranic, and Tank Wastes, Hanford Site, Richland, Washington; Record of Decision," *Federal Register*, Vol. 53, No. 72, pp. 12449-12453, U.S. Department of Energy, Washington, D.C.

Ecology, EPA, and DOE, 1990, *Hanford Federal Facility Agreement and Consent Order*, Vol. 1 and 2, Washington State Department of Ecology, U.S. Environmental Protection Agency, and U.S. Department of Energy, Olympia, Washington.

Table 5-1. Weights from Stakeholders.

	WEIGHTS				Swing Weight Range	
Attribute Description	WHC/PNL	WDOE	Yakima	DOE RL	Best	Worst
CONTRIBUTION TO MISSIONS						
Stored Irradiated Fuel	0.09%	0.00%	0.00%	0.46%	100	0
Contribution to SST Mission	8.61%	12.20%	6.08%	4.56%	100	0
Cs & Sr Capsules	0.00%	0.00%	0.00%	0.00%	NA	NA
TECHNOLOGY ASSURANCE						
Maturity	2.87%	4.39%	9.12%	3.19%	100	0
Adaptability	2.87%	4.88%	4.56%	3.19%	100	0
Reliability	2.87%	2.44%	0.91%	3.19%	100	0
HWVP Downtime (months)	4.10%	0.49%	0.91%	1.28%	0	144
PUBLIC HEALTH AND SAFETY						
Rad Accident-Public	1.15%	1.06%	0.01%	0.36%	0	1
Nonrad Accident-Public	0.23%	1.06%	0.01%	0.36%	0	1
Transport Rad Routine-Public	1.15%	1.06%	0.00%	0.37%	0	1
Transport Rad Accident-Public	3.44%	3.18%	0.04%	1.08%	0	3
Transport Nonrad Accident-Public	0.23%	1.06%	0.01%	0.36%	0	1
WORKER HEALTH AND SAFETY						
Rad Routine-Worker	0.57%	1.06%	0.05%	0.72%	0	1
Nonrad Chem Accident-Worker	0.06%	1.06%	0.03%	0.36%	0	1
Rad Accident-Worker (Rem)	0.29%	2.12%	0.03%	0.36%	0	2
Nonrad Ind Accident-Worker	0.69%	12.73%	0.30%	4.33%	0	12
ENVIRONMENT						
Routine & Nonroutine Effluents	5.74%	8.71%	1.52%	4.10%	100	0
Solid Waste	1.15%	6.10%	30.39%	4.10%	20	200
Number of Grout Vaults	1.15%	4.36%	30.39%	0.04%	35	50
Number of Glass Canisters	11.48%	4.36%	3.04%	4.10%	500	11000
Land Use	0.11%	0.87%	3.04%	0.04%	0	35
SCHEDULE AND COMPLIANCE						
Compliance	5.74%	4.28%	5.47%	15.96%	100	0
HWVP Start Date	11.48%	4.28%	0.03%	3.19%	Dec-99	Oct-2008
SST Closure Date	5.74%	4.28%	2.74%	0.32%	2018	2021
DST Completion Date	5.74%	2.14%	0.27%	0.32%	2010	2034
SST Completion Date	5.74%	2.14%	0.27%	0.32%	2041	2065
COST						
DST $93 (billions)	5.74%	5.31%	0.30%	20.52%	10	20
COST PROFILE						
Average Annual % Increase	7.18%	1.06%	0.30%	0.00%	25.00%	45.00%
Max. Ann. Site Budget Increase	2.87%	2.13%	0.02%	20.52%	5.00%	15.00%
COMMUNITY AND ECONOMY						
Community Economic Impact	0.92%	1.20%	0.15%	2.28%	0	4000
TOTAL SCORE	100.00%	100.01%	99.99%	99.98%		
HEALTH AND SAFETY	7.81%	24.39%	0.48%	8.30%		
ENVIRONMENT	19.63%	24.40%	68.38%	12.38%		
COMMUNITY AND ECONOMY	0.92%	1.20%	0.15%	2.28%		
SCHEDULE & COMPLIANCE	34.44%	17.12%	8.78%	20.11%		
CONTRIBUTION TO MISSIONS	8.70%	12.20%	6.08%	5.02%		
TECHNOLOGY ASSURANCE	12.71%	12.20%	15.50%	10.85%		
COST	5.74%	5.31%	0.30%	20.52%		
COST PROFILE	10.05%	3.19%	0.32%	20.52%		

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ACRONYMS

CC	complexant concentrate
CEPOD	catalyzed electrolytic plutonium oxide dissolution
CFR	*Code of Federal Regulations*
CMPO	octyl(phenyl)-N,N-diisobutylcarbamoylmethylphosphine oxide
DBA	design basis accident
DOE	U.S. Department of Energy
DSS	double-shell slurry
DSSF	double-shell slurry feed
DST	double-shell tank
Ecology	Washington State Department of Ecology
EDTA	ethylenediaminetetraacetic acid
EPA	U.S. Environmental Protection Agency
FY	fiscal year
GDF	Grout Disposal Facility
GTF	Grout Treatment Facility
HDW-EIS	*Final Environmental Impact Statement, Disposal of Hanford Defense High-Level, Transuranic and Tank Wastes, Hanford Site, Richland, Washington*
HEDTA	hydroxyethylenediaminetriacetic acid
HEPA	high-efficiency particulate air
HLW	high-level waste
HNO_3	nitric acid
HWVP	Hanford Waste Vitrification Plant
LLW	low-level waste
NaOH	sodium hydroxide
NCAW	neutralized current acid waste
NCRW	neutralized cladding removal waste
NEPA	*National Environmental Policy Act of 1969*
NPF	new pretreatment facility
NRC	U.S. Nuclear Regulatory Commission
PFP	Plutonium Finishing Plant
PUREX	Plutonium-Uranium Extraction
RCRA	*Resource Conservation and Recovery Act of 1976*
REDOX	Reduction-Oxidation
risk assessment	*Hanford Waste Vitrification Systems Risk Assessment-Final Report*
ROD	record of decision
SREX	strontium extraction
SST	single-shell tank
SW	sludge wash
TBP	tributyl phosphate
Tri-Party Agreement	*Hanford Federal Facility Agreement and Consent Order*
TRU	transuranic
TRUEX	transuranic extraction
WAC	Washington (State) Administrative Code
WESF	Waste Encapsulation and Storage Facility

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6.0 DESCRIPTION OF ALTERNATIVES

6.1 INTRODUCTION

This section provides summary-level descriptions of the facilities and processes considered for pretreatment of tank wastes. An overview of the tank waste disposal program and the functions of the double-shell tank (DST) waste disposal program also are presented.

The pretreatment processes addressed include washing of retrieved tank waste solids as well as existing, advanced, and intermediate technologies for removal of selected radionuclides [e.g., transuranic (TRU) elements, ^{137}Cs, and ^{90}Sr] and destruction of organic compounds. Pretreatment process requirements and alternatives are discussed in Section 6.4.

The pretreatment facilities considered include those already existing at the Hanford Site, specifically B Plant, the Plutonium-Uranium Extraction (PUREX) Plant, 244-AR Vault, and existing DSTs. Potential new facilities also are considered including a pretreatment addition to the Hanford Waste Vitrification Plant (HWVP) and a new pretreatment facility (NPF). Facility requirements are discussed in Section 6.5.

A total of 16 facility and process combinations were chosen for detailed examination, evaluation, and comparison. The selection of alternatives was based on their perceived likelihood of meeting all or most of the objectives for a revised program strategy as discussed in Section 1.4. The selection and descriptions of the 16 facility and process alternatives are presented in Section 6.6.

Section 6.7 addresses the possible pretreatment feeds for the facility and process alternatives.

6.2 TANK WASTE DISPOSAL PROGRAM SUMMARY

Previous sections have described the basis and objectives for the strategy redefinition, the methodology to be used, and the development of stakeholder values to be used in evaluating the process and facility alternatives. This section provides a summary description of the existing tank waste disposal program to establish a perspective for viewing the discussion of facility and process alternatives.

The record of decision (ROD) (DOE 1988) resulting from the *Final Environmental Impact Statement, Disposal of Hanford Defense High-Level, Transuranic and Tank Wastes, Hanford Site, Richland, Washington* (HDW-EIS) (DOE 1987) identified three categories of tank wastes for disposal.

The first category is DST waste. These wastes will be pretreated to separate them into two fractions. The high-level waste (HLW) fraction will be processed into a borosilicate glass waste form in the HWVP and stored onsite until a geologic repository is built and ready to receive the wastes. The low-level waste (LLW) fraction will be solidified as a cement-based grout and disposed of near-surface at the Hanford Site in preconstructed, lined, concrete vaults. The ROD (DOE 1988) identifies B Plant as the current facility for pretreatment of DST wastes.

The second category is single-shell tank (SST) waste. The ROD deferred a decision on final disposal of SST waste pending additional development and evaluation. The development and evaluation effort will focus on methods to retrieve and process the waste as well as to stabilize and isolate the waste in a near-surface repository. The results of this work will be publicly available and analyzed in subsequent environmental documentation, including a supplement to the HDW-EIS (DOE 1987). While not specifically addressing final disposal of SST wastes, the ROD required that the HWVP be capable of processing these wastes should a decision be made to retrieve them.

The third category is radioactive cesium and strontium capsules. Cesium and strontium salts were encapsulated during waste recovery operations, which took place from 1968 to 1985. The encapsulated cesium and strontium wastes presently are stored at the Hanford Site at the Waste Encapsulation and Storage Facility (WESF). These wastes will be packaged in accordance with repository waste acceptance specifications before being sent to a geologic repository.

The program for disposal of each category of tank wastes is summarized in the following sections.

6.2.1 Double-Shell Tank Waste Disposal

Implementing DST waste disposal requires the following activities:

- Waste characterization
  - Evaluate each stage of retrieval, pretreatment, and waste form production operations to establish process characterization needs
  - Acquire and analyze samples
  - Develop analytical methods.
- Waste retrieval
  - Determine retrieval techniques
  - Develop equipment
  - Perform pilot-scale testing
  - Perform full-scale process tests on multiple waste types
  - Install and operate systems for retrieval and transfer of all DST wastes.

- Pretreatment
  - Develop technology and processes
  - Perform laboratory and pilot-scale testing
  - Modify facility and/or construct new facility
  - Perform pretreatment operations.
- Grout LLW
  - Develop process and grout formulation
  - Write performance assessment
  - Construct a grout treatment facility and near-surface vaults
  - Operate facilities and fill vaults.
- Vitrify HLW
  - Develop technology, process, and equipment
  - Qualify waste form
  - Design, construct, and operate the HWVP.

Section 6.3 provides more information on the DST waste disposal program's function with respect to these activities. The Waste Tank Safety, Operations, and Remediation Organization is responsible for the continued safe storage of DST wastes before and after pretreatment and the transfer of wastes between processing facilities.

The scope of the tank waste disposal program includes pretreatment and vitrification of the high-level and/or TRU fraction from the present waste inventory as well as the waste that will be produced during the disposal period:

- Neutralized current acid waste (NCAW), 5,300 m^3 (1.4 Mgal) assuming no future PUREX Plant operations
- Neutralized cladding removal waste (NCRW), 3,300 m^3 (0.875 Mgal) of sludge, assuming no future PUREX Plant operation
- Plutonium Finishing Plant (PFP) waste, 970 m^3 (256,000 gal) of sludge
- Complexant concentrate (CC) waste, 18,200 m^3 (4.8 Mgal).

The LLW fraction from the pretreatment of these wastes together with double-shell slurry feed (DSSF) and other dilute DST wastes will be solidified as grout. The processing of 3,800 m^3 (1 Mgal) of LLW is required to fill one vault containing 5,300 m^3 (1.4 Mgal) of grouted waste.

6.2.2 Single-Shell Tank Closure

Before a decision can be made regarding the disposition of SST wastes, additional development and evaluation will be performed as follows.

- Radioactive and hazardous waste constituents will be characterized.
- Engineered barrier performance will be demonstrated by both instrumented field tests and modeling.
- The need and methods to improve the stability of the waste form will be determined, and destruction or stabilization alternatives for hazardous constituents will be evaluated.
- Methods for retrieving, processing, and disposing of this waste will be evaluated.

Following this additional development and evaluation and before the final disposal decision(s) are made, alternatives for final disposal will be analyzed in a supplement to the HDW-EIS (DOE 1987). This supplement will be issued in draft form for public review and comment before June 2002.

The *Hanford Waste Vitrification Systems Risk Assessment-Final Report* (risk assessment) (Miller et al. 1991) examined the uncertainties associated with the potential vitrification of SST wastes in the HWVP. The ability to integrate the DST and SST processing schedule within the HWVP baseline schedule and design life also was evaluated. The significant findings that related to development of a tank waste disposal strategy follow.

- The HWVP production capacity is sized properly to support the vitrification of all 149 SSTs within the HWVP design life, if the wastes are pretreated to significantly concentrate the HLW fraction using a transuranic extraction (TRUEX) or similar process.
- Preliminary examination showed that B Plant does not have the capacity nor can it be modified to pretreat the much larger volume of SST wastes in a reasonable time period. Thus, a different facility will be required.
- A major risk exists because the necessary environmental and regulatory documentation on retrieval, pretreatment, and vitrification of the SST wastes will not be available when needed to support the efficient integration of the DST and SST vitrification missions. A potential schedule gap of up to 10 yr could occur between the DST and SST vitrification campaigns. This could occur unless the supplemental environmental impact statement and the permitting documentation needed to retrieve and pretreat the SST wastes and complete closure of the SSTs are prepared and approved before the *Hanford Federal Facility Agreement and Consent Order* (Tri-Party Agreement) [Washington State Department of Ecology (Ecology) et al. 1990] milestone. The time to complete environmental documentation also poses a significant risk to the closure of the SSTs by the year 2018, as required by the Tri-Party Agreement.

Further, the risk assessment cited the high probability that the waste from a minimum of 22 SSTs will have to be retrieved because of their TRU and total radionuclide content (they contain approximately 75 percent of all radionuclides in SST wastes). A recommendation was made to prepare a supplemental environmental impact statement with an ROD targeted for the mid-1990's. The ROD would include an option for the retrieval, pretreatment, and immobilization of the waste using the HWVP and grout facilities.

6.2.3 Cesium and Strontium Capsules

The cesium and strontium capsules continue to be stored safely in the WESF adjacent to B Plant.

The overpacking concept for geologic disposal of the capsules is not believed to comply with the statutory requirements for chemical and phase stability defined by Title 10, Code of Federal Regulations (CFR), Section 60.135(a)(2) [10 CFR 60.135(a)(2)] (NRC 1990a) or chemical compatibility defined by 10 CFR 60.135(a)(1) (NRC 1990a). Thus, the overpacked cesium and strontium capsules may not be disposed of without obtaining a waiver for at least these two repository disposal requirements. Uncertainty about the acceptability of overpacked capsules and the high cost of repository disposal per canister (496 canisters would be required at a repository cost of $174 million) suggest that other disposal alternatives be considered.

Recently, the vitrification of cesium and strontium salts in the HWVP was identified as a possible alternative to overpacking. A preliminary evaluation concluded that it was technically feasible to blend the cesium chloride and strontium fluoride salts with NCAW or CC wastestreams and process the waste through the HWVP. Similarly, the evaluation determined that it may be technically feasible to remove the halides (chlorine and fluorine) and blend the resulting cesium and strontium solutions with NCAW or CC waste feedstreams. Blending the capsule waste with NCAW would result in vitrification of five additional canisters. Rough order-of-magnitude cost estimates showed that blending the cesium and strontium salts with the waste, or removing the halides before blending with NCAW, or CC waste are the lowest-cost alternatives.

The feasibility of vitrifying capsule contents in a standalone HWVP mission was also considered. While technically feasible, the production and repository costs for approximately 133 additional canisters make this alternative less attractive than the blending alternatives. Nonetheless, all vitrification scenarios resulted in lower estimated costs than overpacking the capsules for disposal in a geologic repository.

The risk assessment (Miller et al. 1991) recommended development of appropriate supplemental environmental documentation to reassess the disposal methods for these wastes.

The impact of cesium and strontium capsule disposal on the tank waste disposal strategy is minimal. The estimated five added canisters that could result from blending these wastes with NCAW are insignificant. The 133 canisters resulting from a standalone mission could be processed in less than 5 months. This represents approximately 1 percent of plant design life and could be accomplished as "fill-in" between major vitrification campaigns. Accordingly, the disposal of cesium and strontium capsules is not considered further in this document.

6.3 FUNCTIONS OF THE DOUBLE-SHELL TANK WASTE DISPOSAL PROGRAM

The DST system consists of the processing functions listed in Figure 6-1. The immediate emphasis of systems engineering centers on the separation functions, i.e., facility and process alternatives for conducting waste pretreatment. Other DST system functions will be addressed in the near term.

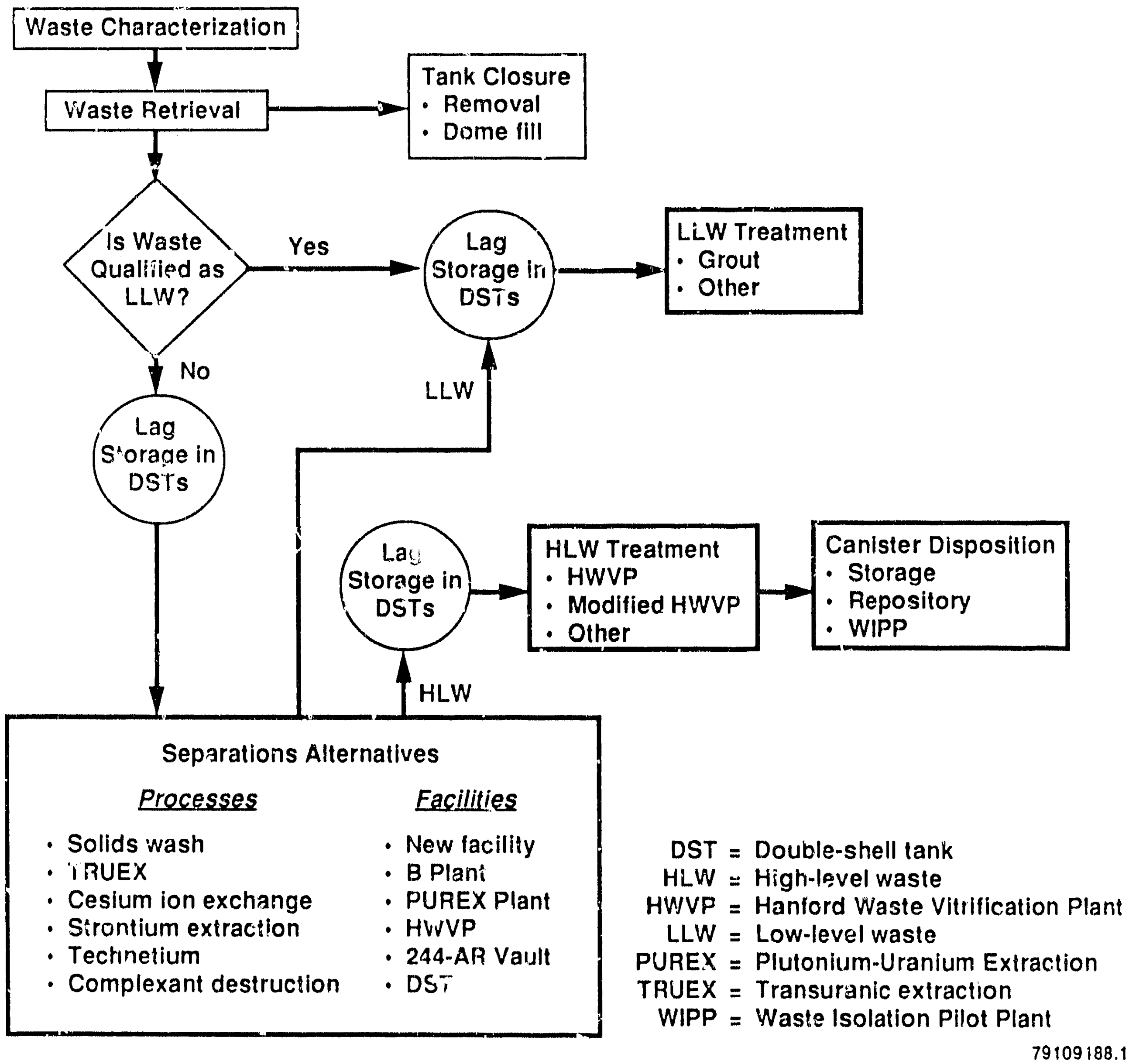
The following sections briefly describe the key functions (see Figure 6-1) that are part of the DST waste disposal program. Important uncertainties relating to the mission functions, which were identified by the risk assessment (Miller et al. 1991), also are described. The issues and programmatic risks identified by the risk assessment provided input into tank waste program redefinition recommendations (Section 3.0). This section (Section 6.0) discusses the identification and comparison of DST waste pretreatment alternative facility and process combinations to allow a low-risk approach to be recommended.

6.3.1 Characterization

Knowledge of the chemical composition and selected physical properties of DST wastes is essential to design and develop retrieval systems and to select and develop appropriate pretreatment processes and technology. Characterization of DST wastes involves three main tasks: (1) acquisition of a statistically significant number of representative samples of liquid and solid waste, (2) chemical analysis of individual waste samples and composite samples, and (3) measurement of selected physical properties (e.g., density, specific gravity, particle size) of solid and/or liquid wastes. Currently, specially designed and remotely operated equipment is inserted through selected risers in the DSTs to obtain core samples in separate 48-cm-long segments. The number of sample segments required is dependent on the total depth of waste in the tank being sampled. The waste segments then are transported to a hot cell where composite waste core samples are prepared for chemical analysis and physical measurements.

Sufficient and accurate characterization of DST wastes is an important part of a revised tank waste disposal program strategy. Methodology and equipment currently "in hand" provide a satisfactory base to build and implement upgraded waste characterization technology and equipment. Such upgrades include a second core drilling and sample truck (recently received onsite), advanced analytical procedures and instrumentation to identify and quantify key organic constituents, and analytical techniques to determine the amount, if any, of ferrocyanide compounds in DST liquid and solid wastes.

Figure 6-1. Double-Shell Tank Waste Disposal System Elements.



Significant uncertainties and risks to the present DST program relating to waste characterization are identified in the risk assessment (Miller et al. 1991). Delays in characterizing the DST wastes have resulted from tank safety issues, limited availability of sampling and laboratory resources, competing characterization priorities, and funding redistributions. These delays are affecting the finalization of the processes and plans for retrieval, pretreatment, vitrification, and grouting of the DST wastes. Lack of needed data could delay startup of HWVP and affect continuity of feed to the HWVP. There is an associated risk that changes to process systems or equipment may be required once the waste compositions are better understood.

6.3.2 Retrieval

Retrieval of DST wastes involves two primary operations: (1) mobilization of solid sludges and (2) transfer of the mobile sludge-supernatant mixture to a pretreatment facility. For all types of DST waste, the goal is to obtain a waste slurry that can be transferred from the DST to a pretreatment facility.

Development, demonstration, and implementation of retrieval technology will focus initially on retrieval of NCAW. Pretreated NCAW feed is a prime candidate feed for startup of HWVP operations in 1999. Process tests to develop and demonstrate a retrieval system for NCAW will be performed on waste in tank 241-AZ-101. The objective of the process tests with tank 241-AZ-101 waste is to demonstrate mobilization of at least 90 percent of the settled solids (50-cm depth) and to demonstrate that a slurry suitable for transfer to a pretreatment facility can be maintained in the tank. The impact of in-tank sludge washing on the retrieval system must also be assessed.

Mixer-type pumps will be used to mobilize sludge in the retrieval process test with tank 241-AZ-101 waste. Such pumps have performed successfully in similar applications at other U.S. Department of Energy (DOE) sites (e.g., Savannah River and West Valley). Initial sludge mobilization process tests will use only two mixer pumps, but provisions will be made to use four pumps if the required degree of sludge mobilization cannot be achieved with two pumps. Adequate instrumentation (e.g., radiation probes, thermocouples) will be available in the retrieval process to determine the progress and results of sludge mobilization.

Rheological and physical properties of NCRW, PFP waste, and CC waste are not as well known as those of NCAW. Because of the anticipated high shear strength of NCRW solids, mixer-type pumps may not be suitable for mobilizing this waste. In any case, experience and knowledge gained in the process tests with tank 241-AZ-101 waste together with results of tests with simulated NCRW, PFP waste, and CC waste will be used to select suitable retrieval equipment for these latter wastes.

Major DST waste retrieval uncertainties and risks (Miller et al. 1991) include the following:

- Technical challenges from the substantial variation in physical properties of wastes to be retrieved and lack of detailed characterization data on those physical properties

- The uncertain condition of the tanks and the potential impacts on the retrieval system designs
- Competition for physical space and workforce resources at the tank farms during construction and operations
- Anticipated budget shortfalls in FY 1992.

One of the primary sources of potential delay to the startup of HWVP is the possible need to remove the sludge heel from the initial HWVP feed tank before it can be filled with pretreated waste. Characterization of the sludge heel with the tank is proceeding to determine appropriate actions. Alternative feed tanks will be available with construction of four new DSTs, planned to be completed in early FY 1999.

A DST waste retrieval approach that will minimize schedule risks for supporting the recommended DST program strategy has been identified as part of the ongoing DST waste system engineering evaluation.

6.3.3 Pretreatment

Pretreatment refers to chemical and physical procedures by which the waste can be separated into a LLW fraction and a HLW fraction. The relatively large (by volume) LLW fraction will be suitable for grouting and disposal in near-surface facilities. A smaller (by volume) HLW fraction will be suitable for vitrification in the HWVP and subsequent, more expensive disposal in a deep geologic repository. Pretreatment processes range from simple to complex physical and chemical operations.

The simplest pretreatment for tank wastes involves solid-liquid separation and solids washing operations; this produces wastes suitable either for further pretreatment or for disposal by grouting or vitrification. Intermediate-to-complex pretreatment operations can involve one or more of the following steps: (1) ion exchange for removal of ^{137}Cs from alkaline liquid waste; (2) destruction of soluble organic components of alkaline or acidified liquid waste; (3) dissolution of washed solids in aqueous HNO_3 media; and (4) liquid-liquid solvent extraction and/or ion exchange technology to remove selected radionuclides including TRU elements, ^{137}Cs, ^{90}Sr, and possibly ^{99}Tc. These and additional alternatives for DST waste pretreatment are addressed in Section 6.4. Uncertainties and risks associated with the present DST waste pretreatment baseline are identified in the risk assessment (Miller et al. 1991) and include the information in Sections 6.3.3.1 and 6.3.3.2.

6.3.3.1 Pretreatment Technology. The risk assessment model showed TRUEX process development is on the critical path for the program and, as a result, introduces a risk of program delay. Technology development for the pretreatment of the NCRW, PFP waste, and CC waste may not be resolved on a schedule that permits the design and construction of the full-scale TRUEX process equipment. The final step in the verification of TRUEX process technology is operation of a pilot plant in the WESF and B Plant. The pilot plant will verify the waste processing flowsheets for NCRW, PFP waste, and CC waste, and materials selection for the process equipment. According to current planning, the first waste type (i.e., NCRW) testing would be completed in parallel with the completion of the TRUEX process plant systems design, approximately 3 yr before actual plant operations with NCRW are scheduled to begin. If significant technical issues were uncovered during testing, the feed availability to HWVP could be jeopardized. The recommended strategy (Section 3.0) will alleviate much of this uncertainty by approaching the development of TRUEX and other actinide partitioning technologies (Section 9.4.4.3) in a series of technology development scales and by developing alternate technologies. The majority of design information needed from the TRUEX process will be obtained from (1) the near-term operations of a radioactive tracer pilot plant which will be tested and evaluated in the mid-1990's and (2) laboratory-scale continuous countercurrent tests with actual wastes. In addition, alternative to extraction, such as solid sorbants and preparation and leaching processes (intermediate processing), will be tested and evaluated.

The risk assessment (Miller et al. 1991) showed that pretreatment processing of CC wastes may take substantially longer than previously estimated. A 1- to 2-yr delay in program completion could occur if process equipment sizing is not optimized for this waste type.

6.3.3.2 Pretreatment Facilities. The principal issues with B Plant are compliance with current regulatory requirements and the ability to accommodate the TRUEX and organic destruction processes. B Plant piping may not be compatible with corrosive solutions generated during pretreatment operations involving the TRUEX process. If B Plant is not viable, substantial delays in the startup of HWVP and the completion of the DST waste program are anticipated unless alternate processing strategies are developed.

Identification of pretreatment process and facility alternatives and a comparison of their associated attributes with respect to the uncertainties and risks identified previously is the key function of Sections 6.0 and 7.0 of this document. It is also a key element in identification of the revised DST waste program strategy recommended in Section 1.0.

6.3.4 Grout Treatment Facility

In accordance with the ROD (DOE 1988) for the HDW-EIS (DOE 1987), the DOE constructed a Grout Treatment Facility (GTF) at the Hanford Site. The GTF is located partly in the 200 East Area and partly in the adjacent 218-E-16 Area. The HDW-EIS refers to the GTF as the Grout Facility, which includes the transportable grout equipment, the Dry Materials Facility, the Grout Disposal Facility (GDF), and the feed transfer system. The grout disposal system is composed of the concrete vaults and associated barrier systems.

The DST waste is classified as an extremely hazardous waste because of the toxicity [40 CFR 261 (EPA 1990a)] (book method) as defined in Washington (State) Administrative Code (WAC) 173-303-101, "Toxic Dangerous Wastes" (Ecology 1991). The waste is characteristically corrosive because of the hydroxide concentration and is characterized as toxic because of the high concentrations of nitrite and hydroxide ion.

Grout treatment is the process of mixing selected DST wastes with grout-forming solids, and possibly with liquid chemical additives, to form a grout slurry that is pumped into near-surface, lined concrete vaults for solidification and permanent disposal. The radioisotope content of the solidified waste is Class C or below as defined by 10 CFR 61 (NRC 1990b).

The Grout Processing Facility is a treatment facility; the GDF (which consists of the grout disposal vaults) is considered a disposal facility. The disposal vaults are managed as surface impoundments while the grout slurry is fluid and also for a period of time after the grout slurry has solidified but before the vaults are closed as landfills.

Potential grout feedstreams include the low-level fraction of DST wastes from past, current, and future Hanford Site operations. Waste from DSTs may require processing before it is considered acceptable as feed to the grout process.

Selected DST wastes are disposed in batch sizes (campaigns) of approximately 3,800 m^3 (1.0 Mgal). The total grout volume when dry-solids are mixed with 3,800 m^3 (1.0 Mgal) of liquid waste for one campaign is approximately 5,300 m^3 (1.4 Mgal).

The disposal of current and projected inventories of DST waste may take up to 25 yr to complete. During this time, vaults will be constructed, filled as surface impoundments, and closed as landfills in accordance with WAC 173-303-650(6)(a)(ii), "Surface Impoundments" (Ecology 1991). At most, four campaigns will be conducted per year.

Sufficient quantities of double-shell slurry (DSS) and DSSF have been identified to allow completion of a minimum of 15 grout campaigns (one campaign of phosphate-sulfate waste has been completed) before the LLW fraction from pretreatment is required for grout feed. During these campaigns, GTF operations are independent of the vitrification program activities. The vitrification program, however, depends on GTF operations to generate the DST space needed for retrieval and pretreatment operations. If grout campaigns are delayed, the vitrification program could be impacted.

A current ruling from the U.S. Nuclear Regulatory Commission (NRC) designates DSS and DSSF as LLW. However, the NRC's ruling on a petition, submitted by the regulatory agencies to require pretreatment of these wastes to remove the largest technically achievable amount of radionuclides could result in the need to pretreat some or all of the DSS and DSSF. This would increase the burden on the pretreatment facility or require the construction of additional pretreatment facilities and could increase significantly the volume of wastes to be processed in the HWVP. Space in DSTs would be limited until the pretreatment of DSS and DSSF wastes is accomplished.

An evaluation of the impacts of a revision to the current NRC rules on the tank waste disposal program is presented in Section 7.11. The use of alternate waste forms for the disposal of LLW from DSTs is not considered in this study, but will be the subject of a future study. Alternate waste forms for LLW are discussed in Section 9.5.

6.3.5 Hanford Waste Vitrification Plant

The HWVP is being constructed as a major system acquisition project. This $1.06 billion (capital funds) plant will be the largest construction project initiated on the Hanford Site in many years. Project scope includes technology development, process design, detailed design, construction, testing, and startup.

The principal function of the HWVP is to immobilize the high-level and/or TRU fraction of pretreated waste in a borosilicate glass matrix that conforms to repository waste acceptance specifications.

Technology being developed in support of the HWVP includes a wide range of activities that provide data for design of primary and secondary processes, operations, and waste form qualification. The primary focus of work for the HWVP is to provide specific data to the Hanford Site DST waste types. A glass composition envelope is being developed for the HWVP pretreated feeds (NCAW, NCRW, CC waste, and PFP waste) that takes into account the major components of each waste type as well as the frit that must be used to make an acceptable glass. Preliminary acceptable glass composition boundaries have been established that meet process and waste acceptance criteria for the borosilicate glass waste form. Further refinement of the preliminary envelope is in progress and will continue for several years. Information from the glass envelope definition is essential to determine the impacts of feed pretreatment alternatives.

A major part of the overall technology development effort will be to ensure that the final waste form complies with the repository waste acceptance specifications. Although efforts to date have relied on the waste acceptance preliminary specifications, considerable progress has been made toward issuing a waste acceptance specification that will be generic for all waste producers. Development activities include demonstrating process control within bounds that will ensure an acceptable glass product through process modeling, preparing radioactive glass from core samples of tank wastes and then measuring glass properties, and bench-scale testing in the WESF to provide data for correlation with simulated feed results.

Because Hanford Site-specific waste acceptance specifications have not been formulated for the HWVP, the HWVP process, material balance flowsheet, and product specifications have been established to provide a vitrified glass product that meets the requirements for waste form qualification. This was identified for the Defense Waste Processing Facility in *Waste Acceptance Preliminary Specifications for the Defense Waste Processing Facility High-Level Waste Form*, OGR/B-8 (DOE-OCRWM 198[illegible]). Recently, a draft waste acceptance specification document, based on OGR/B-8, was prepared. The draft criteria includes the HWVP-specific glass product characteristics.

To minimize the processing periods and operating costs for processing DST wastes and to provide the capability for processing SST wastes, the HWVP melter capacity was established at 100 kg/h (220 lb/h) of vitrified product, the same as for the Defense Waste Processing Facility at the Savannah River Site. This processing capacity permits maximum use of the technology and equipment developed for the Savannah River Site.

The HWVP process will consist of five major activities: (1) feed preparation, (2) vitrification, (3) canister handling, decontamination, and welding, (4) melter offgas and vessel vent treatment, and (5) process waste treatment. Process equipment associated with these activities is operated and maintained remotely and will be located within cells in the vitrification building. Cold chemical and utility systems and personnel support services required to support the vitrification process will be located in adjacent buildings.

The HWVP will have storage capacity for 2,000 canisters of vitrified waste. This capacity will allow the onsite storage of all vitrified waste from the NCAW, NCRW, and CC waste and PFP waste tanks, providing these wastes are pretreated as currently planned (see Sections 6.6 and 6.7). The design will permit expansion for additional canister storage.

The 40-yr design life of the HWVP will accommodate the defense HLW vitrification needs of both the DST and SST missions.

The risk assessment (Miller et al. 1991) did not identify any major uncertainties with regard to the basic technology or plant design for the HWVP. This was attributed to the HWVP being a second-generation facility modeled after the Defense Waste Processing Facility and having benefitted from more than 20 yr of vitrification technology and pilot- and plant-scale operating experience in the U.S. and foreign countries.

The risk assessment also acknowledged a number of technical uncertainties that could result in process or facility changes. These uncertainties include (1) lack of an approved waste acceptance criteria from the repository, (2) open technical issues under investigation at the Savannah River Site and the Hanford Site, such as hydrogen generation in the waste feed formatting process and noble metal deposition in the glass melter, (3) lack of firm definition of feed composition to the plant for three of the four waste forms, and (4) lack of acceptance of the supplemental environmental analysis for the facility. In addition, the plant capacity may be inadequate to process the increased volume of wastes within a reasonable time if the TRUEX process is not successful in substantially reducing the total amount of wastes to be vitrified.

The most significant findings of the risk assessment (Miller et al. 1991) with regard to the HWVP were the potential lack of pretreated feed for startup in December 1999, and the inability to ensure a continuous or nearly continuous feedstream.

6.3.6 Closure of Double-Shell Tank Farms

The DST system currently operates as a interim status storage and treatment waste management unit under a *Resource Conservation and Recovery Act of 1976* (RCRA) Part A permit application. The pending DST System Dangerous Waste Permit Application indicates that the closure will occur subsequent to closure of the SSTs due to their presumed use in SST closure. Current development plans also consider this strategy.

Closure describes the final disposition of the DSTs following waste removal. Closure addresses disposition of the waste residues left in the tanks, the tanks themselves, ancillary equipment, and contaminated soils. Closure strategies must address the disposition of both the dangerous and radioactive constituents that make up the waste residues. The DST closure could potentially deal with three categories of mixed waste, but it is presumed that waste retrieval activities will render the DSTs sufficiently free of HLW and TRU waste. The residual waste is a mixed waste and Ecology will regulate the tank closure after the waste is removed.

The DSTs must be closed as specified in the state-approved dangerous waste permit application. The WAC 173-303 regulations require clean closure of tank systems. The WAC does not allow for landfill closure of a tank system.

Closure options derived from these regulatory assumptions focus in two primary areas: in situ remediation and tank system removal. The objective of in situ remediation is the removal or in situ treatment of all residual waste to maximum levels achievable using best demonstrated available technology. Then presumably, with contaminant levels below acceptable concentrations or a satisfactory waste form derived from treatment, the DSTs may be closed as landfills with appropriate barriers and monitoring. The objective of removal is "clean closure." The enormity of the removal and subsequent treatment and disposal option favors the use of in situ remediation where at all possible.

Numerous technologies for contaminant removal from steel, concrete surfaces, and piping are established and routinely used in decontamination and decommissioning efforts. Technologies also are available for removing contaminants in soil and the immobilization, macroencapsulation, and fixation of contaminants both in soil and on surfaces. Using and adapting these technologies for DST units will require validation, demonstration, and development, but it appears that in situ remediation is technically viable.

Part of in situ remediation, following residual waste removal or treatment, is the stabilization of subsurface structures. This is described as the filling of structural voids with grout or other load-bearing materials to ensure surface soil stability throughout the future. This is particularly important in the performance of infiltration barriers should they be deemed necessary.

In those areas where in situ technologies are not practical or allowable under the regulations, removal of contaminated DST structures, soil, etc., will be considered. Removal of shallow land structures such as pits, piping, ducting, and spills may be found to be the preferred method of closure; whereas tank structures, etc., would undergo in situ remediation and stabilization.

6.4 DOUBLE-SHELL TANK WASTE PRETREATMENT PROCESS ALTERNATIVES

Alternative processes for pretreatment of DST wastes are described in this section. The choice of pretreatment alternatives will ensure that the most cost-effective method to meet environmental and regulatory standards for final disposal of Hanford Site wastes is used. A major goal of processing Hanford Site tank waste is to reduce disposal costs by reducing the volume of waste that must be vitrified and disposed of in a deep geologic repository. To accomplish this goal, consideration is given to processes that efficiently partition the waste into (1) a large, LLW fraction suitable for less expensive, near-surface disposal in grout and (2) a much smaller fraction of TRU (>100 nCi/g TRU) and/or HLW that must be vitrified for disposal in a geologic repository.

Two reference processing alternatives are considered for all waste types:

- Separation of solids or sludges from supernatant liquids and washing the solids with water to remove soluble salts
- Solid-liquid separations coupled with sludge dissolution and removal of TRU components from acidic waste solutions using the TRUEX process.

Other pretreatment methods are specific to a particular waste type. For example, pretreatment methods specific to NCAW and CC wastes are as follows:

- Removal of ^{137}Cs from alkaline NCAW and CC waste supernatant
- Destruction of complexants in CC waste to remove complexed TRU elements and/or provide a feed for grouting that is free of organic constituents.

6.4.1 Description of Requirements for Waste Processes

Pretreatment of DST wastes is done to separate these wastes into a low-level, low-hazard fraction for disposal as grout in near-surface concrete vaults and a TRU (>100 nCi/g TRU) and/or high-level, high-hazard fraction for vitrification in borosilicate glass.

The pretreatment process for DST wastes must produce a LLW fraction that meets the following requirements. For near-surface disposal of LLW, the DOE has specified the TRU element concentration must be less than 100 nCi/g (DOE 1990a). The U.S. Environmental Protection Agency (EPA) and Ecology regulate the land disposal of hazardous materials that can be incorporated into grout (EPA 1991; Ecology 1991). A management plan has been developed to ensure compliance with the regulations for land disposal of mixed radioactive and hazardous wastes (Hendrickson 1990). The NRC has specified radionuclide concentration limits for land disposal of LLWs (NRC 1982). Additionally, structural and thermal limitations of the grouted LLW and the concrete vault will limit the concentration of radionuclides that can be incorporated into grout.

The NCAW consists of an alkaline supernatant liquid contaminated with cesium in contact with solids that contain TRU elements and strontium. The pretreatment process for NCAW must separate the solids from the alkaline supernatant. The resulting clarified supernatant must contain less than 100 nCi/g of TRU elements. Also, the ^{137}Cs concentration of the supernatant must be reduced to a level consistent with NRC concentration limits for land disposal of the resulting LLW and grout formulation requirements.

For NCRW and PFP waste pretreatment, the TRU element fraction must be separated so that the resulting LLW fraction contains less than 100 nCi/g TRU elements.

Pretreatment of CC waste is more complicated than for other DST wastes. The TRU elements and the ^{137}Cs must be removed from the waste to produce a LLW fraction suitable for disposal as grout. The TRU element concentration of the resulting LLW fraction must be less than 100 nCi/g. The ^{137}Cs concentration of CC wastes must be reduced by 95 percent (Bernero 1989; Rizzo 1989). Decomposition of organic compounds present in CC waste may be necessary to comply with regulations for land disposal of hazardous materials or specific grout structural requirements.

The resulting HLW fraction from pretreatment of DST wastes must meet the vitrification feed specifications to produce a suitable borosilicate glass.

6.4.2 Description of Waste Process Alternatives

Table 6-1 shows the application of sludge washing and TRUEX process for pretreatment of the various DST wastes. Figures 6-2 through 6-10 show conceptual flow diagrams for these two pretreatment concepts for each waste type. Preliminary chemical process material balances (flowsheets) for the sludge wash and TRUEX process alternatives for each waste type were reported by Lowe (1991).

Table 6-1. Summary of Reference Pretreatment Processes.

Double-shell tank waste	Sludge washing			Transuranic extraction			
	Sludge washing	Cesium ion exchange	Complexant destruction	Sludge washing	Cesium ion exchange	Complexant destruction	Transuranic extraction
Neutralized current acid waste	X	X		X	X		X*
Neutralized cladding removal waste	X			X			X
Plutonium Finishing Plant waste	X			X			X
Complexant concentrate waste	X	X	X		X	X	X

*Transuranic extraction process may incorporate an extractant for strontium recovery.

6.4.2.1 Sludge Separation and Washing. Solids in DST wastes can be conveniently separated from associated liquid phases by a combination of settle-decant and filtration methods. Settle-decant technology typically provides for bulk separation of solid and liquid phases. Filtration, e.g., pneumatic hydropulse filtration, can remove finely divided solids from the partially clarified liquid phase.

Figure 6-2. Neutralized Current Acid Waste -- Sludge Washing and Cesium Ion Exchange.

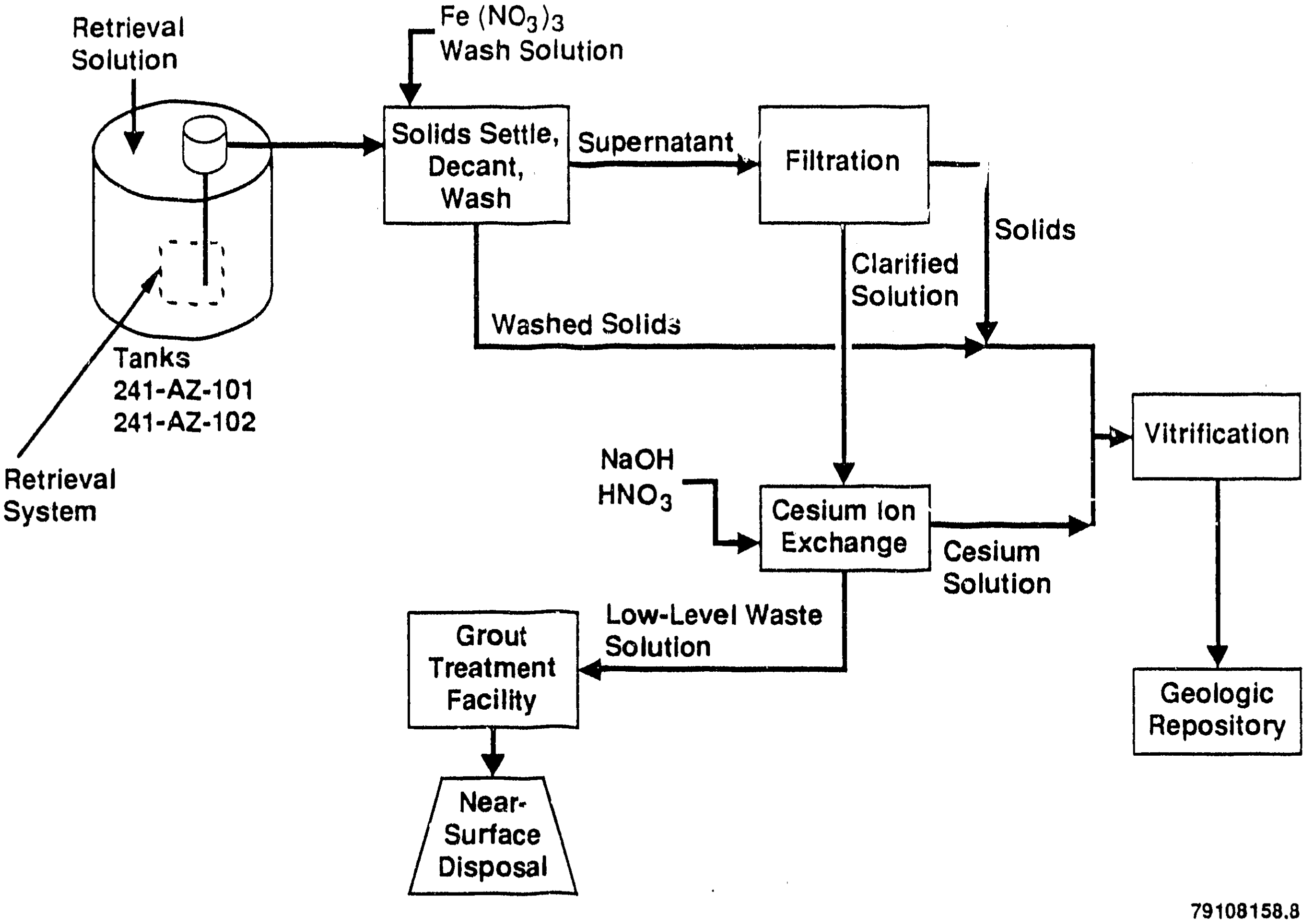


Figure 6-3. Neutralized Current Acid Waste -- Transuranic Extraction Process.

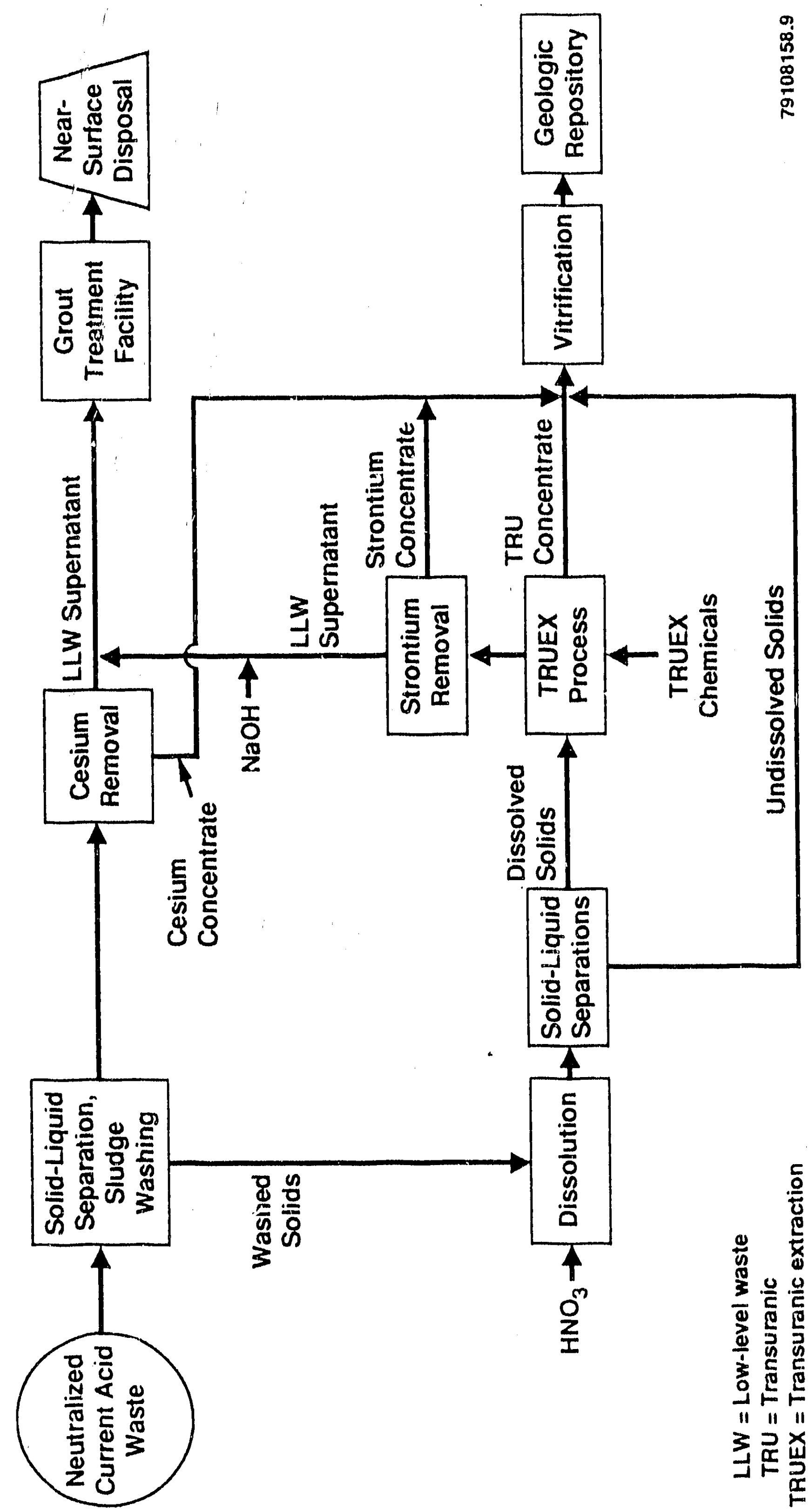


Figure 6-4. Neutralized Cladding Removal Waste -- Sludge Washing.

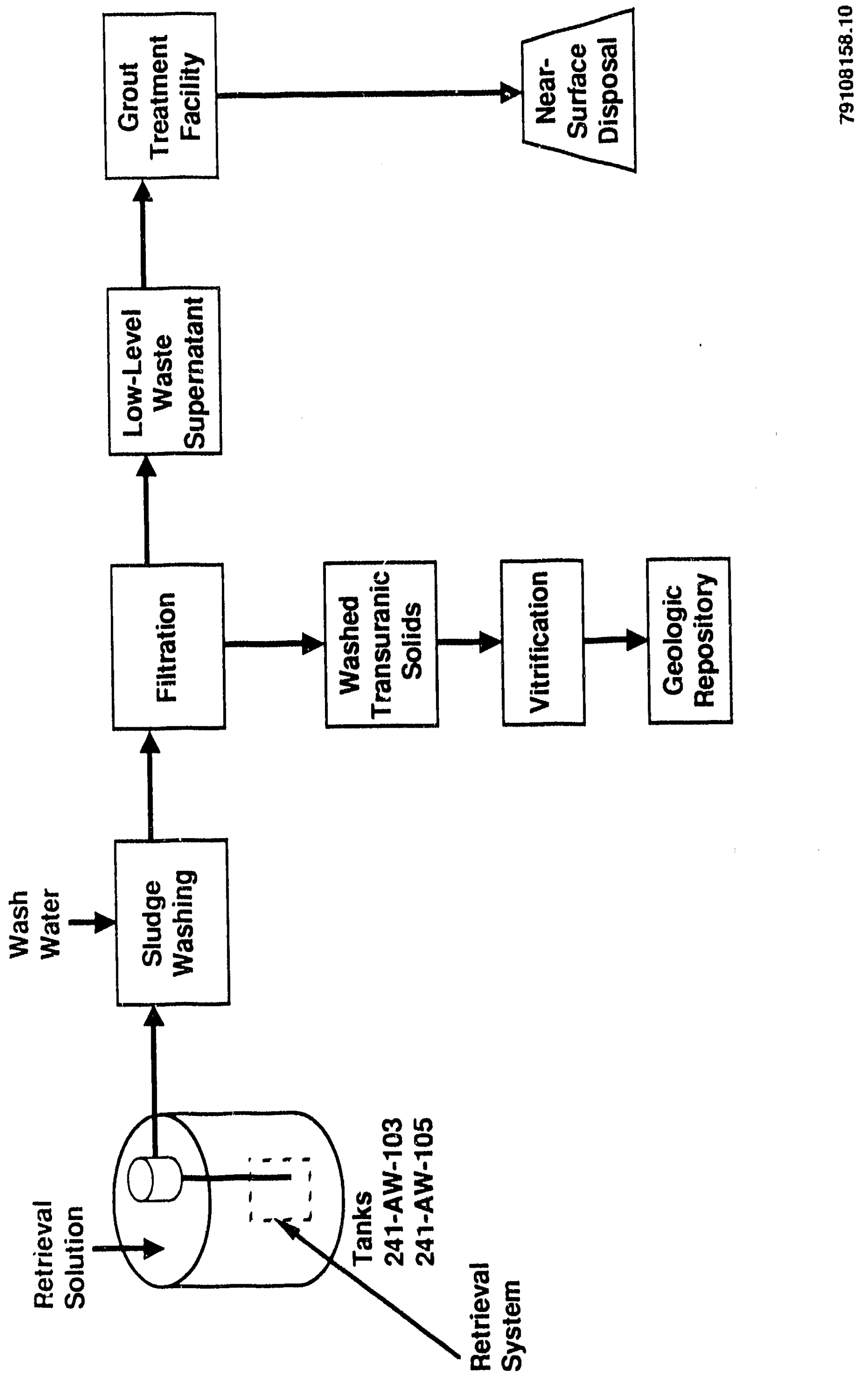


Figure 6-5. Neutralized Cladding Removal Waste -- Transuranic Extraction Process.

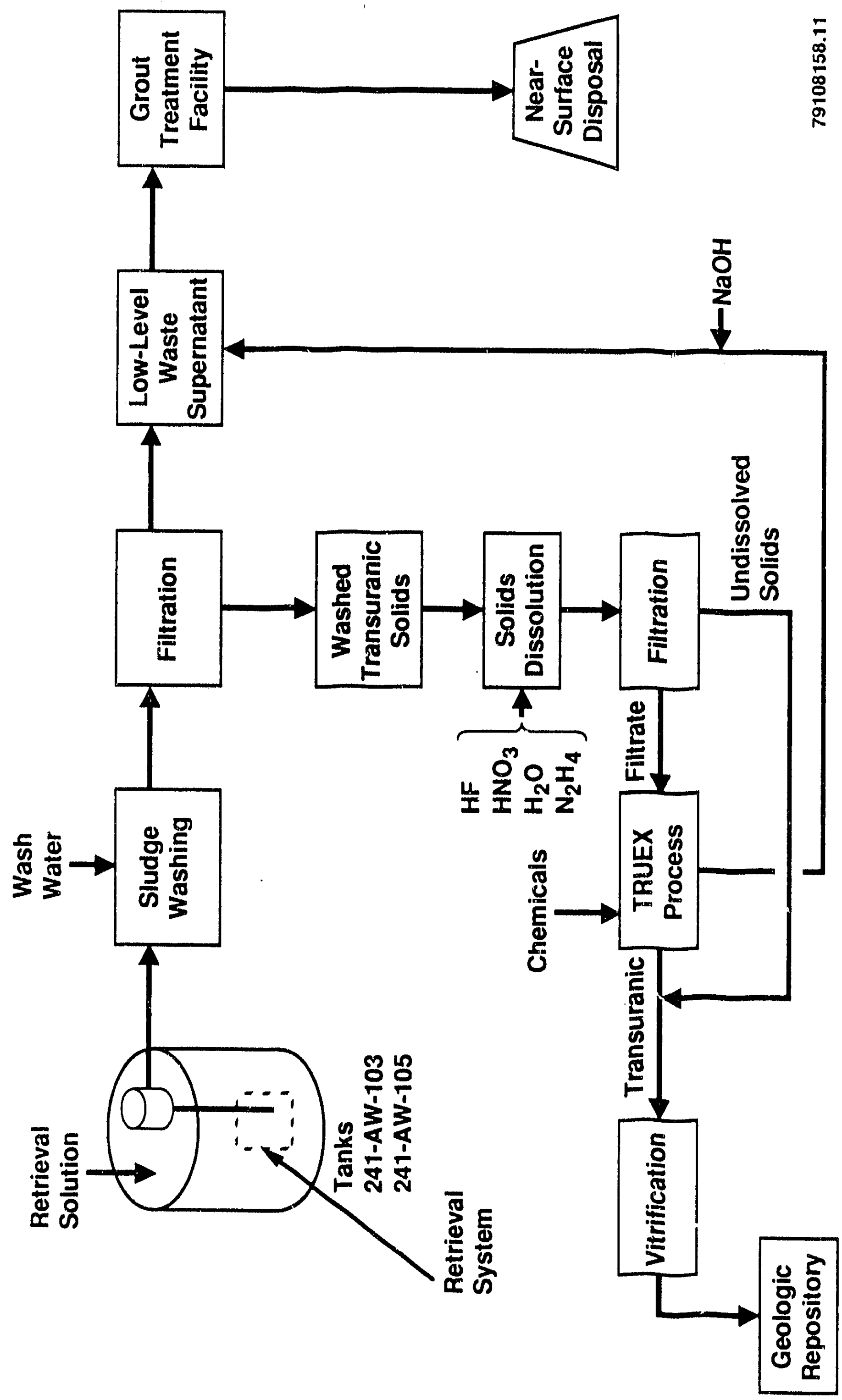


Figure 6-6. Plutonium Finishing Plant Waste -- Sludge Washing.

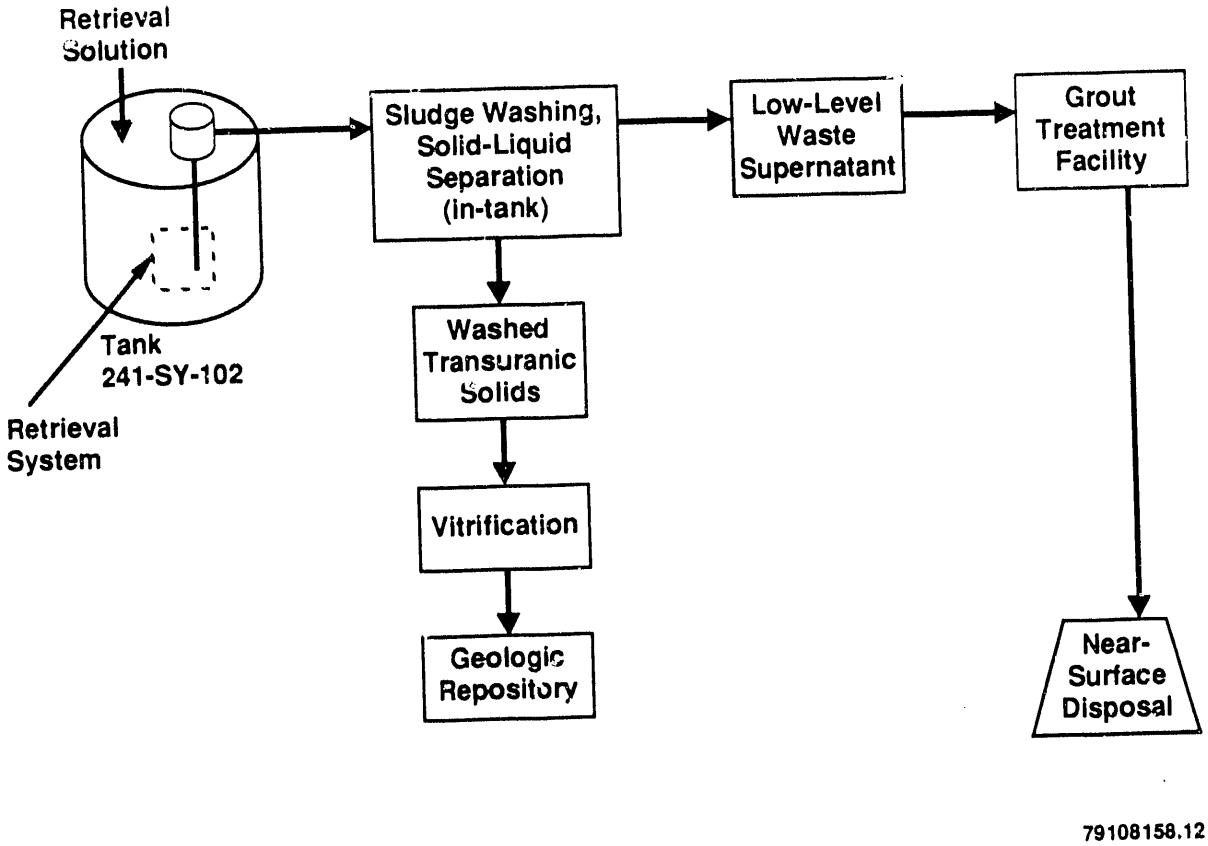


Figure 6-7. Plutonium Finishing Plant Waste -- Transuranic Extraction Process.

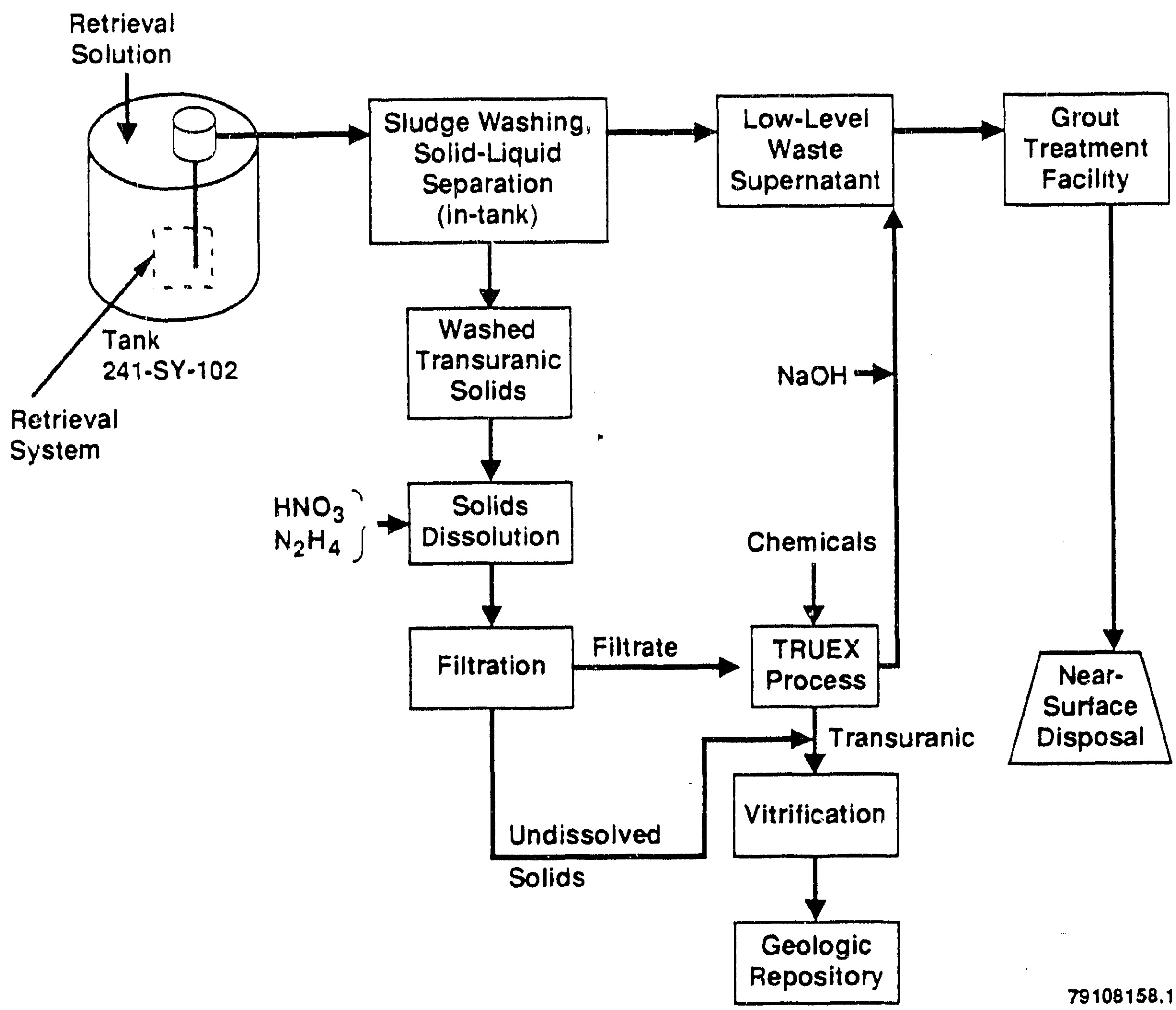


Figure 6-8. Complexant Concentrate Waste -- Sludge Washing.

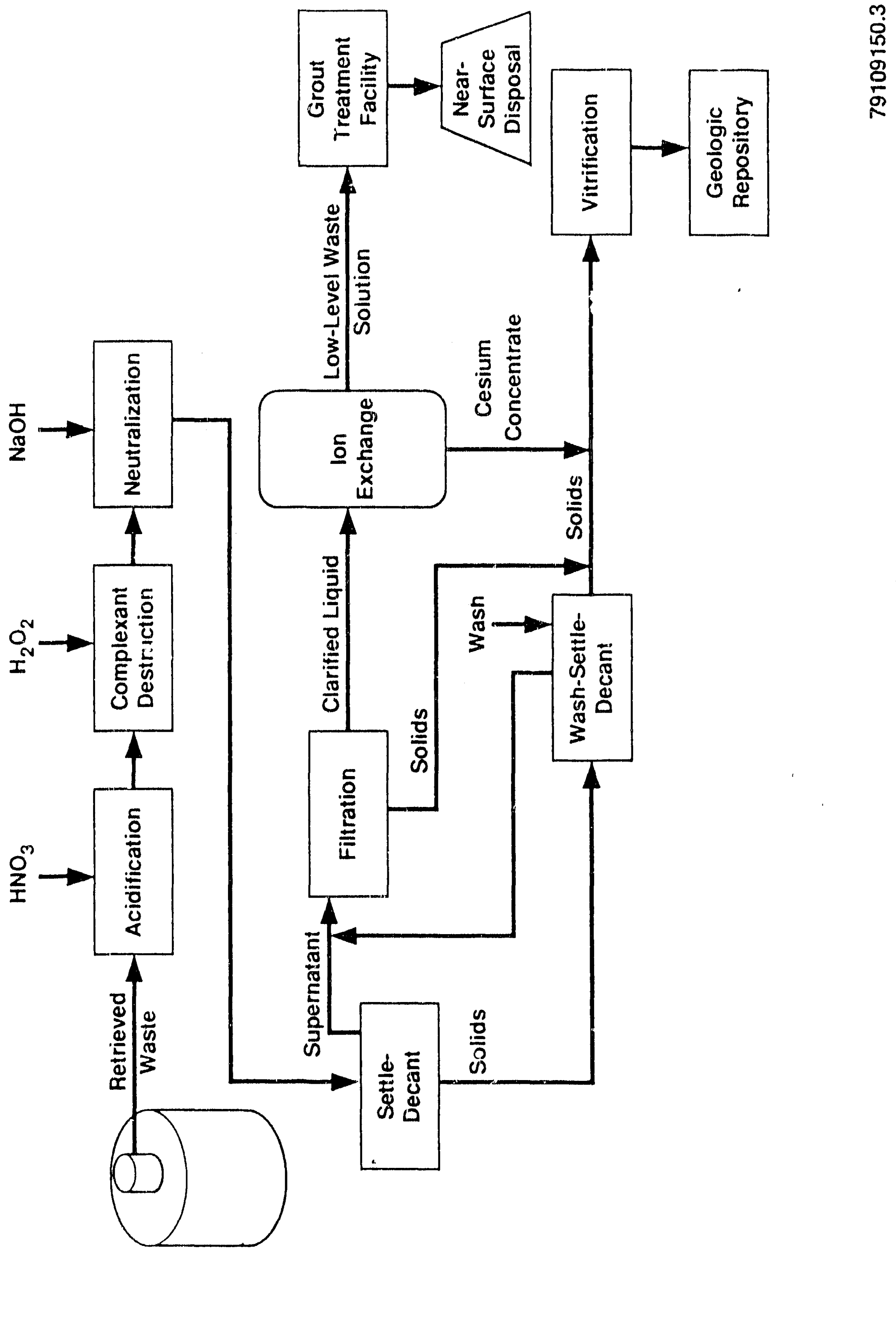


Figure 6-9. Complexant Concentrate Waste -- Alternate Sludge Washing.

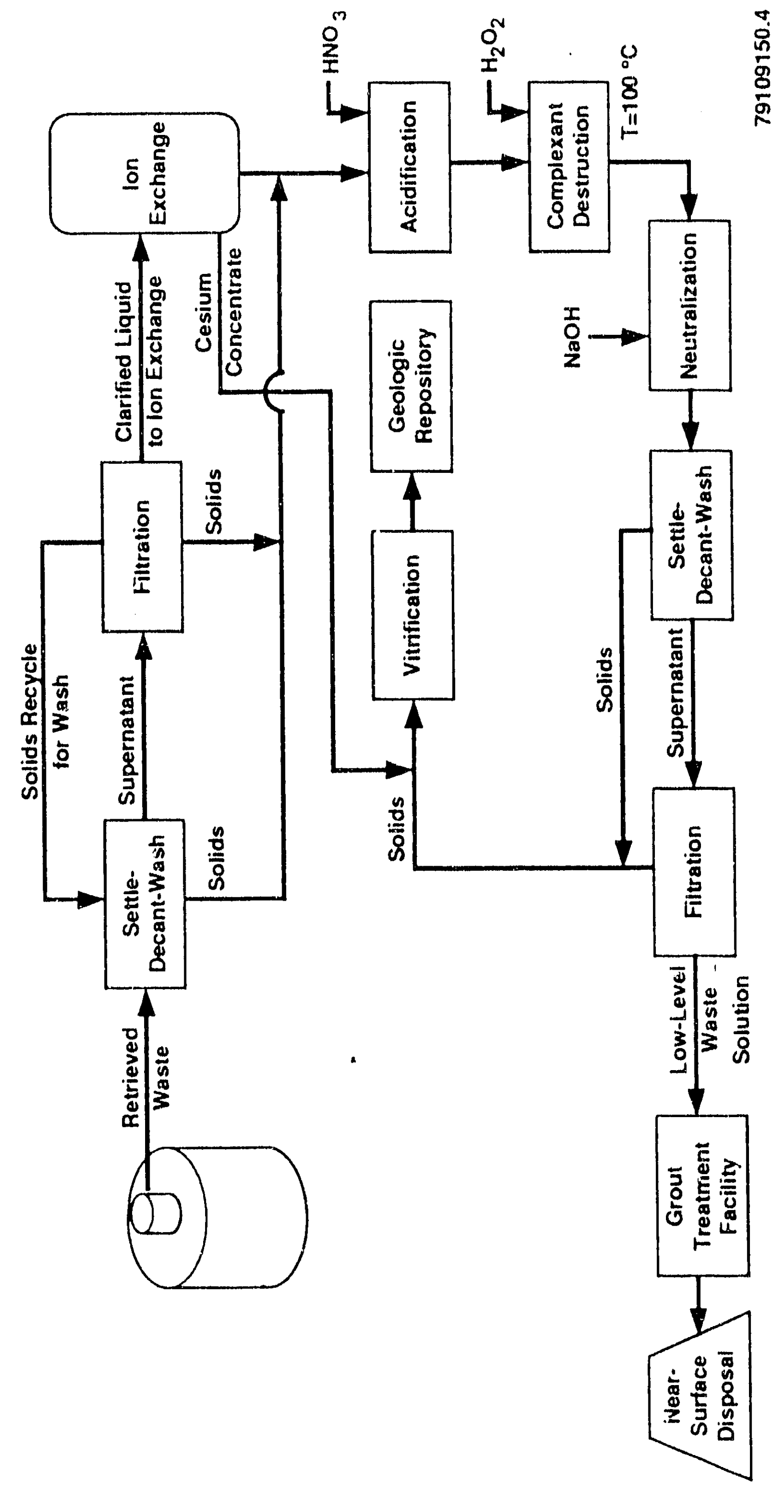
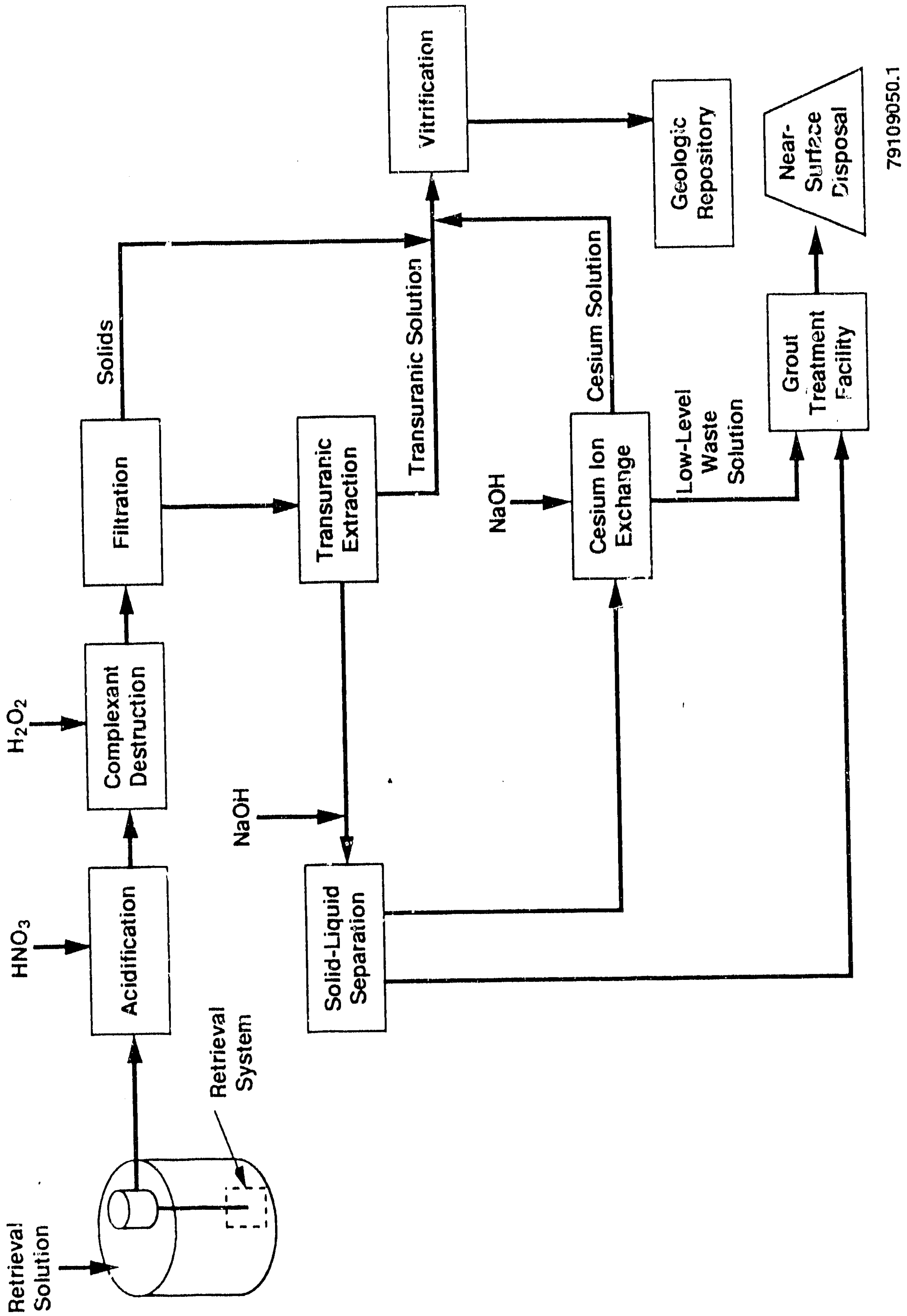


Figure 6-10. Complexant Concentrate Waste -- Transuranic Extraction Process.



Washing separated DST sludges with water removes soluble components, e.g., sodium salts, and thereby reduces the amount of waste that must be vitrified. Water washing also removes soluble sulfate ions that interfere with the vitrification process.

Sludge-washing operations can be performed either in existing DSTs or in stainless steel tanks with associated equipment installed in shielded canyon-type facilities (e.g., B Plant, PUREX Plant). Washing operations performed in existing DSTs (which are constructed from carbon steel) must be restricted to using water and other aqueous solutions that are not excessively corrosive. Bulk separation of solids and liquids in DSTs can be accomplished by simple gravity settling or by centrifugation. Filtration methods used in a shielded facility outside the DSTs will suffice for final clarification of supernatant and spent washes. New DSTs, constructed from stainless steel, can be used for sludge washing using aggressive chemical solutions.

6.4.2.2 Removal of ^{137}Cs. The alkaline liquid portion of NCAW and CC waste contains significant concentrations of ^{137}Cs. The ^{137}Cs must be removed from these solutions to permit their disposal as grout in near-surface facilities.

Ion exchange technology for effective and selective removal of ^{137}Cs from highly alkaline solutions is well known and demonstrated (Schulz and Bray 1987). Such technology was used at the Hanford Site in the 1970's and 1980's to concentrate and purify million curie quantities of ^{137}Cs. Both inorganic (e.g., zeolite-based materials) and organic ion exchange materials have been used successfully on a plant-scale for removal of ^{137}Cs from aqueous alkaline solutions. Organic ion exchange materials are preferred with highly alkaline solutions because zeolites may dissolve in such media.

After recent bench-scale tests, Duolite[1] CS 100 (a phenolic-type cation exchanger) appears to be particularly well-suited for removal of 95 to 99 percent of the ^{137}Cs from clarified NCAW supernatant. Also, Duolite CS 100 resin may work with clarified CC supernatant.

A second cycle of ion exchange is required to further increase the cesium/sodium ratio and eliminate impacts to the canister production requirements from high sodium concentrations in the HWVP feed. Feed for the second cycle ion exchange is prepared by concentrating (to reduce its volume) the acidic eluate from the first ion exchange cycle and then adding NaOH to adjust to the desired feed pH. The second-cycle ion exchange process follows the same sequence of steps used in the first-cycle ion exchange process. The final ^{137}Cs product is concentrated and stored as feed to the HWVP. Cesium-free streams from the first and second ion exchange cycles are concentrated and stored for eventual incorporation into grout.

Fixed-bed ion exchange separation and purification of ^{137}Cs can be most conveniently performed in shielded pretreatment facilities, e.g., B Plant, PUREX Plant, or NPF. Alternatively, the cesium ion exchange process is simple enough to be operated satisfactorily in equipment installed in the HWVP or an annex to the HWVP if space is limited.

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[1]Trademark of Rohm and Haas, Inc.

6.4.2.3 Solids Dissolution. In some cases (e.g., NCAW), separated and washed DST sludges can be vitrified without further pretreatment. In other cases (e.g., PFP, CC, or NCRW sludges), further pretreatment to remove TRU elements may be necessary or desirable before vitrification. The washed DST sludges must be treated to prepare an aqueous HNO_3 feed to remove TRU elements by the TRUEX liquid-liquid extraction process.

Recent bench-scale tests with actual waste indicate that unwashed NCRW sludge readily dissolves in HNO_3 solutions (Swanson 1991a, 1991b, 1991c). Extensive water washing of NCRW solids removes fluoride ion that is necessary for dissolution of the large amounts of zirconium present in NCRW solids. The dissolution properties of washed CC and PFP waste sludges have not been studied extensively, but judging from a few laboratory-scale tests with actual waste samples of each type of sludge, both the washed CC and PFP sludges may be quite soluble in HNO_3 or HNO_3-HF media. Candidate reagents and procedures for solubilizing all the various types of SST sludges have been addressed by Schulz and Kupfer (1991).

Sludge dissolution operations cannot be performed in carbon steel DSTs. Rather, such pretreatment operations require installation of suitable dissolution vessels and associated equipment in shielded, remotely operated facilities.

6.4.2.4 TRUEX Process. The TRUEX process is a recently developed liquid-liquid extraction process capable of extracting all actinide elements in their +3, +4, and +6 oxidation states from waste solutions containing HNO_3 (Horwitz and Schulz 1985, 1986, 1987). Octyl(phenyl)-N,N-diisobutylcarbamoyl-methylphosphine oxide (CMPO), a commercially available bifunctional organophosphorus reagent, is the extractant in the TRUEX process; in practice, the CMPO is diluted with tributyl phosphate (TBP) and a suitable mixture of normal paraffin hydrocarbons. The TRUEX process solvent selectively and effectively extracts actinides over a wide range of aqueous feed acidities, e.g., 0.5M to 8M HNO_3. Bench-scale batch and countercurrent tests have demonstrated that the TRUEX process can convert many TRU-type wastes (i.e., wastes containing >100 nCi TRU elements/g of waste) to LLW suitable for disposal in near-surface facilities. Successful laboratory-scale tests have been performed with actual NCRW sludges (Swanson 1991a, 1991b, 1991c).

The TRUEX process is equally applicable to alkaline supernatant liquors that have been acidified (e.g., CC waste) and to HNO_3 or HNO_3-oxalic acid solutions from aqueous dissolution of TRU-bearing solids in DSTs and/or SSTs. A limited number of laboratory-scale batch contact tests have been performed with actual CC waste and PFP waste. A particularly important feature of the TRUEX process is that it can selectively partition (strip) groups of transuranic elements.

Conventionally, the TRUEX process is used in centrifugal contactors to take advantage of very low phase residence times and high throughputs. But, if desirable or necessary, the TRUEX process can be successfully operated in pulse columns such as those used for many years at the Hanford Site. Shielded, canyon-type facilities (e.g., B Plant, PUREX Plant, or an NPF) are required for installation of TRUEX process equipment.

6.4.2.5 Destruction of Organic Compounds. The CC waste, as noted previously, contains high concentrations of organic compounds such as ethylenediaminetetraacetic acid (EDTA), hydroxyethylenediaminetriacetic acid (HEDTA), nitrilotriacetic acid, citrate, and glycolate and their chemical and radiolytic degradation products. Initial pretreatment of CC waste involves removal of ^{137}Cs and TRU elements. Further pretreatment may be required before its final disposal in grout in near-surface facilities. Unless destroyed before grouting, organic complexants may greatly facilitate unacceptable transport of radionuclides or toxic metals leached from the grouted waste to the environment. Certain organic components also may be listed as hazardous constituents.

Technology for destroying aqueous-soluble organic complexants in radioactive waste solutions is far less developed than are other alternate pretreatment processes. Various methods of destroying organic components in CC waste have been proposed and, in some cases, partially demonstrated. Among others, these methods include (1) ozonolysis of alkaline CC waste, (2) treatment of acidified CC waste with hydrogen peroxide, (3) super critical water oxidation of dissolved organic materials, (4) high temperature calcination of CC waste, and (5) electrochemical oxidation. Bench-scale ozonation of diluted alkaline CC waste successfully oxidized many of the organic constituents but appeared to convert them only to oxalate and, perhaps, acetate ions and not to the desired carbon dioxide and water (Lutton et al. 1980). Preliminary bench-scale tests with acidified CC waste also indicate that hydrogen peroxide will oxidize at least some of the organic substances present in solution. However, data are not available to determine if hydrogen peroxide will oxidize all the various organic substances in CC waste and/or if the end products are carbon dioxide and water or some intermediate organic materials (e.g., acetate ion).

In preliminary tests conducted at Los Alamos National Laboratory with diluted simulated CC waste, super critical water readily oxidized greater than 99 percent of all the organic compounds present to carbon dioxide and water. Extensive (i.e., 5 to 10 fold) dilution of the CC waste was necessary to prevent crystallization of sodium salts under super critical water oxidation conditions. Although super critical water oxidation of organic compounds in CC waste is likely to be very effective in completely destroying such compounds, it involves operating pressurized equipment containing high levels of radioactivity at elevated temperatures with all the attendant safety hazards. Rheological problems, if any, involved in direct calcination of CC waste, which contains large amounts of sodium salts, have not yet been investigated experimentally.

Electrochemical oxidation has been shown to be applicable to a wide variety of hazardous organic compounds and in experiments at the Pacific Northwest Laboratory it has been shown to be effective in the destruction of organic compounds in synthetic and radioactive CC waste.

6.4.2.6 Removal of ^{90}Sr. The pretreatment facility and process alternative that involves NCAW sludge dissolution for separation of TRU elements requires addition of a ^{90}Sr removal process, either concurrent with or following removal of TRU elements. For this alternative, removal of the large amount of ^{90}Sr in NCAW sludge is a necessary precursor to waste grouting and near-surface disposal of the treated sludge (see Figure 6-3).

The strontium extraction (SREX) process, a liquid-liquid extraction process recently developed by Horwitz et al. (1991) at the Argonne National Laboratory, appears to be far superior to previously used technology for removal of ^{90}Sr from strongly acidic (i.e., >0.5M HNO_3) solutions. The SREX process extractant is bis-t-butyl-cis-cyclohexano- 18-crown-6, a commercially available macrocyclic crown ether. Horwitz et al. (1991) have shown that the SREX process can be used for ^{90}Sr removal from acidic wastes either after TRUEX process operation or as part of a combined TRUEX-SREX process. For the former case, the crown ether extractant is diluted with n-octanol. In the latter case, it is diluted with TBP and CMPO.

The SREX process solvent is very selective for ^{90}Sr; after the actinides have been extracted by the TRUEX process there are a number of contaminants left; however, only barium and technetium co-extract with strontium to any extent. Thus, the SREX process yields a highly purified strontium concentrate suitable as feed to a vitrification process. Resistance of the SREX process solvent to both radiolytic and hydrolytic attack appears to be excellent.

Both batch and countercurrent tests with simulated waste solutions attest to the high potential efficiency of the SREX process reagent for extracting ^{90}Sr from strong HNO_3 media. In one batch countercurrent test, 95.7 percent of the strontium was removed from a simulated Hanford Site waste in six extraction stages. Dilute HNO_3 readily strips strontium from the SREX process solvent. The SREX process and the TRUEX-SREX process have not yet been tested with actual waste solutions.

6.4.3 Estimated Glass and Grout Volumes for Reference Processes

Material balances were developed for pretreating the NCAW, NCRW, PFP sludge waste, and CC waste stored in DSTs. The material balances were used to estimate the number of canisters of glass produced by the HWVP for these waste types (Lowe 1991). Grout volumes also were estimated using the material balances from Lowe (1991). Table 6-2 summarizes the glass and grout volumes for the two levels of waste treatment described in Section 6.4.2, i.e., simple sludge washing versus TRU removal using the TRUEX process.

The material balances and glass and/or grout volumes are based on the best information currently available. However, technical uncertainties exist for each of the waste types, and the material balances and canister estimates should be considered preliminary and subject to change. Process development testing is ongoing to resolve the uncertainties. Best estimates were used in the material balances for missing information.

The number of canisters of glass previously were provided for updating the *Integrated Data Base for 1990: U.S. Spent Fuel and Radioactive Waste Inventories, Projections, and Characteristics*, DOE/RW-0006 (Newland 1991). The canister projections in Table 6-2 differ from those provided by Newland (1991) based on updated information from recent TRUEX process development tests and sludge washing experiments at the Pacific Northwest Laboratory. Additionally, the assumed volumes of waste requiring pretreatment recently have been revised based on estimated operational waste volume projections.

Table 6-2. Glass and Grout Volumes.

Double-shell tank waste	Process alternatives			
	Sludge washing		Transuranic extraction	
	Grout (m^3)	Total canisters[a]	Grout (m^3)	Total canisters
Neutralized current acid waste	d	580	e	145
Neutralized cladding removal waste	d	2,200[b]	e	110
Plutonium Finishing Plant waste	d	2,500[c]	e	250
Complexant concentrate waste	d	5,100	e	400

[a]Waste loading in glass is 25 wt% unless otherwise noted.
[b]Waste loading in glass is 16 wt% because of zirconium limit.
[c]Waste loading in glass is 2.5% because of chromium limit.
[d]203,000 to 219,000 m^3 (approximately 38 to 41 vaults) for all DST waste.
[e]203,000 to 267,000 m^3 (approximately 38 to 50 vaults) for all DST waste.

The canister estimates given in Table 6-2 illustrate the potential economic incentive of acidification and TRUEX processing for reducing the volume of vitrified waste as compared to the sludge-washing approach. Compared to earlier canister estimates, the revised estimates for use of the TRUEX process have been reduced primarily as a result of laboratory evidence that higher than previously assumed percentages of sludge are dissolved when acidified. Use of the TRUEX process results in a large volume of LLW that must be disposed of compared to the sludge washing process. Thus, a maximum of approximately 64,000 m^3 (17 Mgal) of additional grout, or about 12 grout vaults, results from using the TRUEX process rather than sludge washing.

6.4.4 Alternative (Intermediate) Pretreatment Processes

6.4.4.1 Introduction. Several potential alternatives to some of the reference pretreatment processes have been identified and are discussed briefly in this section. These alternatives represent an intermediate position between simple water washing of sludges (minimum treatment, maximum canisters) and sludge dissolution and TRUEX process operation (maximum treatment, minimum canisters). The candidate intermediate pretreatment processes briefly described in the following text are of interest because they could reduce the number of canisters of glass to be produced. Some of the intermediate processes appear suitable for operation in DSTs while others could be operated only in pretreatment facilities external to the DSTs. Although intermediate processes would not reduce the number of canisters to levels expected when using the TRUEX process, use of intermediate processes either in DSTs or in facilities with minimal process requirements could potentially challenge processes (e.g., TRUEX) that must use costly facilities for reducing the volume of waste to be vitrified. In addition, intermediate processing could be used to process some DST wastes before startup of a TRUEX process facility, thus reducing HWVP downtime, although with an increased number of canisters compared to using the TRUEX process. It is important to note that some pretreatment (e.g., cesium ion exchange and complexant destruction) could not be performed in minimal facilities (i.e., these processes will require the use of new or existing shielded processing facilities such as B Plant or an NPF). All of these alternative pretreatment technologies require extensive development and testing.

6.4.4.2 Dissolution of Nonradioactive Sludge Components. Many of the solid fractions of DST wastes contain large amounts of certain nonradioactive components that limit glass waste loading. For example, PFP waste and CC waste solids contain significant amounts of chromium and aluminum while the solid portion of NCRW essentially is hydrated zirconium oxide. Selective leaching or dissolution of the load limiting inert constituents would allow increased glass waste loading. This would result in a decrease in the number of canisters of glass requiring geologic disposal.

Some preliminary bench-scale tests with actual PFP waste solids indicate that washing with dilute potassium permanganate ($KMnO_4$) solution oxidizes insoluble chromium (III) to soluble chromium (VI). Also, water washing of PFP waste solids removes part of the phosphorus content. One bench-scale test with actual NCRW solids indicates that oxalic acid may remove some of the zirconium. Known chemistry suggests that leaching of PFP waste and CC waste solids with a warm NaOH solution would dissolve substantial amounts of aluminum compounds.

Washing of DST waste solids with special aqueous solutions that selectively remove load-limiting nonradioactive components currently appears to be the most viable intermediate pretreatment process. Technological issues associated with this approach include the need for additional laboratory-scale of actual wastes, testing, tank farm logistics, tank materials considerations, and mixing of solids and dissolution solutions.

6.4.4.3 Selective Leaching of Transuranic Elements. Another intermediate pretreatment process involves using special aqueous solutions to selectively leach TRU elements from NCRW solids and, possibly, the solid fraction of CC waste. This would eliminate the need to dissolve such solids and, possibly, to operate a large-scale TRUEX process with the resulting dissolver solution.

Laboratory-scale tests with actual NCRW solids indicate that it may be possible to leach the TRU elements without dissolving much of the inert components. Promising TRU removal procedures and reagents include dilute HNO_3-silver persulfate solutions, sodium carbonate-sodium bicarbonate solutions containing an oxidant such as potassium ferrate, and catalyzed electrolytic plutonium oxide dissolution (CEPOD) technology. Technological issues associated with this approach include the need for additional laboratory scale testing, tank farm logistics, tank materials considerations, and mixing.

6.4.4.4 Blending. The HWVP feeds that are limited in waste loading by one or more components will be considered for a blending strategy. In this strategy, a feed that is limited in one component will be mixed with a different feed that has a low quantity of the limiting component. This, in effect, dilutes the limiting component and allows a higher waste loading in the glass to be obtained. In theory, blending can be applied to any of the feeds to the HWVP including those that may result from the intermediate processing approaches. Because of limited compositional data, blending is examined briefly using feeds from sludge washing and/or inert dissolution.

While a blending strategy is conceptually simple, there are some practical difficulties that need to be addressed. These include suspension, transfer and measurement of the appropriate quantities of each type of solids, mixing and solid-liquid separation.

6.4.4.5 Alternative Methods for Complexant Concentrate Waste Supernatant. Application of titanium-loaded zeolite or resin (titanate adsorption) has been suggested for removal of TRU components, strontium, and cesium from alkaline supernatant. Limited testing in the Pacific Northwest Laboratory indicates that removal of cesium, plutonium, and some americium is feasible. Additional laboratory testing of this approach with CC waste supernatant is warranted to improve removal of americium and strontium.

6.4.4.6 Canister Production Estimates for Intermediate Processing. The potential impact of several of the intermediate processing approaches on glass canister production is shown in Table 6-3. The top two entries in Table 6-3 indicate the number of canisters that result from the current bounding approaches of sludge wash and TRUEX for pretreatment of the DST waste. In all cases, it is assumed that the NCAW solids are treated by washing to remove the soluble components. Removal of cesium from the supernatant by ion exchange does not affect the canister estimate significantly. The next three entries in Table 6-3 show the number of canisters that could be produced, assuming various components are leached from the sludges. Note, zirconium dissolution and TRU leaching of NCRW have not been demonstrated on a bench scale but have been included to demonstrate the potential reduction in canisters. The last set of canister estimates includes a variety of chromium leaching and blending alternatives. These alternatives are attractive because the number of canisters produced is reduced using relatively simple technologies that have the greatest chance of success. For the blending-leaching alternatives, wastes listed on the table and separated by a slash (/) are assumed to be blended together. Wastes that are to be treated for chromium removal are followed by (chromium leach). Additional reductions in the number of canisters might be achieved using NaOH to dissolve some of the aluminum compounds.

Additional reductions in the number of canisters produced also might be obtained through increased waste loading in the glass. The two methods that are being examined are tailored frit and high-temperature melters. Preliminary results indicate that it may be possible to further reduce the number of canisters up to 30 percent.

Table 6-3. Effect of Intermediate Double-Shell Tank Pretreatment Alternatives on Canister Production. (sheet 1 of 2)

Pretreatment approach	NCAW	NCRW	PFP	CC 200 East Area	CC 200 West Area	Total canisters	Percent of SW case
Sludge wash only	580	2,200[a]	2,500	1,400[b]	3,700[b]	10,380	
Baseline - NCAW (SW)/TRUEX	580	110	250	<--- 400 --->		1,340	13
Leaching processes							
PFP/CC (chromium leach)	580	2,200[a]	1,230[c]	720[d]	1,740[d]	6,470	62
PFP/CC (chromium leach) NCRW (zirconium dissolution)	580	550	1,230[c]	720[d]	1,740[d]	4,820	46
PFP/CC (chromium leach) NCRW (TRU leach)	580	300	1,230[c]	720[d]	1,740[d]	4,570	44
Blending-leaching alternatives							
NCRW/PFP/CC 200 East/ CC 200 West	580	<--- 7,100[b] --->				7,680	74
NCRW/PFP (chromium leach)/ CC 200 East/CC 200 West chromium leach)	580	<--- 3,500 --->				4,080	39
NCRW/PFP/CC 200 East	580	<--- 4,420 --->			3,700[b]	8,700	84
NCRW/PFP (chromium leach)/ CC 200 East	580	<--- 2,800 --->			3,700[b]	7,080	68
NCRW/CC 200 East PFP (chromium leach)	580	2,200[a,e]	1,230[c]	a,e	3,700[b]	7,710	74

Table 6-3. Effect of Intermediate Double-Shell Tank Pretreatment Alternatives on Canister Production. (sheet 2 of 2)

Pretreatment approach	NCAW	NCRW	PFP	CC 200 East	CC 200 West	Total canisters	Percent of SW case
NCRW/PFP (chromium leach)/ tank 241-SY-101 CC 200 East (chromium leach), tank 241-SY-103 (chromium leach)	580	<--- 2,335[f] --->		720[d]	945	4,580	44
NCRW/PFP (chromium leach)	580	<--- 2,200[a] --->		1,400[b]	3,700[b]	7,880	76
NCRW/PFP (chromium leach) CC (chromium leach)	580	<--- 2200[a] --->		720[d]	1,740[d]	5,240	50
Minimum cans: Blend all sludges (chromium leach, aluminum dissolution)	580	<--- 2600 --->				3,180	31

[a]Limited by zirconium
[b]Limited by chromium
[c]Limited by phosphorus
[d]Limited by aluminum
[e]NCRW and CC 200 East Area wastes blended
[f]NCRW/PFP (chromium leach)/tank 241-SY-101 blended.

CC = Complexant concentrate
NCAW = Neutralized current acid waste
NCRW = Neutralized cladding removal waste
PFP = Plutonium Finishing Plant
SW = Sludge wash
TRUEX = Transuranic extraction.

The canister estimates are based on the following assumptions.

- The compositions used for the canister estimates are based on existing flowsheet calculations for sludge wash and TRUEX process (Lowe 1991) alternatives.
- The specific waste volumes are those assumed in Section 6.2.1.
- The number of canisters are estimated by comparing the flowsheet values for the HWVP feed composition to the HWVP feed specifications and identifying the limiting components, if any.
- In general, there is considerable uncertainty associated with the canister numbers, primarily because of incomplete characterization of the wastes (especially CC wastes) and incomplete bench-scale testing with actual wastes.
- The blending scenarios shown are based on the total tank contents of the wastes, but tank size and solids suspension capabilities will limit the amount of blended solids that can be prepared at any one time. This will make it necessary to mix portions of each waste type to achieve the desired blend. It may be difficult to suspend, transfer, and measure the required solid quantities of each waste type. Ultimately, it will be necessary to consider blending wastes on a tank-by-tank basis because of the limits on the amount of solids that can be handled at one time and because of the significant differences in waste compositions.

6.4.5 Additional Radionuclide Removal

Based on comments from regulatory agencies (NRC, EPA, and Washington State) and future comprehensive performance assessments, it may be desirable to reduce the concentrations of radionuclides in LLW grouts to significantly lower levels than those defined by the current grout criteria. The primary radionuclides of concern and considered as candidates for additional radionuclide removal are ^{90}Sr, ^{137}Cs, and ^{99}Tc.

6.4.5.1 Technetium-99 Removal. As noted earlier, the reference suite of processes for pretreatment of DST wastes does not involve removal of long-lived ($t_{1/2}$ = 2 x 10^5 yr) ^{99}Tc. Technetium, which exists as the pertechnetate (TcO_4^-) anion in both alkaline and acidic waste solutions, is extremely mobile in the environment. Thus, further evaluation and analysis of near-surface waste disposal systems may demonstrate the need for removing ^{99}Tc from some DST wastes including DSSF waste.

Various liquid-liquid extraction, ion exchange, and even precipitation processes can separate ^{99}Tc from either acidic or alkaline waste solutions. However, much of this separation technology is only partially developed.

Both the TRUEX and SREX process solvents extract ^{99}Tc (as $HTcO_4$) from HNO_3 media. Because the distribution of technetium into TRUEX and SREX process solvents is relatively low compared to TRU elements, appropriate adjustments in process flowsheets (e.g., increased organic flows, more extraction stages) must be made to remove 99+ percent of the technetium from acidic solutions. Dilute sodium carbonate solutions effectively strip ^{99}Tc (and uranium) from the TRUEX process CMPO solvent. Liquid-liquid and extraction chromatographic processes using primary or secondary amines have been proposed for separating ^{99}Tc and uranium in carbonate solutions.

Sorption of TcO_4^- on a strong base anion exchange resin is a highly-effective method for removing ^{99}Tc from alkaline waste solutions. Because the $^{99}TcO_4^-$ is held so tightly by the anion exchange resin, strong HNO_3 solutions are required to elute it. The need to recover and reuse HNO_3 is a disadvantage to anion exchange resin removal of ^{99}Tc from alkaline solutions.

Other proposed methods for removing ^{99}Tc from alkaline waste solutions include a liquid-liquid extraction process using cyclohexanone as the extractant (Schulz 1980). Water can strip ^{99}Tc from the organic phase, thus this extraction scheme avoids the HNO_3 recovery problem associated with the anion exchange method. However, this process has not been tested beyond the bench scale. Scientists at the DOE Savannah River Site have conducted preliminary studies of organic precipitation reagents, such as tetraphenylarsonium acid, to scavenge ^{99}Tc from alkaline waste solutions.

6.4.5.2 Enhanced Removal of ^{90}Sr. The SREX process and the TRUEX-SREX processes for removal of ^{90}Sr from HNO_3 solutions are discussed in Section 6.4.2.6. The reference suite of pretreatment processes does not include removing ^{90}Sr from DST wastes. However, for certain DST wastes, particularly CC wastes but also the solid portion of NCAW, the TRUEX-SREX process, rather than the simple TRUEX process, would enable simultaneous removal of ^{90}Sr as well as TRU elements. Removal of ^{90}Sr from CC waste may be desirable to facilitate near-surface disposal of pretreated waste. Removal of ^{90}Sr from NCRW and PFP wastes is not required because those DST wastes contain only minor amounts of ^{90}Sr.

6.4.5.3 Enhanced Removal of ^{137}Cs. The reference pretreatment processes include ion exchange removal of ^{137}Cs from alkaline CC waste and NCAW wastes. If desirable or necessary, the same equipment and technology could be applied to removing ^{137}Cs from DSSF waste. The DSSF waste probably would have to be diluted substantially to effectively remove ^{137}Cs. Bench-scale tests with simulated and actual DSSF wastes are required to develop ion exchange technology for removal of ^{137}Cs.

6.5 FACILITY ALTERNATIVES

Facility alternatives for performing the waste treatment processes described in Section 6.4 are evaluated in this section. Section 6.4.3 stresses the potential economic incentives for applying the TRUEX process to reduce the volume of waste feed that must be vitrified and sent to a geologic repository. To achieve this goal, methodology must be developed to verify that the TRUEX process can be successfully applied to the candidate wastes. The alternative of washing all of the sludge wastes rather than using the TRUEX process must be kept open until the appropriate TRUEX process technology has been developed. A decision analysis is presented in Section 8.0 that depicts, on a timeline, the technical and programmatic decisions required to arrive at a preferred pretreatment plan.

Five facility alternatives are evaluated as possible locations where TRUEX process pretreatment operations could be performed:

- DSTs
- B Plant
- PUREX Plant
- A standalone NPF
- An expanded HWVP.

For cases where sludge washing of DST wastes is performed instead of using the TRUEX process, it is assumed that PFP waste and waste solids can be washed directly in DSTs using mixer pumps. Because of problems (discovered during laboratory experiments) separating washed NCRW solids from liquid supernatants, a facility must be used to filter the waste and provide effective solid-liquid separations. Although the present baseline for washing NCAW solids assumes use of the 244-AR Vault, NCAW washing could be performed in a DST.

6.5.1 Facility Requirements

6.5.1.1 General Facility Requirements. New or modified facilities used to pretreat DST wastes must comply with the design criteria in DOE Order 6430.1A (DOE 1989b) and the WAC 173-303 (Ecology 1991). In addition, facilities must comply with the national consensus codes and standards as developed by such organizations as the American Concrete Institute, American National Standards Institute, American Society of Mechanical Engineers, National Fire Protection Association, and the Institute of Electrical and Electronic Engineers.

6.5.1.2 Requirements for Modification of Existing Facilities. The Hanford Site has several facilities that could be modified to pretreat DST wastes. However, because of the useful life, size, and location to interface with other facilities, as well as availability of the facility required, only B Plant in conjunction with 244-AR Vault and the PUREX Plant are suitable. The following specific areas of B Plant, 244-AR Vault, and the PUREX Plant require further evaluation to demonstrate compliance with DOE Order 6430.1A and other codes and standards as required to use either facility as a radioactive liquid waste treatment facility (WHC 1991; Ludowise 1989).

- Structure
  - A natural forces (0.2*g* design basis earthquake site specific) evaluation shall be performed, and deficiencies shall be corrected. Deficient systems may include emergency power, ventilation, and instrumentation of Safety Class 1 and 2 systems.

  - Safety Class 1 and 2 systems shall have redundant systems installed to ensure systems can continue to perform during normal operations, routine abnormal events, and design basis accidents (DBA).

  - The life-limiting features of the facility must be examined and reviewed to determine aspects demanding attention (e.g., embedded piping, hot cell wiring). Recommendations shall be made, and deficiencies shall be corrected.

- Confinement

  - Available double-walled piping transfer routes shall be examined to ensure integrity of the systems.

  - A confinement system shall be designed to ensure adequate redundancy and to maintain airflow during normal operations, routine abnormal events, and DBAs.

  - Systems shall have multiple confinement.

  - A high-efficiency particulate air (HEPA) filtration system shall be installed to prevent blow-back from process areas to occupied areas or the environment. Inlet air to control rooms shall be filtered. Different ventilation zone areas shall be evaluated, and where determined necessary, air locks shall be installed.

  - Exhaust filter systems, which are no longer used, shall be evaluated via a safety analysis (to be performed) to ensure DBAs and design basis earthquake conditions could not cause releases of radioactive or hazardous materials exceeding DOE standards. Based on the recommendations from the safety analysis, these systems shall be removed or isolated. Standard decontaminating and decommissioning procedures will be used.

- Electrical, Instrumentation, and Control

  - Instrumentation and control equipment shall be reviewed by the facilities to ensure adequate redundancy for Safety Class 1 and 2 systems.

  - Safety class instrumentation and control systems shall be supplied with an uninterruptible power source.

  - Wiring runs into process cells shall be evaluated and replaced as necessary.

  - All safety class systems that will operate in anticipated operational occurrences, DBAs, and for safe shutdown will have emergency backup power.

- Industrial Safety

  - An annual fire safety analysis shall be reviewed to ensure that all recommended measures are put in place. This evaluation will incorporate an improved level of risk of fire protection to the facility. This will include providing a fire protection water system that is not hindered when process water is used.

  - The facility design shall provide separation against fire, explosion, and failure of fire suppression systems to ensure that redundant safety class components can perform.

  - The facilities shall have improved methods for obtaining process solution samples. The improved methods shall be within as low as reasonably achievable guidelines, to lower hazardous material exposure to personnel.

  - The asbestos material used throughout the facility should be evaluated. The asbestos should be removed.

- Waste Management

  - The facility shall be capable of treating mixed waste, HLW, and LLW. Also, the facility shall be capable of separating and segregating wastes.

  - The facility shall be able to adequately sample effluent streams.

  - The facility will need to anticipate the effluent streams and how to treat them. The facility may be required to install closed-loop cooling to eliminate effluent streams currently discharging to a soil column or retention basin system. A safety analysis and best available technology methods will be used to determine if a closed-loop cooling system shall be installed.

  - The facility shall have improved methods for inspecting tanks, sumps, hot-pipe trench, and instrumentation in high-radiation areas by remote systems.

- Secondary Containment for Tank Systems

  - B Plant. Secondary containment for the B Plant canyon tank system consists of concrete cells, cell drain header, collection vessel TK-10-1, and liquid leak detection and monitoring instrumentation. An analysis of the B Plant secondary containment system by Westinghouse Hanford Company has concluded this system complies with Washington State regulations (Corcoran and Weingardt 1991). The DOE and Washington State have not yet responded to this analysis.

  - PUREX Plant. The secondary containment system for PUREX Plant canyon vessels consists of concrete cells, sumps, and liquid leak detection and monitoring instrumentatation. Ecology concluded that the PUREX Plant secondary containment system must be modified (Nord 1991) to comply with WAC 173-303 (Ecology 1991).

6.5.1.3 Interface Requirements. The pretreatment facility separates DST wastes into a low-level, low-hazard fraction for disposal in grout and a high-level and/or TRU, high-hazard fraction for vitrification. Pretreatment of DST wastes is performed to minimize total program costs for waste disposal and to remove waste constituents that are detrimental to the long-term stability of glass and grout or detrimental to the environment.

The pretreatment process must ensure the resulting low-level, low-hazard waste fraction complies with DOE limits for TRU concentration (DOE 1990a), EPA and Washington State regulations for disposal of hazardous materials (EPA 1990b; Ecology 1991), and NRC licensing requirements (NRC 1990b). Additional pretreatment process requirements are derived from physical property requirements for grout and glass waste forms. Except for the blending of pretreated wastes, the pretreatment process is the primary factor in controlling the composition of low-level and high-level and/or TRU waste fractions. Thus, pretreatment must ensure compliance with State and Federal regulations as well as waste form physical property requirements. As such, the pretreatment process and facility combination is the pivotal component in an integrated DST and SST waste disposal program.

A network of underground transfer lines, DSTs, and the 242-A Evaporator-Crystallizer interconnect the pretreatment facility with HWVP and the GTF. The 242-A Evaporator-Crystallizer reduces the volume of waste solutions by evaporation, with the distillate treated and handled in the Liquid Effluent Retention Facility and the Treated Effluent Disposal Facility. The network of underground transfer lines are secondary-contained piping and transfer the following:

- Waste from the DSTs to the pretreatment facility
- Pretreated waste from the pretreatment facility to DSTs for characterization and lag storage
- Pretreated wastes from DSTs to the GTF or HWVP
- The LLW and HLW byproduct solutions generated by the HWVP to DSTs for pretreatment processing.

Solutions transferred through underground transfer lines and stored in DSTs must comply with specific criteria. The criteria were established from safety analyses and operating specifications to ensure structural integrity and system functions are not degraded. These criteria are in tank farm operating specification documents.

Operation of the pretreatment facility and the HWVP will generate secondary waste solutions, typically steam condensate from heating systems, condensed process distillates from evaporation of wastes solutions, and water used to cool process equipment. These secondary waste solutions may contain trace quantities of radioactive or otherwise hazardous constituents. Local treatment of secondary wastestreams is provided at the pretreatment facility and HWVP, with the treated secondary wastes transferred to the Treated Effluent Disposal Facility through secondary-contained underground piping. Secondary waste treatment criteria are specified in *Environmental Compliance*, WHC-CM-7-5 (WHC 1990b).

6.5.1.4 Regulatory Compliance. Pretreatment of DST waste will require adherence to a number of regulatory requirements and regulations. The primary environmental statute that will impact pretreatment of DST waste is the RCRA and the corresponding *Dangerous Waste Regulations* established in the WAC 173-303 (Ecology 1991). In addition, requirements established under the *Atomic Energy Act of 1954* and implemented through DOE orders must be addressed. Finally, construction of NPFs will require an evaluation for significant environmental impacts as required in accordance with the *National Environmental Policy Act of 1969* (NEPA).

6.5.1.4.1 Permitting. Facilities used to pretreat DST waste will be required to secure a Part B permit. For existing interim status facilities, amendments to an existing Part A permit may be required to address additional design capacity or waste codes and process changes.

Construction of an NPF will require that a Part B permit be obtained before start of construction, unless interim status expansion is granted by Ecology. Interim status expansion would allow construction to begin after a Notice of Intent was submitted to Ecology in accordance with WAC 173-303-281 (Ecology 1991). Ecology must receive the Notice of Intent 150 days before an application for a permit or permit revision for the new facility can be filed. If interim status expansion is approved, construction could be initiated while the Part B permit application is being developed. A milestone then could be added to the Tri-Party Agreement (Ecology et al. 1990) for submittal of the associated Part B permit application.

If, on closure, all waste cannot be removed and a landfill closure is required, then the DOE will be required to submit a revised Part A to include disposal of hazardous waste and submit a postclosure permit application. In this case, a RCRA landfill cover will be required as well as postclosure monitoring for at least 30 yr.

6.5.1.4.2 Treatment and Storage in Tanks. All pretreatment operations that are conducted in tanks and units meeting the definition of tanks will be required to address the technical requirements of WAC 173-303-640. New tank systems must meet the following requirements.

- The owner or operator must determine that the tank system is not leaking or unfit for use. A written assessment attesting to the tank system's integrity must be obtained. The written assessment must be reviewed and certified by an independent, qualified registered professional engineer, in accordance with WAC 173-303-810 (Ecology 1991).

- Secondary containment and release detection that meets the standards of WAC 173-303-640(4)(e) must be provided for the tanks and associated piping.

- The general operating requirements of WAC 173-303-640(5) must also be met, including provisions for waste compatibility, prevention of spills and overfills, release response, and tank labeling.
- The owner or operator must respond to leaks by removing sufficient waste to prevent further leakage within 24 h or the earliest practicable time. Failed tanks either must be repaired and certified as being fit for use, replaced, or closed in accordance with WAC 173-303-640(7).
- Respond to leaks and spills in accordance with WAC 173-303-640(7).

Upon closure of a tank system, the owner or operator must remove or decontaminate all waste residues, contaminated system components, contaminated soils, and structures and equipment contaminated with waste. All of these items then are managed as dangerous waste. If the owner or operator can demonstrate that it is not practicable to remove all contaminated soils, the tank system must be closed as a landfill. It is important to note that this landfill closure alternative was intended to apply only to contaminated soils. A recent interpretation by the EPA (December 10, 1987) clarified that under limited conditions tanks may be closed with waste remaining in place under the provisions for landfills. However, this interpretation has not been incorporated into regulation.

6.5.1.4.3 Storage in Containers. Any DST waste that is retrieved and waste generated as a result of waste retrieval will require management in accordance with the requirements of WAC 173-303-630 (Ecology 1991). In the event that containerized waste will be stored at a given pretreatment facility for greater than 90 days, a dangerous waste storage permit will be required. In this case, the permitting requirements discussed previously will be applicable.

Newly constructed container storage areas and 90-day accumulation areas must be constructed with secondary containment. If concrete is used to meet the secondary containment requirement, the concrete must be lined with an impervious coating that is compatible with the waste being stored. In addition, if the waste being stored meets the criteria of extremely hazardous waste, the containers must be protected from the elements by a building or other protective covering.

6.5.1.4.4 DOE Orders. The management and pretreatment operations for DST waste will be subject to a number of DOE orders that may include the following:

- DOE Order 5400.3, *Hazardous and Radioactive Mixed Waste Programs* (DOE 1989a)
- DOE Order 5400.5, *Radiation Protection of the Public and the Environment* (DOE 1990b)
- DOE Order 5820.2A, *Radioactive Waste Management* (DOE 1990a)
- DOE Order 6430.1A, *General Design Criteria* (DOE 1989b).

6.5.1.4.5 National Environmental Policy Act Requirements. Closure of the DSTs and/or construction of pretreatment facilities may require additional evaluation for compliance with the NEPA. The final disposition of DST waste was addressed in the HDW-EIS (DOE 1987). While a discussion of potential pretreatment alternatives, including the use of B Plant, was discussed in the HDW-EIS, it is possible that DOE-Headquarters may require additional NEPA evaluation for pretreatment facilities. This decision may be based in part on whether the scope of the HDW-EIS included the pretreatment activities and whether information was included in significant detail to fulfill NEPA requirements.

6.5.2 Descriptions of Candidate Pretreatment Facilities

Table 6-4 and Figure 6-11 identify candidate existing and new facilities for performing the reference pretreatment processes (see Section 6.4). The new sludge wash facilities (SW B-E) and TRUEX process facilities (TRUEX A-F) called out in Table 6-4 and Figure 6-11 are new treatment facility alternatives sized (Boomer et al. 1990) to pretreat waste from varying numbers of DSTs and SSTs.

As indicated in Figure 6-11, some of the candidate pretreatment facilities can be used to pretreat all or part of the waste from DSTs and SSTs. Further discussion of SST waste pretreatment is provided in WHC-EP-0338 DRAFT (Boomer et al. 1990). Some of the candidate facilities also can accommodate removal, if desired, of ^{137}Cs and ^{99}Tc from DSSF waste.

The following sections (Sections 6.5.2.1-6.5.2.7) provide summary descriptions of the pretreatment facility equipment and the candidate pretreatment facilities. Section 6.5.2.8 describes alternate pretreatment facility design concepts.

Descriptions of the proposed standalone facilities are provided in Appendix G. Conceptual facility layouts also are shown.

6.5.2.1 Equipment Description. The equipment used for waste pretreatment includes tanks, filters, columns, centrifugal contactors, dissolvers, and evaporators. Pumps are used to transfer waste from the tank farms to the pretreatment facility and to transfer material inside the plant. Equipment is made of stainless steel unless a special material is required.

The equipment for new facilities is sized to support continuous operation of a 100 kg/h melter at the HWVP. For existing facilities, equipment is sized to obtain the maximum throughput rate possible within the limitations of the size of the facility (Section 6.5.2.2).

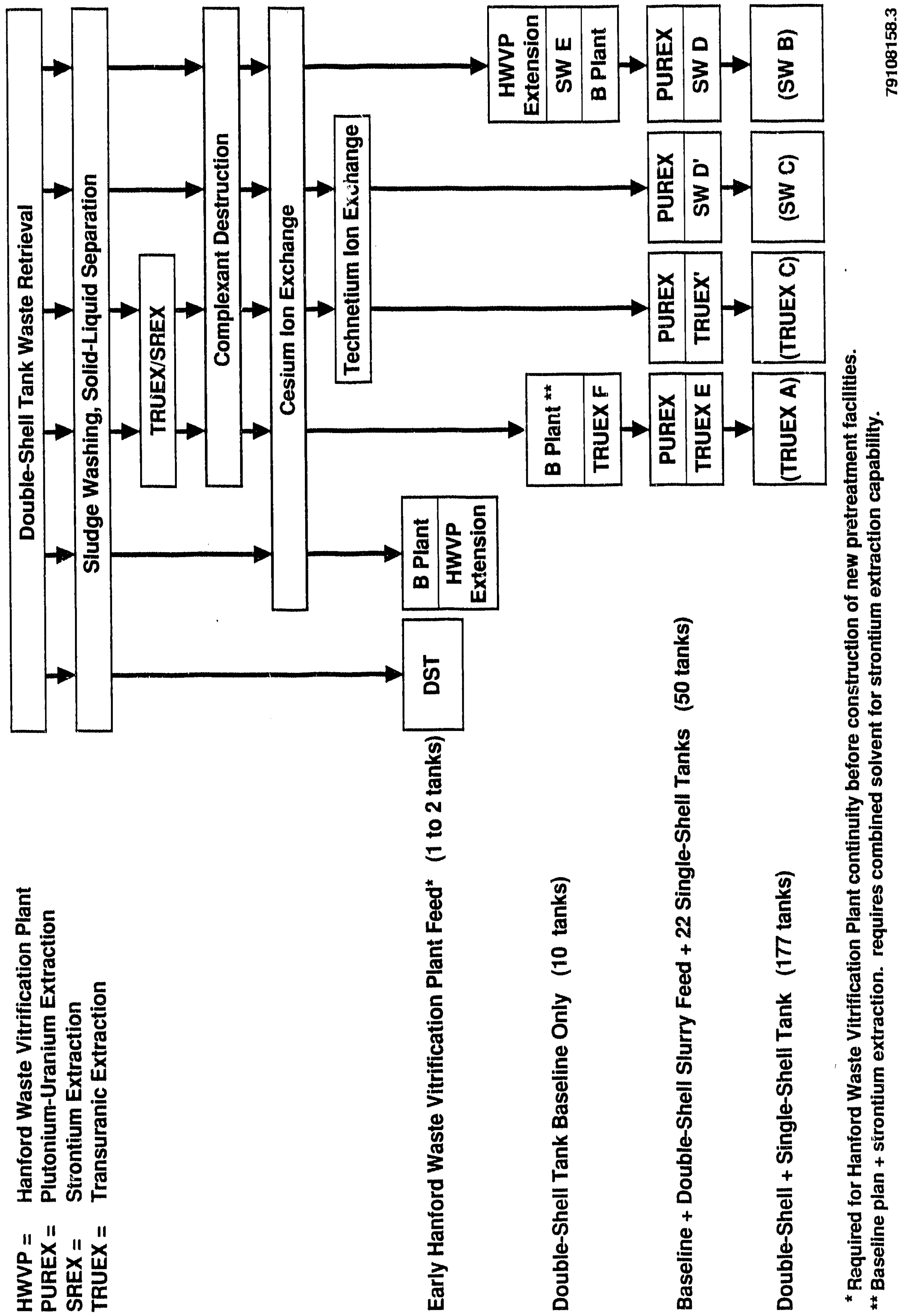
Tanks are used to receive waste from the tank farms. Tanks are used to stage feed to the various unit operations and to receive waste and products from each operation. Tanks also are used for settle-decant operations to separate solids from liquids. Tanks are sized to match the particular process need within the constraints of space availability of the specific facility.

Table 6-4. Capabilities of Candidate Pretreatment Facilities.

Process	Facility									
	B Plant alternatives			PUREX Plant alternatives		HWVP alternatives		DST sludge wash and intermediate processes	New facility alternatives	
	B Plant[a] (TRUEX)	B Plant (sludge wash)	B Plant (cesium ion exchange)	PUREX (TRUEX)	PUREX (sludge wash)	HWVP (sludge wash)	HWVP (cesium ion exchange)		Sludge wash facilities (SW B-E)[b]	TRUEX Facilities (TRUEX A-F)[b]
Sludge washing	X	X	X	X	X	X		X	X	X
Filtration	X	X	X	X	X	X	X		X	X
Cesium ion exchange	X	X	X	X	X	X	X		X	X
Complexant destruction	X	X		X	X	X			X	X
Transuranic extraction	X			X						X
Strontium extraction										X

[a]Baseline case
[b]See Figure 6-11.
DST = Double-shell tank
HWVP = Hanford Waste Vitrification Plant
PUREX = Plutonium-Uranium Extraction
SW = Sludge wash
TRUEX = Transuranic extraction.

Figure 6-11. Tank Waste Pretreatment Facility and Process Alternatives.



Dissolvers are constructed of Hastelloy[1] C to provide corrosion resistance to HNO_3/HF solutions. Dissolvers are used to prepare feed for solvent extraction and for digestion of CC wastes for destruction of complexants. For sludge wash processes, the dissolvers are used for settle/decant operations.

Filters are used for solid-liquid separation. Feed to process steps, such as ion exchange or solvent extraction, must be free of solids. Filters are used to make these polishing separations. Pneumatic hydropulse filters are used in the NCAW pretreatment process. Testing of other filtration equipment is expected before filter designs are finalized for each specific waste and process.

Continuous centrifuges are used for some solid-liquid separations in the new processing facility. Continuous centrifuges also could be used to improve throughput rates in existing facilities. Additional testing is required to confirm the potential uses of centrifuges.

Ion exchange columns are used to separate cesium from alkaline wastes. The columns are cylindrical tanks specifically designed to hold the ion exchange resin that removes cesium.

Centrifugal contactors are used for solvent extraction operations. The contactors provide a high-efficiency and high-throughput operation within a minimum amount of plant space. Pulse columns are used for solvent extraction operations in the PUREX Plant. The PUREX Plant is designed specifically for using pulse columns and the columns require a minimum amount of area within the plant.

Thermosyphon evaporators are used to reduce the volume of wastestreams. The evaporators are sized to match process needs within the facilities.

6.5.2.2 Equipment Sizing and Time Cycles.

6.5.2.2.1 B Plant. The DST waste pretreatment equipment must be placed within a shielded facility to limit the radiation exposure to operating personnel and to protect the environment from process solutions and offgases. The shielded process area within B Plant consists of 40 cells, numbered sequentially 1 through 40. The size and configuration of the shielded process area at B Plant limits the size of pretreatment equipment that can be placed within this facility.

The rate-limiting step in pretreatment of NCAW is separating the cesium from the alkaline liquid waste using an ion exchange process. The cesium separation rate is limited by the size and number of ion exchange columns as well as the rate at which dilute solutions can be evaporated. Existing process equipment within cells 11 through 14 and 17 through 25 was installed during the 1960's to recover cesium from some SST wastes. Process equipment consists primarily of storage tanks, an ion exchange column, two thermosyphon evaporators, and offgas treatment equipment. With replacement of selected equipment, this existing process equipment can provide the optimum processing rate for NCAW at B Plant. Pretreatment of NCAW can be accomplished in

[1]Trademark of Cabot Corporation.

approximately 10 months. Continued use of selected existing process equipment is a significant cost and time savings compared to replacement. The existing ion exchange column, one thermosyphon evaporator, and offgas treatment equipment would be replaced with three cesium ion exchange columns and one larger capacity thermosyphon evaporator specifically designed for pretreatment of NCAW.

For pretreatment of NCRW, PFP wastes, and CC wastes, the rate-limiting pretreatment step is dependent upon the method of pretreatment. The rate-limiting step for sludge washing these DST wastes is the solid-liquid separation steps. The rate-limiting step for dissolving the sludges to separate TRU elements using the TRUEX process is the sludge dissolution step.

Required pretreatment equipment can be installed in process cells 5 through 8 and 26 through 33. During the sludge dissolution and TRUEX process steps, the chemical solutions used are corrosive to the existing stainless steel piping at B Plant. Because of a limited ability to install new corrosion-resistant piping, only process cells 26 through 33 can have sludge dissolution and TRUEX process equipment installed. The limited number of process cells and the relatively small size of these cells will not allow installation of sufficient sludge dissolution and TRUEX pretreatment process equipment to support continuous operation of the 100 kg/h melter at HWVP. Thus, significant standby time at the HWVP would result. Pretreatment of NCRW, PFP, and CC wastes is estimated to require 30, 3, and 88 months of operation, respectively, at the B Plant.

Sufficient space is available within B Plant for installation of sludge-washing equipment capable of pretreating DST wastes at a rate higher than that required to support continuous operations at HWVP. Thus, no standby time at HWVP is incurred from sludge-washing pretreatment operations at B Plant. Pretreatment of NCRW and CC wastes using the sludge-washing process is estimated to require 16 and 46 months respectively at the B Plant. PFP pretreatment using the sludge-washing process can be conducted in a DST, requiring approximately 6 months to complete.

The equipment for supporting pretreatment is designed to obtain the maximum throughput rate and therefore minimize total operating time.

6.5.2.2.2 PUREX Plant. For each of the waste types, schedule requirements for processing waste through the PUREX Plant were estimated. The NCAW processing is the same for both alternatives. The PFP waste is processed in-tank if only sludge washing is used for pretreatment. The time cycles for NCRW and CC waste for either TRUEX process or sludge washing are effectively the same since the TRUEX process is not the limiting step in the pretreatment processing.

Neutralized Current Acid Waste. Cesium ion exchange is the limiting operation for NCAW pretreatment. Two ion exchange systems were considered for the PUREX Plant. Assuming each column has a resin volume of 11.4 m^3 (3,000 gal) and each two-column system contains 22.8 m^3 (6,000 gal) of resin, the following was determined. Using two ion exchange columns (one two-column system), approximately 6 months is required to pretreat NCAW. Using four columns (two independent two-column systems), the processing time is reduced to 4.4 months.

Neutralized Cladding Removal Waste. The limiting operation for processing NCRW is the washing and solid-liquid separation steps. The TRUEX process operation does not become the limiting operation because pulse columns of an adequate size are installed and operated to match the throughput capacity of other process steps.

To obtain the desired throughput rate for NCRW processing, two parallel sets of equipment are used to wash and filter the solids before dissolution. Three dissolvers are used to dissolve the washed solids. The solution from the dissolvers is fed to the TRUEX process solvent extraction system to separate the TRU elements from the solution.

The TRUEX process raffinate is concentrated to recover some HNO_3 and to reduce the volume of waste for neutralization. The evaporator and the associated equipment are sized adequately to easily support the requirements for raffinate and waste handling.

Plutonium Finishing Plant Waste. For pretreatment of NCRW, facility operations are conducted for approximately 9 months.

Equipment installed for NCRW pretreatment can be used for PFP waste pretreatment. The PFP solids are dissolved to prepare feed for TRUEX process operation. Three dissolvers are used for dissolution operations. Filtration after solids dissolution is the limiting operation. The time required to process PFP sludge is 1 month. However, for conservatism a processing time of 3 months is assumed.

Complexant Concentrate Waste. The limiting operation for CC waste pretreatment is the operation of the dissolution vessels. To dissolve and digest all of the CC waste will require about 3 yr. The cesium ion exchange operation will match the instantaneous feed rate requirements for the dissolution cycle.

Two solvent extraction columns will be used for the TRUEX process. The TRUEX process can operate at more than twice the rate needed to match the instantaneous rate of the dissolution cycles. The TRUEX process will not be limiting, even if the dissolution process is improved to reduce its time cycle requirements.

For sludge wash treatment of CC waste, the process steps are the same as the TRUEX process through dissolution or digestion. Since the acid dissolution or peroxide digestion process is the limiting process, sludge washing of CC waste requires the same amount of time for processing as TRUEX processing of CC waste.

Table 6-5 summarizes the time cycles for pretreatment of DST waste in B Plant and the PUREX Plant.

6.5.2.2.3 New Pretreatment Facilities. The new TRUEX process facility for DST waste pretreatment (TRUEX E facility) is sized to provide pretreated waste at a rate that supports nearly continuous operations of the HWVP 100 kg/h melter (see Section 7.3). This facility also will accommodate limited amounts of SST waste (see Figure 6-11). The TRUEX E facility will pretreat DST waste in approximately 5 yr and is used in this study as the reference facility for DST waste pretreatment. The TRUEX F facility (Figure 6-11) was sized for comparison purposes to be similar to the new TRUEX facility for DST wastes described in WHC (1990a). Time cycle calculations indicate that the TRUEX F facility is not sized properly to provide pretreated DST feed to HWVP at an adequate rate. This conclusion was made based on updated conceptual flowsheets (Lowe 1991) and revised DST waste pretreatment requirements described in Section 6.4.1 (e.g., the added requirement for removing ^{137}Cs from CC waste).

Table 6-5. Time Cycles for Double-Shell Tank Waste Pretreatment in Existing Facilities.

DST waste	Time cycle (months)			
	B Plant (sludge washing)	B Plant (TRUEX process)	PUREX Plant (sludge washing)	PUREX Plant (TRUEX process)
NCAW (cesium ion exchange)	6	10	6	6
NCRW	16	30	12	9
Feed change	6	6	6	6
PFP waste	In DST	3	In DST	3
Feed change	--	6	--	6
CC waste	46	88	36	3

CC = Complexant concentrate
DST = Double-shell tank
NCAW = Neutralized current acid waste
NCRW = Neutralized cladding removal waste
PFP = Plutonium Finishing Plant
PUREX = Plutonium-Uranium Extraction
TRUEX = Transuranic extraction.

Section 7.0 evaluates the impacts on waste remediation mission costs, schedules, and other attributes of an ROD to retrieve and process SST wastes. For reference purposes, it is assumed in this report that this decision will likely require pretreatment of the vast majority of the wastes in the 149 SSTs. If the majority of waste in SSTs is retrieved, larger sized TRUEX process facilities would be required to process the waste. The TRUEX A and TRUEX E facilities (see Figure 6-11) are sized to pretreat all SST wastes in 10 yr (Boomer et al. 1991) and will process SST plus DST waste in 14 yr. Only TRUEX process facilities are considered for pretreatment of all SST waste in this study since treatment of the waste using only sludge washing would result in operation of the vitrification facility far beyond its projected design life. In this report, the TRUEX A facility is assumed as the reference facility for SST wastes. Boomer et al. (1990) describes several pretreatment alternatives for SST wastes that use both TRUEX process and sludge washing approaches. Such facilities are also noted in Figure 6-11.

A new sludge washing facility for processing DST waste (SW E) will complete waste pretreatment in approximately 5 to 7 yr. Detailed descriptions of the candidate NPFs for DST and SST waste are provided in Appendix G. Descriptions of candidate SST pretreatment facilities also are described in Boomer et al. (1990).

6.5.2.3 B Plant Facility Description.

6.5.2.3.1 Introduction. The B Plant complex includes the 221-B canyon and the adjoining 271-B office building (Figure 6-12). Built from 1943 to 1944 as part of the wartime Manhattan Project, B Plant is one of the oldest chemical processing facilities. After extensive modification, B Plant and the WESF were used from 1965 to 1985 to separate, purify, solidify, encapsulate, and store megacurie amounts of ^{137}Cs and ^{90}Sr. Based on this latter use, B Plant is the reference facility for pretreatment of DST waste. Concerns over the viability of B Plant for this purpose were noted in Section 1.0 of this document.

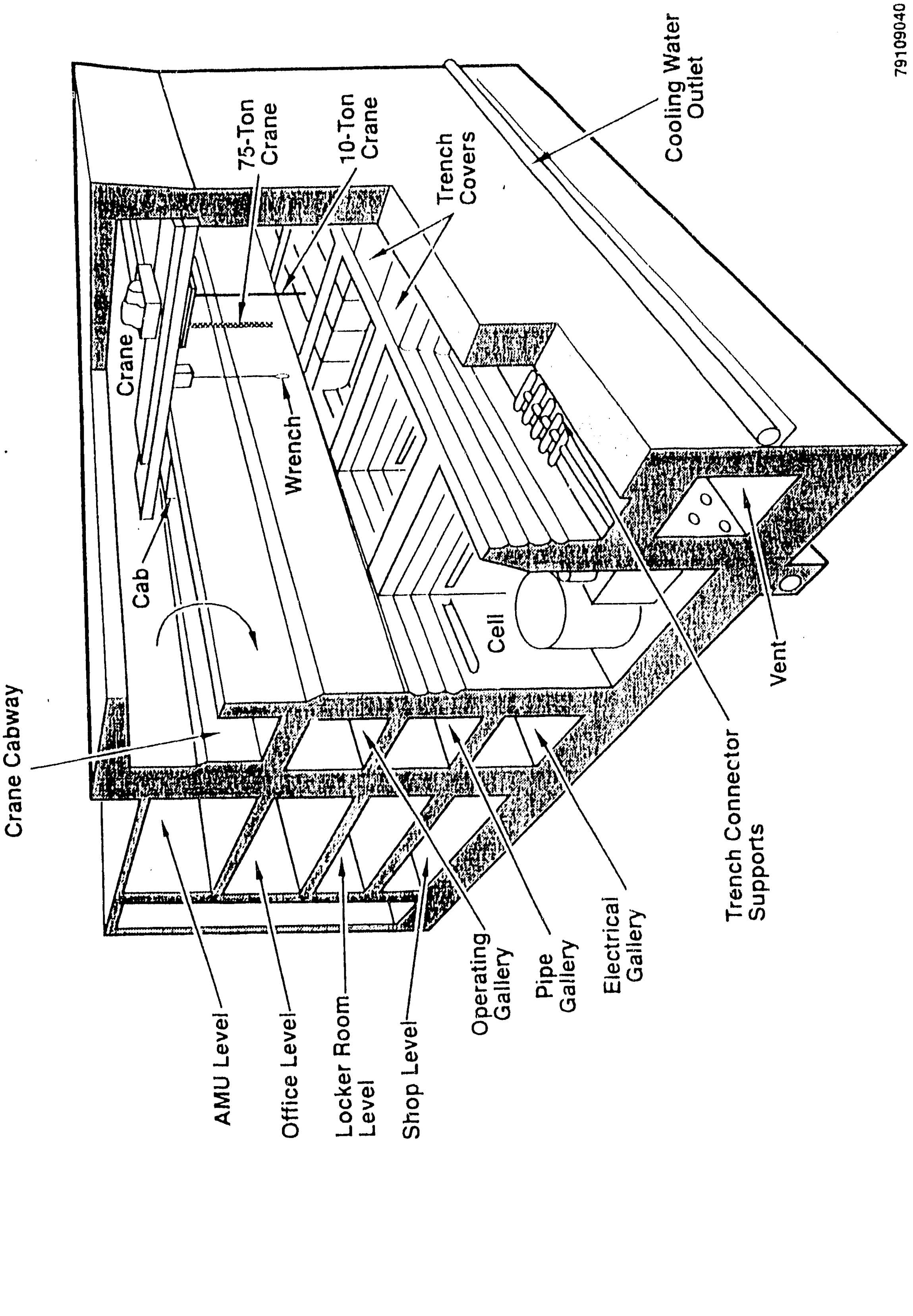
6.5.2.3.2 Description. The 221-B canyon is a reinforced concrete structure 246 m long and 23.4 m high. The cross-sectional width is 20.0 m up to a height of 18.1 m and then increases to 20.7 m at roof top. The canyon is supported on a 1.82-m-thick concrete slab.

The 221-B canyon is divided into 20 sections, each consisting of a shielded process area and an accompanying service area. The shielded process area is composed of 40 cells (2 per section), an interconnecting process pipe trench (cells 5 through 40), and an exhaust ventilation air tunnel. Except for cells 1 through 4 and cell 10, each cell is 5.35 m long, 3.94 m wide, and 6.67 m deep and is separated from adjoining cells by 2.12-m-thick concrete walls. The cells and process pipe trench are covered with removable blocks for remote access to process equipment and piping. An underground, concrete-encased, vitrified, clay-pipe services processes cells and the pipe trench. Process fluid leaks within the cells or pipe trench are channelled through this vitrified clay pipe and collected within a stainless steel tank located in cell 10. The process cell (i.e., concrete), drainage collection pipe, and stainless steel tank serve as the secondary containment system for process vessels and piping. A 34-tonne-capacity overhead bridge crane provides remote access to process cells and the pipe trench. This crane is equipped with a 4.54-tonne-capacity hoist, two 0.45-tonne-capacity hoists, and an electric wrench.

6.5.2.3.3 B Plant Facility Modifications for Pretreatment of DST Wastes. The B Plant complex currently is being modified to comply with environmental and safety regulations, codes, and standards to support continued safe storage of encapsulated ^{90}Sr and ^{137}Cs. These upgrades are required whether or not B Plant is used to pretreat DST wastes.

For pretreatment of DST wastes at B Plant, some additional environmental and safety modifications are required. These latter items include installation of a system for treating process effluents, replacement of the 221-B canyon exhaust ventilation fans and stack, and replacement of the process vessel ventilation system. Lining of process cells with stainless steel or Hastelloy-C is recommended to provide a secondary containment compatible with wastes and chemicals used during pretreatment operations.

Figure 6-12. Buildings 221-B and 271-B.



To remove ^{137}Cs from DST waste using the Duolite CS 100 resin (Section 6.4.2.2), the present ion exchange column in cell 18 must be replaced with a new unit suitable for operation with acidic effluents. A system for control and dilution of the acidic eluent must be installed in the 276 Building. Process control valves and instrumentation systems for transfer of process solutions and monitoring of equipment must be upgraded. Also, process equipment in cells 11 through 14 must be replaced with additional ion exchange equipment to achieve enhanced removal of ^{137}Cs from some DST wastes (e.g., CC waste).

The B Plant canyon must be upgraded and modified to perform solid-liquid separations, wash separated solids, and destroy organic compounds in CC wastes. Specifically, existing equipment in cells 6 through 8, 22, and 26 through 32 must be removed and replaced with new, appropriately sized tanks and filters. Existing process control valves, instrumentation, and electrical systems in these cells also need to be replaced.

Existing process equipment in cell 35 and in cells 26 through 32 must be removed and new TRUEX process equipment installed. Centrifugal contactors, solid dissolution equipment, equipment for treatment of offgases, and support tanks will be installed. Existing instrumentation, process control valves, and electrical systems will need to be replaced. Once the TRUEX process modifications are in place, installation of a new transfer line from tank farms to cell 31 in B Plant will permit concurrent cesium ion exchange and TRUEX process operations.

Figure 6-13 shows how the B Plant canyon would be configured to accomplish only solid-liquid separation, sludge washing, cesium separation, and destruction of organic complexants in CC waste. Figure 6-14 details the proposed canyon configuration for additional pretreatment operations involving solids dissolution and TRUEX process operation. Figure 6-15 provides estimates of the time required to complete various B Plant upgrades.

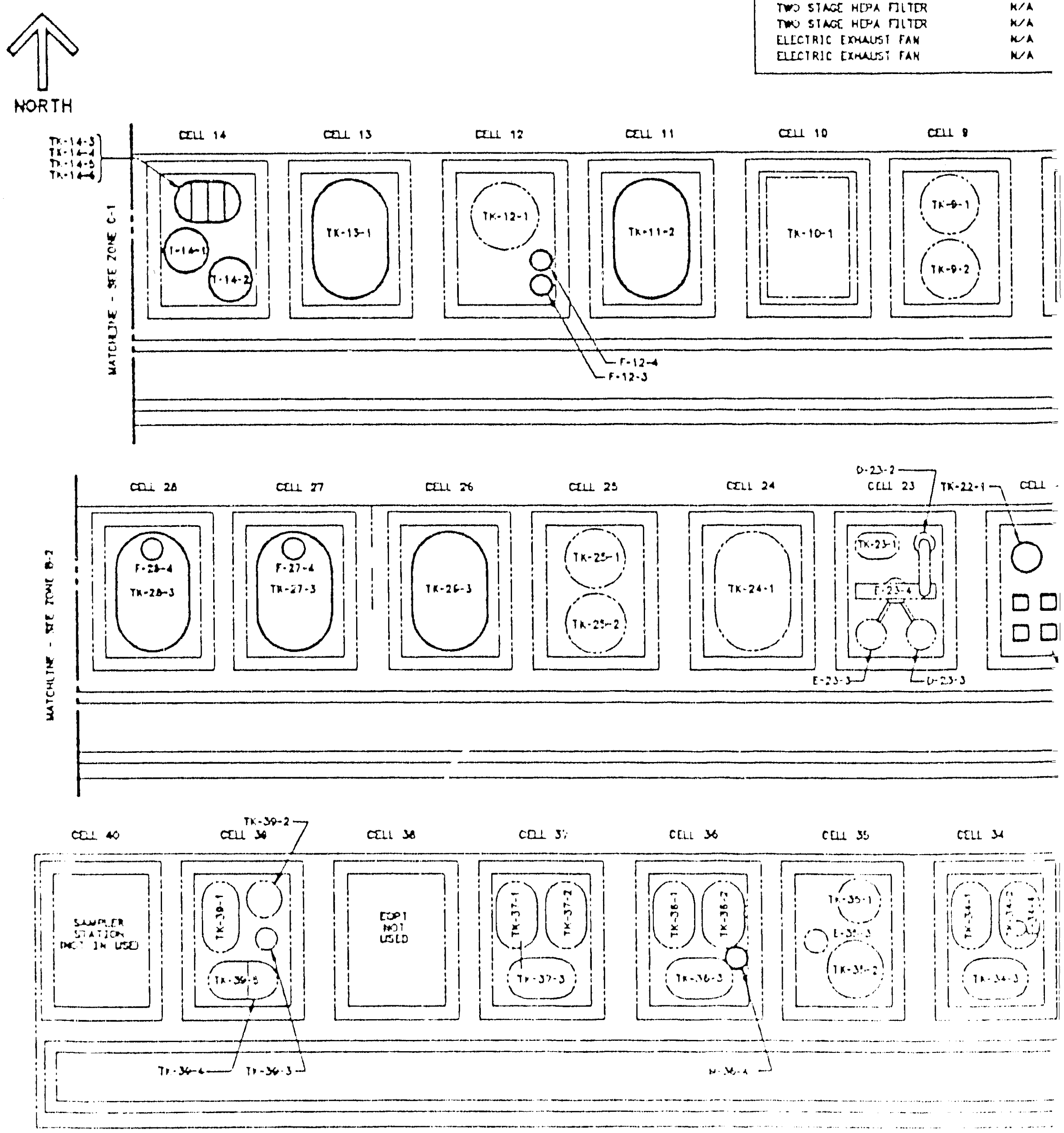
6.5.2.3.4 Costs of Upgrades to B Plant. Table 6-6 summarizes estimated costs of various upgrades and modifications to B Plant to ready the facility for pretreatment of DST wastes.

Table 6-6. Estimated Costs of B Plant Upgrades.

Upgrade description	Estimated cost (million FY 1991 $)
Environmental and safety modifications[a]	98
Additional enhanced cesium removal capability	95
Capability for destruction of organic compounds in complexant concentrate waste	278
Solids dissolution and transuranic extraction process capability	275

[a]Ongoing to support continued safe storage of encapsulated cesium and strontium.

EQUIPMENT NAME	GALLON CA[PACITY]
NCRW SOLIDS WASH/CC WASTE RECEIVER VESSEL	14,000
NCRW SOLIDS WASH/CC WASTE COMPLEXANT DESTRUCTION VESSEL	14,000
NCRW SOLIDS WASH/CC WASTE COMPLEXANT DESTRUCTION VESSEL	14,000
WASHED NCRW SOLIDS STOR/CC WASTE COMPLEXANT DESTRUCTION WASTE NEUTRALIZATION VESSEL	14,000
NCRW SOLIDS WASH/CC WASTE COMPLEXANT DESTRUCTION VESSEL	14,000
NCRW SOLIDS WASH/CC WASTE COMPLEXANT DESTRUCTION VESSEL	14,000
WASHED NCRW SOLIDS STOR/CC WASTE COMPLEXANT DESTRUCTION WASTE NEUTRALIZATION VESSEL	14,000
OFF GAS SCRUB SOLUTION STORAGE VESSEL	500
OFF GAS NO_x SCRUB TOWER	N/A
HEME FILTER	N/A
HEME FILTER	N/A
ELECTRIC OFF GAS HEATER	N/A
TWO STAGE HEPA FILTER	N/A
TWO STAGE HEPA FILTER	N/A
ELECTRIC EXHAUST FAN	N/A
ELECTRIC EXHAUST FAN	N/A



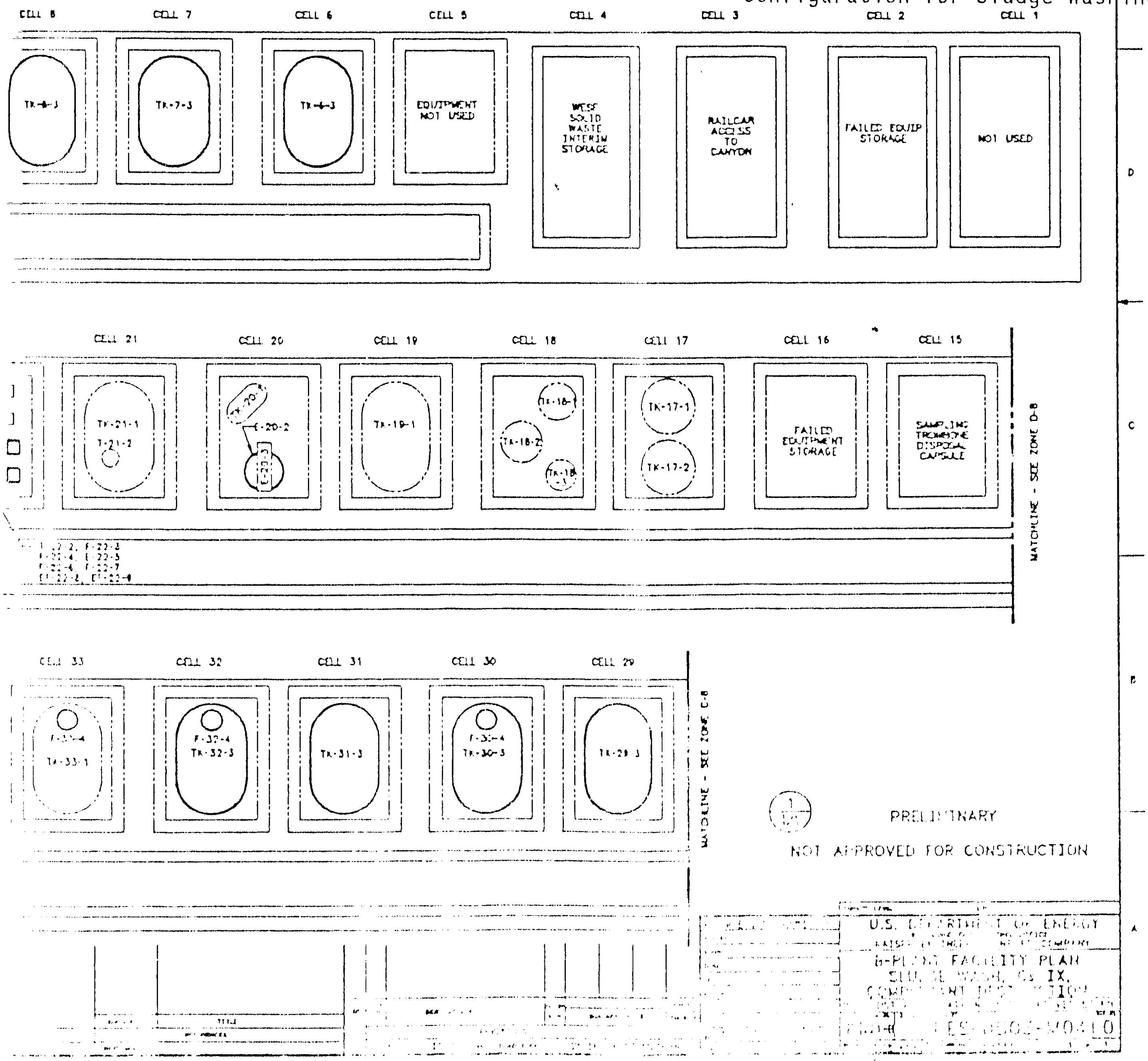
221-B BUILDING
OPERATING GALLERY LEVEL

ACITY	VESSEL SIZE	EQPT ID
	16'X10'X14'	TK-32-3
	16'X10'X14'	TK-31-3
	16'X10'X14'	TK-30-3
	16'X10'X14'	TK-29-3
	16'X10'X14'	TK-28-3
	16'X10'X14'	TK-27-3
	16'X10'X14'	TK-26-3
	4'X6'	TK-22-1
	N/A	T-22-2
	N/A	F-22-3
	N/A	F-22-4
	N/A	E-22-5
	N/A	F-22-6
	N/A	F-22-7
	N/A	EF-22-8
	N/A	EF-22-9

NEW EQUIPMENT LIST

EQUIPMENT NAME	GALLON CAPACITY	VESSEL SIZE	EQPT ID
CESIUM EVAPORATOR	250	4'-6"X21'	E-20-2
CESIUM ION EXCHANGE COLUMN	(2) 2,000	6'X12'	TK-14-1, -2
IX COLUMN FEED VESSEL	(2) 500	5'-6"X9'X6'-6"	TK-14-3, -5
IX COLUMN EFFLUENT COLLECTION VESSEL	(2) 500	5'-6"X9'X6'-6"	TK-14-4, -6
POLISH FILTER FEED VESSEL	14,000	16'X10'X14'	TK-13-1
WASTE RECEIVER	14,000	16'X10'X14'	TK-[illegible] 2
CC WASTE COMPLEXANT DESTRUCTION VESSEL	14,000	16'X10'X14'	TK-8-3
CC WASTE COMPLEXANT DESTRUCTION WASTE NEUT VESSEL	14,000	16'X10'X14'	TK-7-3
CC WASTE COMPLEXANT DESTRUCTION VESSEL	14,000	16'X10'X14'	TK-6-3
SOLIDS FILTER UNIT	N/A	6'-3"X1'-2"	F-33-4
SOLIDS FILTER UNIT	N/A	6'-3"X1'-2"	F-32-4
SOLIDS FILTER UNIT	N/A	6'-3"X1'-2"	F-30-4
SOLIDS FILTER UNIT	N/A	6'-3"X1'-2"	F-28-4
SOLIDS FILTER UNIT	N/A	6'-3"X1'-2"	F-27-4
SOLIDS FILTER UNIT	N/A	6'-3"X1'-2"	F-12-3
SOLIDS FILTER UNIT	N/A	6'-3"X1'-2"	F-12-4
TRU MONITOR	50	3'X3'	M-36-4

Figure 6-13. Possible B Plant Canyon Configuration for Sludge Washing.

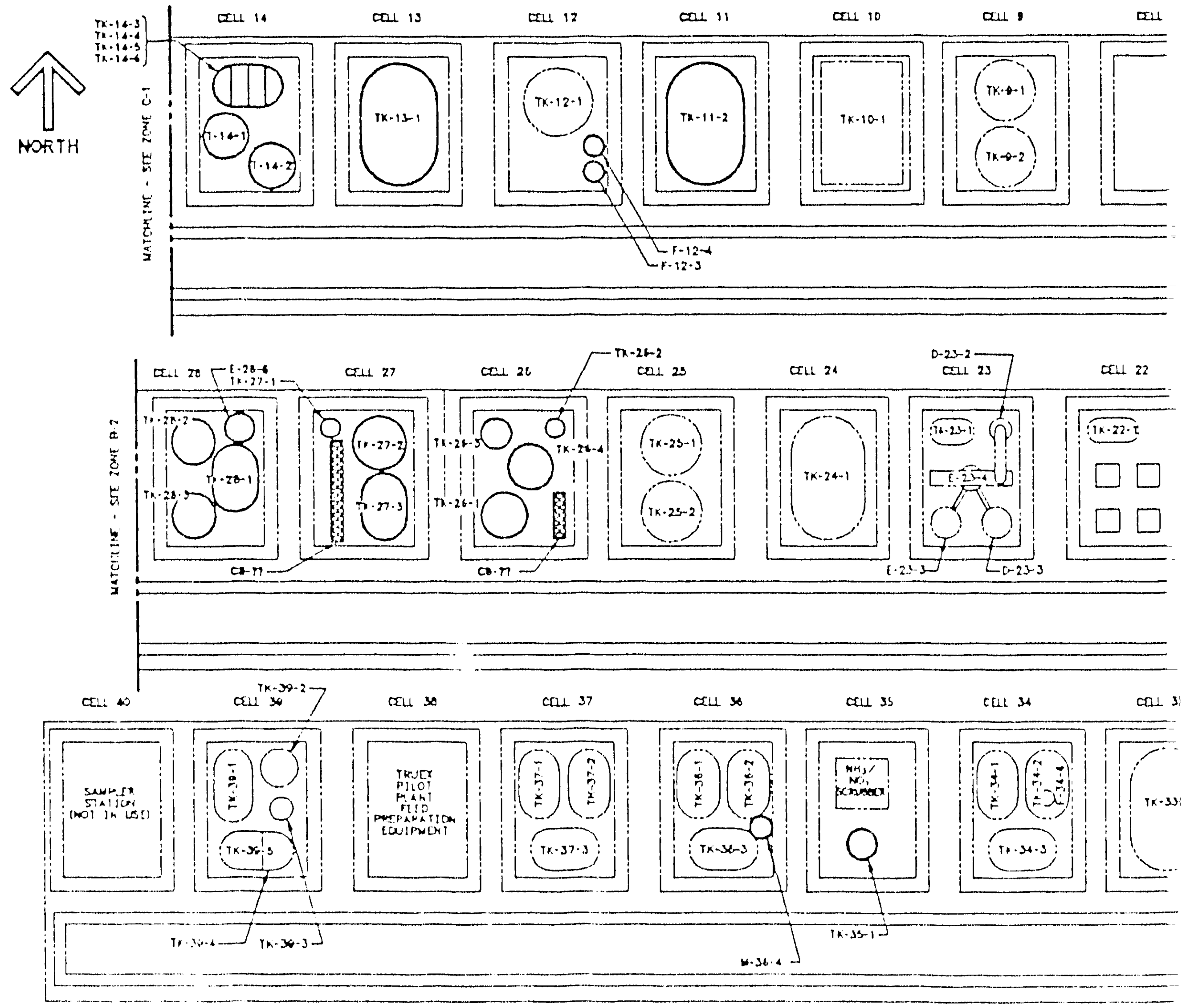


NEW EQUIPMENT LIST

EQUIPMENT NAME	GALLON CAPACITY	VESSEL SIZE	EQPT ID
OFF GAS NOx SCRUB TOWER	N/A	N/A	T-35-9
ELECTRIC EXHAUST FAN	N/A	N/A	EF-35-8
ELECTRIC EXHAUST FAN	N/A	N/A	EF-35-7
HEME FILTER	N/A	N/A	F-35-6
HEPA FILTER	N/A	N/A	F-35-5
HEPA FILTER	N/A	N/A	F-35-4
ELECTRIC OFF GAS HEATER	N/A	N/A	E-35-3
SHELL-AND-TUBE CONDENSER	N/A	N/A	E-35-2
OFF GAS SCRUB SOLUTION STORAGE VESSEL	500	4'X6'	TK-35-1
WASTE RECEIVER VESSEL	14,000	16'X10'X14'	TK-32-3
WASTE RECEIVER/SOLIDS DISSOLUTION VESSEL	14,000	16'X10'X14'	TK-31-3
WASTE RECEIVER/SOLIDS DISSOLUTION VESSEL	14,000	16'X10'X14'	TK-30-3
WASTE RECEIVER/SOLIDS DISSOLUTION VESSEL	14,000	16'X10'X14'	TK-29-3
TRUEX FEED VESSEL	4,000	6'X8'-9"X12'	TK-28-1
TRU SOLIDS AND AQUEOUS WASTE COLLECTION TANK	3,000	6'X16'	TK-28-2
CONT STIRRED TK REACTOR (NCRW DISSOLUTION) OR TRU FEED LAG STOR	3,200	6'X16'	TK-28-3
CONDENSER FOR CONTINUOUS STIRRED WASTE REACTOR	N/A	N/A	E-28-6
SOLVENT PUMP TANK	100	2'-6"X3'	TK-27-1
AQUEOUS TRUEX COLLECTION VESSEL	2,000	7'X7'	TK-27-2

NEW EQUIPM

EQUIPMENT NAME	GALLON CAPACITY
NON-TRUEX RAFFINATE WASTE COLLECTION VESSEL	4,000
CENTRIFUGAL CONTACTORS	N/A
CLEAN SOLVENT STORAGE VESSEL	1,600
SOLVENT PUMP TANK	100
NITRIC ACID SOLVENT WASH SOLUTION STORAGE	500
CARBONATE SOLVENT WASH SOLUTION STORAGE	1,200
SOLVENT CLEAN CONTACTORS	N/A
CESIUM EVAPORATOR (15 GPM)	250
CESIUM ION EXCHANGE COLUMN	(2) 2,000
IX COLUMN FEED VESSEL	(2) 500
IX COLUMN EFFLUENT COLLECTION VESSEL	(2) 500
POLISHED FILTER FEED VESSEL	14,000
WASTE RECEIVER	14,000
SOLIDS FILTER UNIT	N/A
SOLIDS FILTER UNIT	N/A
SOLIDS FILTER UNIT	N/A
SOLIDS FILTER UNIT	N/A



221-B BUILDING
OPERATING GALLERY LEVEL

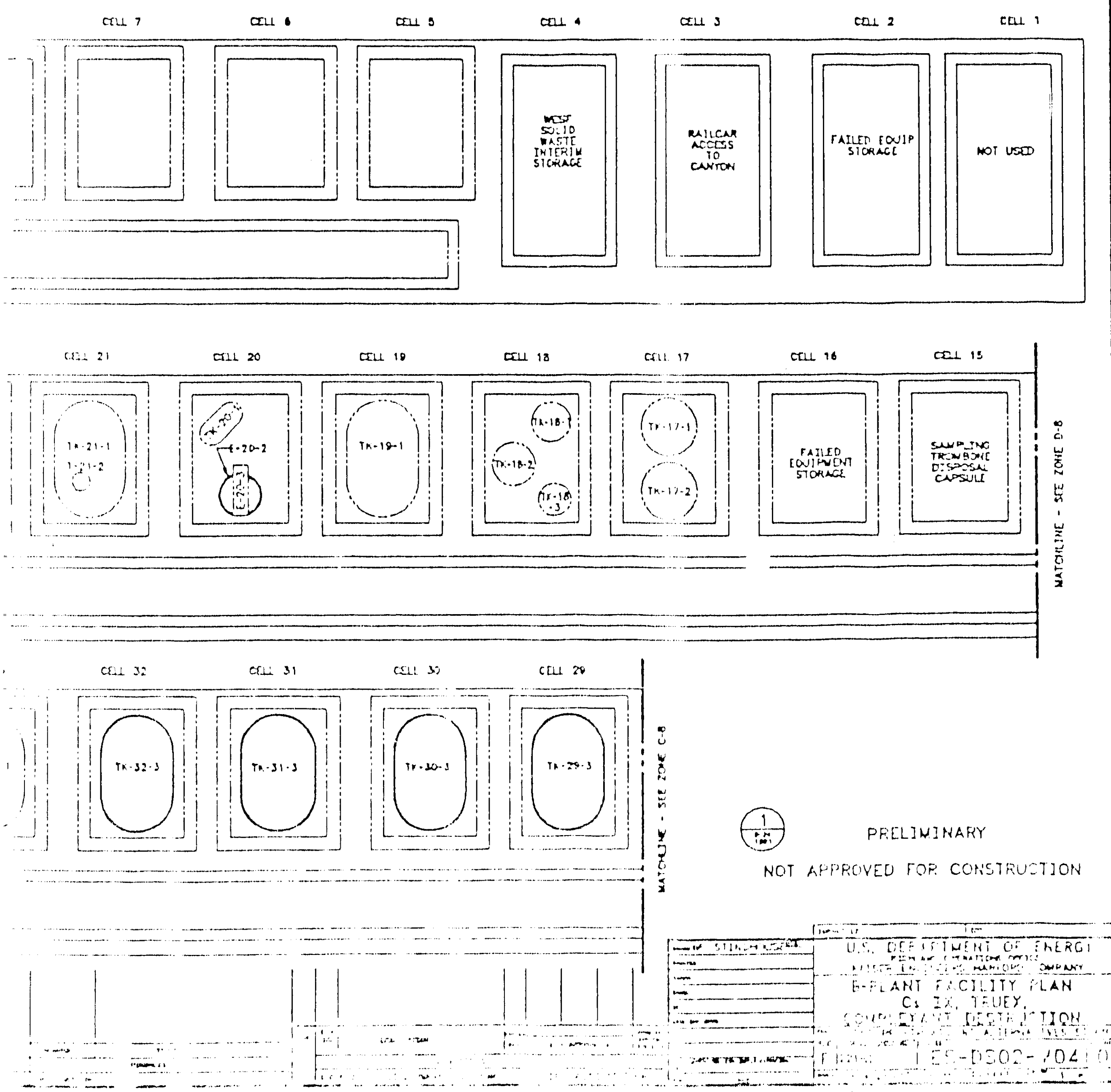
...ENT LIST

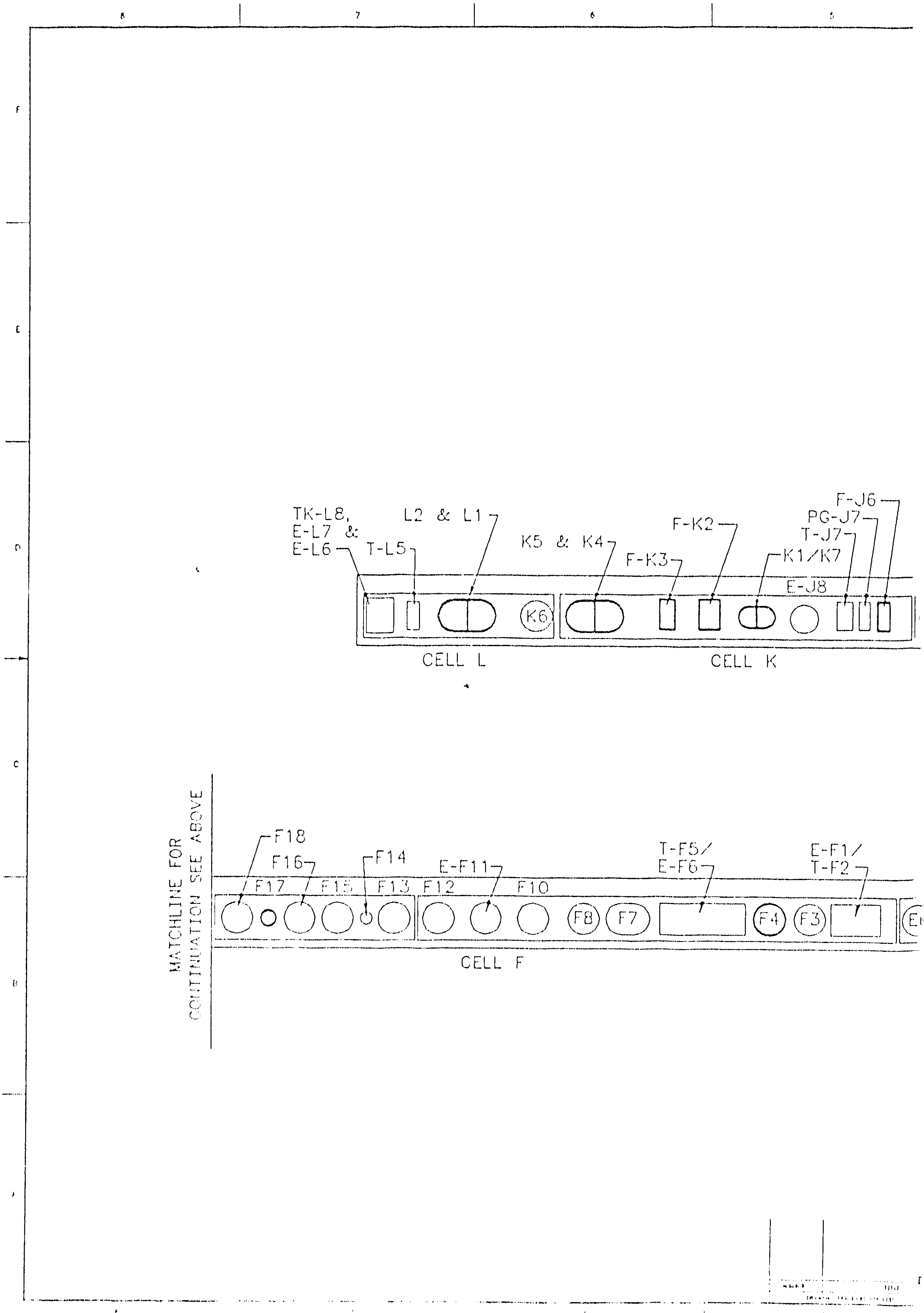
VESSEL SIZE	EQPT ID
6'X8'-9'X12'	TK-27-3
N/A	CENTRIFUGAL CONTACTORS
8'X8'	TK-26-1
2'-6"X3'	TK-26-2
4'X6'	TK-26-3
6'X6'	TK-26-4
N/A	CENTRIFUGAL CONTACTORS
4'-6"X21'	E-20-2
6'X12'	TK-14-1, -2
5'-6"X9'X8'-6"	TK-14-3, -5
[illegible]	TK-14-4, -6
18'X10'X14'	TK-13-1
18'X10'X14'	TK-11-2
6'-3"X1'-2"	F-33-4
6'-3"X1'-2"	F-32-4
6'-3"X1'-2"	F-30-4
6'-3"X1'-2"	F-30-5

NEW EQUIPMENT LIST

EQUIPMENT NAME	GALLON CAPACITY	VESSEL SIZE	EQPT ID
SOLIDS FILTER UNIT	N/A	6'-3"X1'-2"	F-28-4
SOLIDS FILTER UNIT	N/A	6'-3"X1'-2"	F-12-3
SOLIDS FILTER UNIT	N/A	6'-3"X1'-2"	F-12-4
TRU MONITOR	50	5'X5'	M-36-4

Figure 6-14. Possible B Plant Configuration for Transuranic Extraction Process.

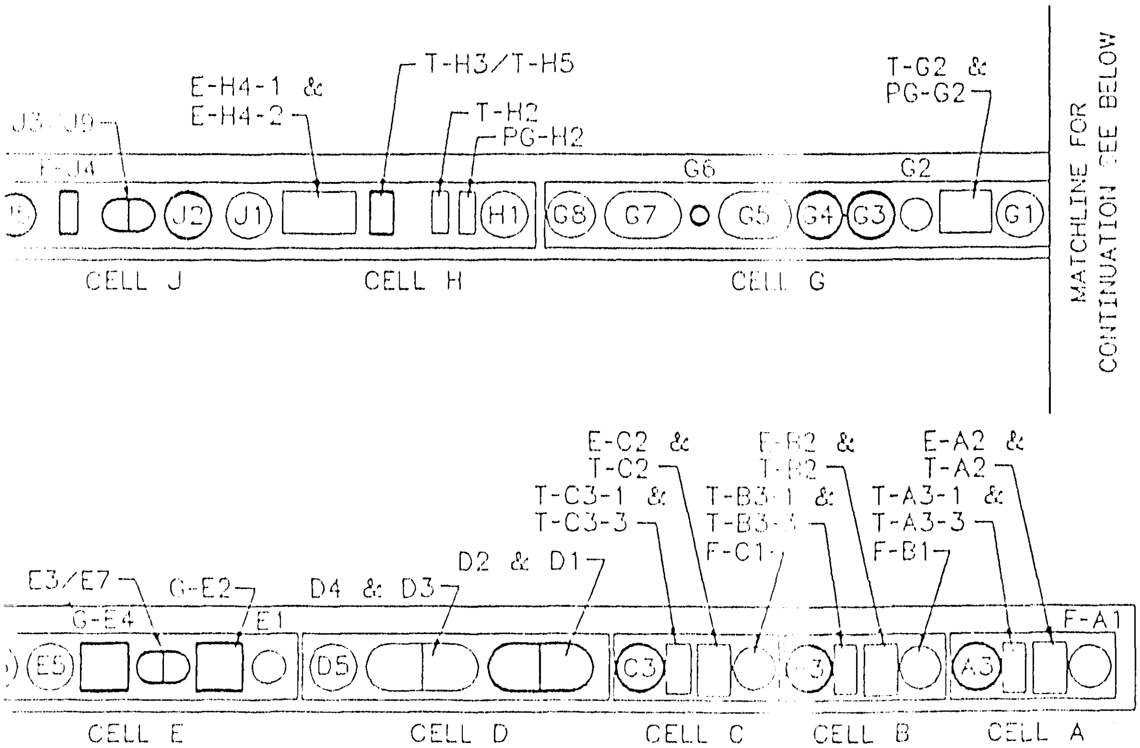



TK-L8, E-L7 & E-L6
T-L5
L2 & L1
K5 & K4
F-K3
F-K2
K1/K7
T-J7
PG-J7
F-J6
E-J8
K6
CELL L
CELL K
MATCHLINE FOR CONTINUATION SEE ABOVE
F18
F16
F14
F17
F15
F13
F12
E-F11
F10
F8
F7
T-F5/ E-F6
F4
F3
E-F1/ T-F2
CELL F

NEW EQUIPMENT LIST

EQUIPMENT NAME	EQPT ID	EQUIPMENT NAME	EQPT ID
SOLIDS DISSOLVER	TK-A3	FILTER	F-K2
SOLIDS DISSOLVER	TK-B3	FILTER	F-K3
SOLIDS DISSOLVER	TK-C3	CLARIFIED SOLUTION/TRUEX FEED ADJUSTMENT	TK-K4,K5
FEED TANK	TK-D1,D2	SAMPLING TANK/FEED TANK	TK-L1,L2
CENTRIFUGE	G-E2		
FEED TANK	TK-E3,E7		
CENTRIFUGE	G-E4		
CENTRATE RECEIVER	TK-F4		
Cs PRODUCT CATCH TANK	TK-F17		
Cs IX WASTE TANK	TK-G3,G4		
LLW RECEIVER	TK-G6		
CESIUM ION EXCHANGE COLUMNS	T-H3/T-H5		
RECEIVER TANK	TK-J2		
FILTER FEED TANK	TK-J3/J9		
FILTER	F-J4		
FILTRATE RECEIVER	TK-J5		
FILTER	F-J6		
FILTER FEED TANK	TK-K1/K7		

Figure 6-16. Configuration of Plutonium-Uranium Extraction Plant for Sludge Washing.



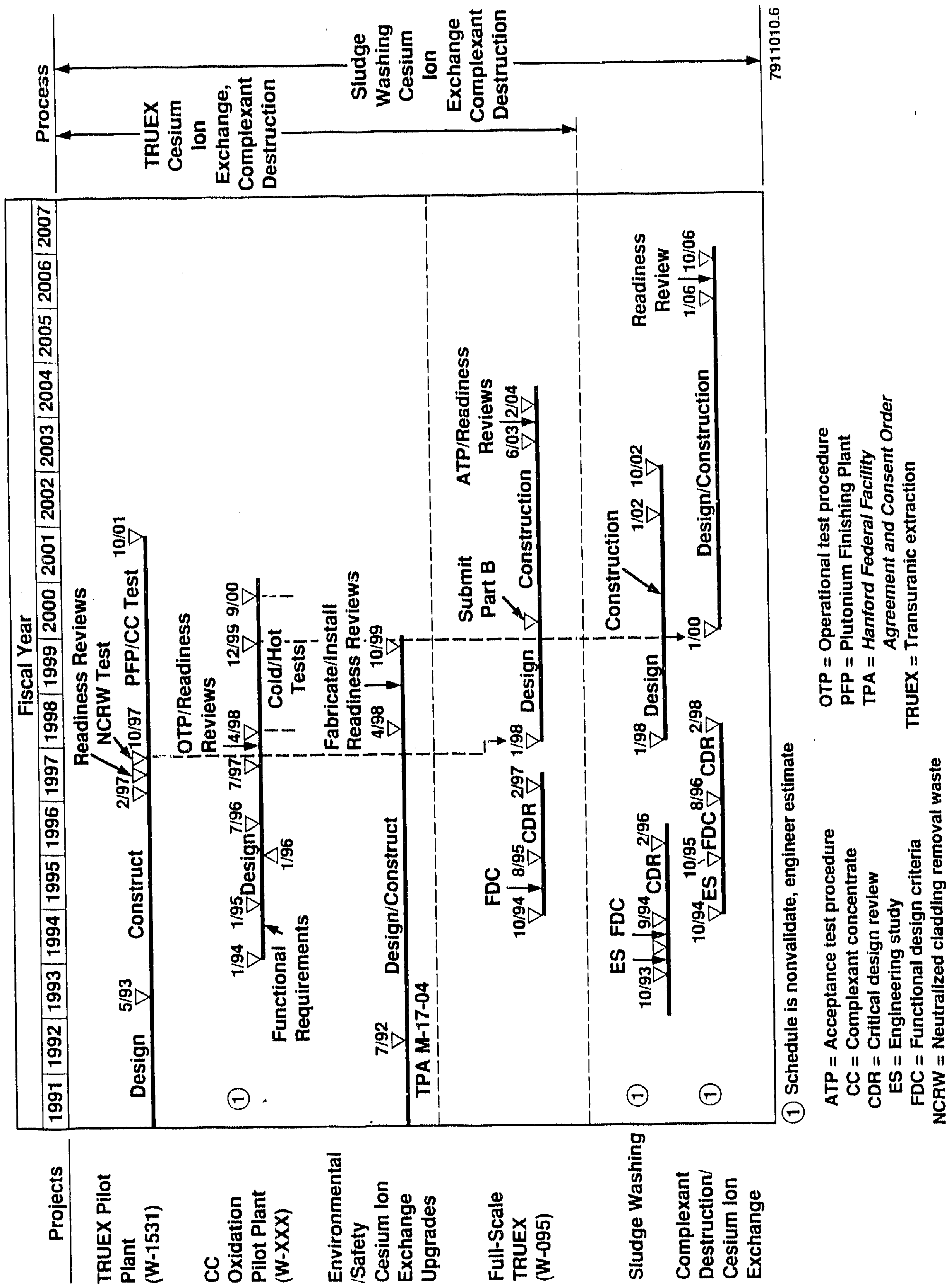
PRELIMINARY

NOT APPROVED FOR CONSTRUCTION

U.S. DEPARTMENT OF ENERGY
RICHLAND OPERATIONS OFFICE
KAISER ENGINEERS HANFORD COMPANY
ALTERNATIVE W/O TRUEX
PUREX FACILITY
CELL PLAN

ES-DS07-01

Figure 6-15. Schedule for Completion of Waste Pretreatment Upgrades in B Plant.



6.5.2.4 Double-Shell Tanks.

6.5.2.4.1 Introduction. Existing and/or new DSTs are viable candidate facilities for separation of DST waste liquids and solids and/or washing the separated solids. In some cases (e.g., NCAW), the washed solids would be a desirable feed to the HWVP. Further pretreatment of the separated liquid and solid waste fraction would necessitate using a second pretreatment facility, e.g., B Plant or the PUREX Plant, or a new facility.

Solid-liquid separations in a DST would be achieved by settle-decant technology. A floating suction pump could be used to remove partially clarified supernatant to another waste pretreatment facility for final clarification by filtration and removal of ^{137}Cs. The settled solids would be suspended for washing by mixer-type pumps proposed for retrieval of NCAW. The suspended solids would be washed one or more times with a dilute $NaOH-NaNO_2$ solution (to minimize corrosion of the carbon steel tanks). Spent washes would be combined with the original supernatant liquid.

6.5.2.4.2 Description. Four new DSTs, similar in design to existing tanks in the 241-AY and 241-AZ Tank Farms, are planned to support normal tank farm operations, pretreatment of DST wastes, and to provide storage for feed to the HWVP. Each of the new tanks will have a nominal capacity of 3,800 m^3 and will be designed to exceed all applicable WAC requirements for treatment, storage, and disposal facilities. To improve safe operations and compliance with environmental regulations, the following features are being considered for incorporation in the new DSTs and tank farm.

- The tank bottoms will be sloped to facilitate retrieval operations.
- Mixing pumps will be used to suspend solids more effectively than the air lift circulators currently used in 241-AY and 241-AZ Tank Farms.
- Instrumentation and controls will be integrated with a modern, microprocessor-based, distributive process control system.
- Upgraded corrosion monitoring will include a corrosion coupon retrieval system, ultrasonic tank wall measurements, and closed-circuit television for visual inspections.
- Sampling equipment will be operated remotely to reduce radiation exposure to personnel and to improve containment of radionuclides and hazardous chemicals.
- Washable metal filters will be used in offgas systems to remove particulates.
- A building will cover the entire tank farm to eliminate the operational impact of inclement weather (e.g., wind, snow).
- Redundant primary tank and annulus ventilation systems will be provided for each tank.
- All primary tanks will be constructed of stainless steel.

- Tank pits will have active ventilation systems to improve containment of radionuclides and hazardous chemicals.

- A change facility and control room will be provided with the project.

One of the new DSTs will be designated for use in pretreatment of DST wastes, i.e., for solid-liquid separations and for washing of settled solids. Because the primary tank (i.e., inner tank of the DST) will be constructed of stainless steel, it also may be possible to conduct some additional large-scale pretreatment operations (i.e., acid dissolution of washed sludges or intermediate pretreatment processing).

6.5.2.4.3 Facility Modifications for Pretreatment of DST Wastes. Upgrades and modifications to existing DSTs to prepare them for solid-liquid separation and sludge-washing operations with NCAW, PFP waste, and CC waste include the following:

- Provide additional cooling capacity to dissipate heat energy from incoming waste solutions that have been heated during retrieval or transfer operations

- Provide improved equipment to sample supernatant liquids to reduce personnel exposure to radiation and to improve containment of samples

- Install a retractable floating suction pump to withdraw clarified solution from the top of the DST while waste solids continue to settle in the lower portion of the DST

- Provide instrumentation to monitor sludge levels

- Install equipment to add flocculating agents to improve solid-liquid separation kinetics and efficiency

- Install equipment to make up and deliver dilute NaOH-$NaNO_2$ wash liquid to the DST.

6.5.2.5 PUREX Plant.

6.5.2.5.1 Introduction. The PUREX Plant was built in the 1950's and operated from 1956 to 1972 and from 1973 to 1988 to recover various actinide elements from irradiated fuel generated at Hanford Site reactors. The PUREX Plant is presently not operating, awaiting completion of a supplemental EIS to determine disposal of the remaining N Reactor fuel. If processing of N Reactor fuel is not conducted the PUREX Plant is a candidate for performing the pretreatment of DST wastes.

6.5.2.5.2 Description. The principal structures in the PUREX Plant complex are (1) a concrete canyon (202-A Building) that contains equipment for processing radioactive solids and liquids, (2) the pipe and operating, sample, and storage galleries, and (3) an annex that houses offices, process control facilities, laboratories, and building services. Some support facilities are located external to these three structures.

The PUREX Plant canyon is about 305 m long, up to 36 m wide, and about 30 m high; about 12 m of the canyon height is belowgrade. The 11 canyon cells, (A through L; no I) also belowgrade, are about 4.27 m wide, 12 m deep, and vary in length. Each of the cells can contain several pieces of processing equipment. The equipment now installed in the PUREX Plant canyon is designed for remote operation and maintenance. A shielded crane is used to install and remove process equipment.

A pipe trench provides piping routes between process equipment. Enough piping options are provided to provide process flexibility. A sample gallery provides remote, shielded capability to sample process solutions. In-line instrumentation also can be installed conveniently in the sample gallery.

A process control laboratory for analysis of both radioactive and nonradioactive samples also is included in the PUREX Plant complex. The general support and utility systems needed to support a major fuel reprocessing plant are also present.

6.5.2.5.3 PUREX Facility Modifications for Pretreatment of Double-Shell Tank Wastes. To accomplish the presently envisioned DST waste pretreatment operations, irradiated fuel dissolvers in cells A, B, and C would be replaced with large vessels for dissolution of solids and for chemical destruction of organic compounds in CC waste. The existing dissolver offgas treatment systems would be used to the extent possible. New solid-liquid separations equipment would be installed in cells E, J, and K; various new tanks would be installed in cells F, G, J, K, and L.

Four new ion exchange columns and associated equipment would be installed in one or more cells for removal of ^{137}Cs from NCAW supernatant. If, as expected, removal of ^{137}Cs from liquid CC waste requires only two ion exchange columns, two of the four columns would be removed and replaced with other waste pretreatment equipment.

The PUREX Plant presently is equipped with pulse columns for performance of liquid-liquid extraction processes, such as the TRUEX process. For operation of the TRUEX process for pretreatment of NCRW, PFP waste, and CC waste, some new pulse columns must be installed. Three columns may be required for TRUEX process operations with NCRW and PFP waste while likely only two columns would be required for TRUEX process feeds prepared from CC waste. Existing solvent washing equipment can be used for routine cleanup of the TRUEX process solvent. Because of the special dimensions of PUREX Plant cells, operation of the TRUEX process in pulse columns rather than centrifugal contactors will provide more process flexibility and require less cell floor space.

The PUREX Plant already contains much of the equipment needed for ion exchange removal of ^{99}Tc from either DSSF waste or NCAW if such removal is necessary. For example, the currently installed acid fractionator could be used to recover HNO_3 from the ^{99}Tc eluate for reuse. An ion exchange column and supporting ^{99}Tc recovery equipment would have to be installed.

Some general upgrades to the PUREX Plant are required to support continued use of the facility. New closed loop heating and cooling systems would eliminate the need to dispose of large volumes of potentially contaminated water. Other major upgrades would include installing stainless steel liners in cell B and, perhaps, in other cells and constructing new transfer lines connecting the PUREX Plant to the tank farms.

Also, the PUREX Plant currently does not meet all stated DOE requirements [DOE Order 6430.1A (DOE 1989b)] for new nuclear facilities and does not meet some hazardous waste handling requirements. The PUREX Plant must be upgraded to meet all these requirements or, if equivalency to the requirements or no increased risks can be shown, have the appropriate federal and state agencies waive the requirements.

Figures 6-16 and 6-17, respectively, illustrate the configurations of the PUREX Plant for the sludge-washing alternative and for the TRUEX process alternative.

Figure 6-18 presents a schedule for completing PUREX Plant upgrades that would allow pretreatment of DST wastes.

6.5.2.5.4 Costs of Upgrades to PUREX Plant. Table 6-7 summarizes the estimated costs of various upgrades and modifications to the PUREX Plant to ready the facility for pretreatment of DST wastes.

6.5.2.6 Hanford Waste Vitrification Plant Pretreatment Modifications Description.

6.5.2.6.1 Introduction. An important objective of a revised strategy for the Hanford Site Tank Waste Remediation Program is to vigorously support, if justified, startup of the HWVP in December 1999. The key element of support is to ensure an adequate and reliable supply of pretreated DST waste for the December 1999 startup and for sustained HWVP operations.

Performance of some or all the following sludge-washing alternative pretreatment processes in the HWVP itself or in an adjoining annex to the HWVP could provide the necessary supply of pretreated wastes (i.e., feed) to the vitrification process:

- Bulk (gravity settling) solid-liquid separation
- Sludge washing
- Filtration of supernatants and sludge wash solutions
- Ion exchange removal of ^{137}Cs from alkaline wastes (e.g. NCAW or CC wastes)
- Destruction of organic complexants.

The TRUEX process pretreatment alternatives would not be performed either in the HWVP or in an annex to the HWVP.

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Figure 6-16. Configuration of Plutonium-Uranium Extraction Plant for Sludge Washing.

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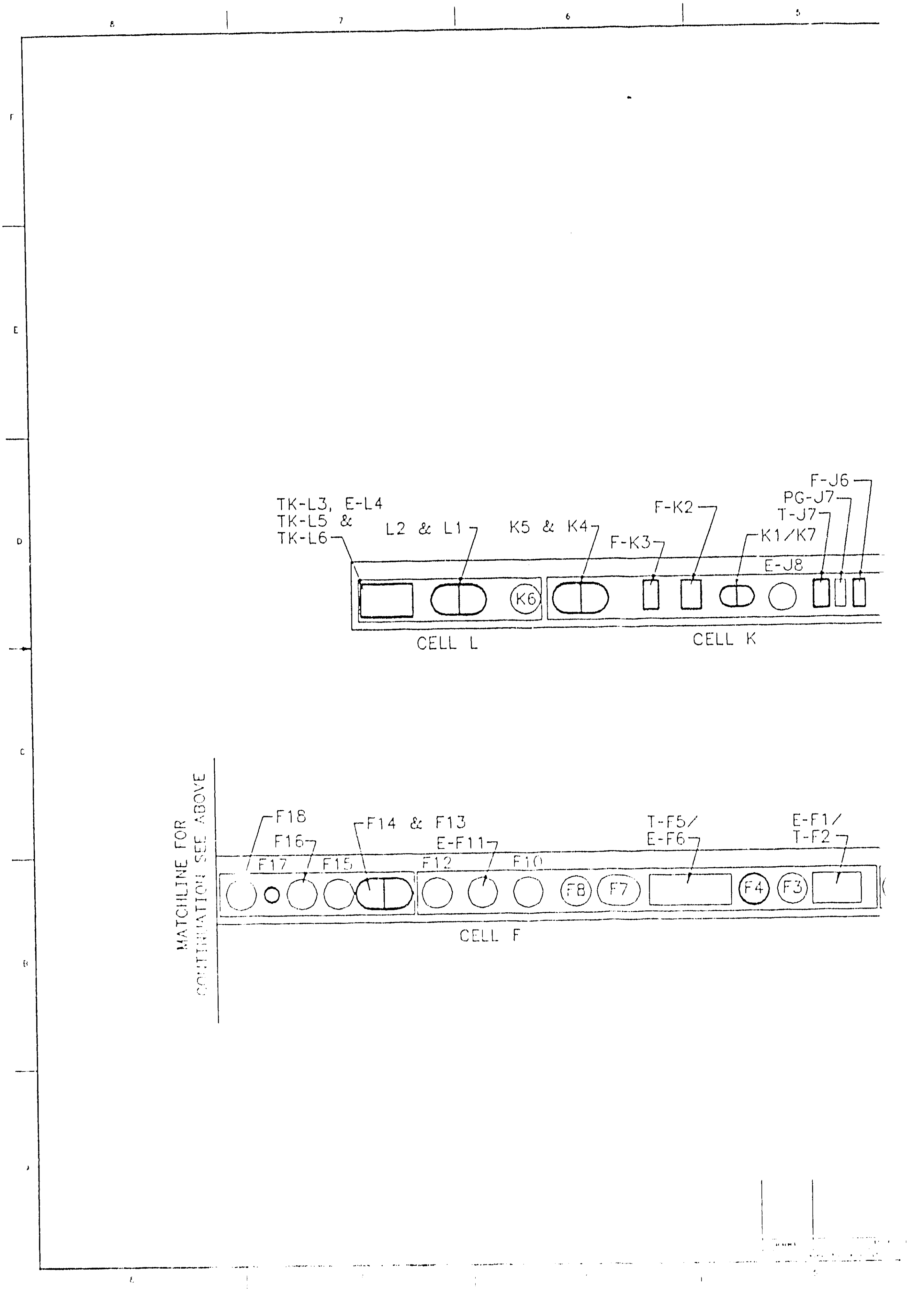
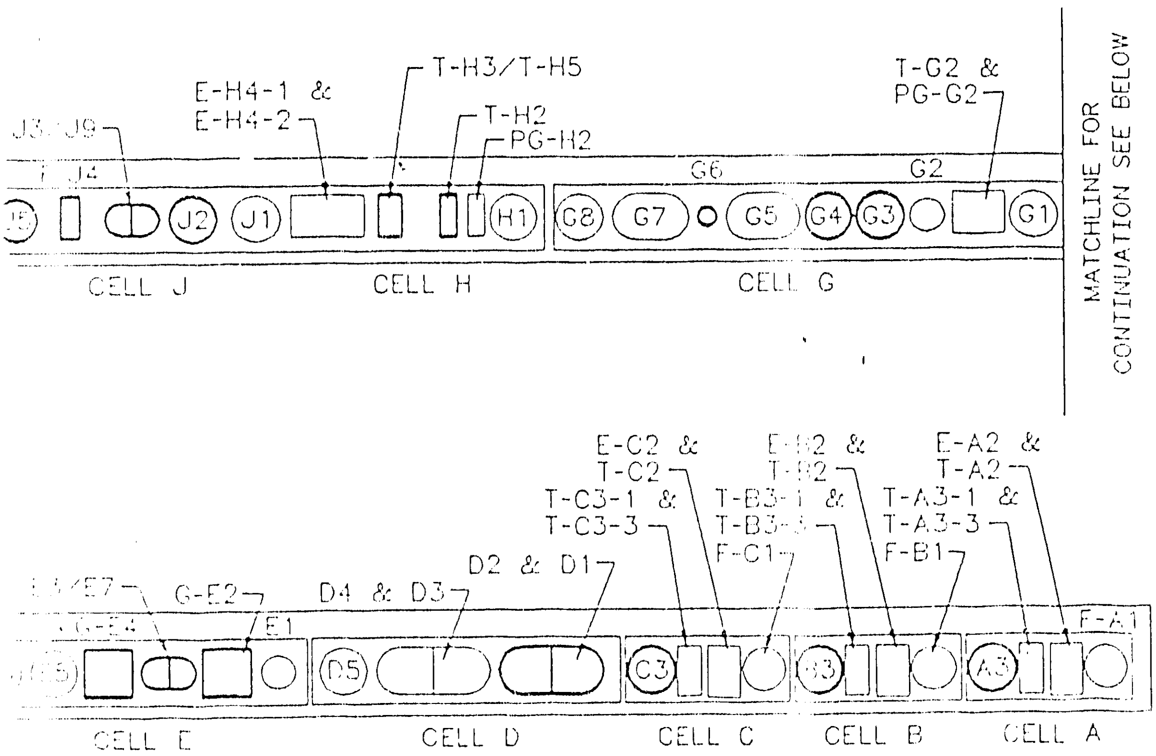

TK-L3, E-L4
TK-L5 &
TK-L6
L2 & L1
K5 & K4
F-K3
F-K2
K1/K7
T-J7
PG-J7
F-J6
E-J8
K6
CELL L
CELL K
MATCHLINE FOR
CONTINUATION SEE ABOVE
F18
F16
F17
F15
F14 & F13
F12
E-F11
F10
F8
F7
T-F5/
E-F6
F4
F3
E-F1/
T-F2
CELL F

NEW EQUIPMENT LIST

EQUIPMENT NAME	EQPT ID	EQUIPMENT NAME	EQPT ID
SOLIDS DISSOLVER	TK-A3	FILTER	F-K2
SOLIDS DISSOLVER	TK-B3	FILTER	F-K3
SOLIDS DISSOLVER	TK-C3	CLARIFIED SOLUTION/TRUEX FEED ADJUSTMENT	TK-K4,K5
FEED TANK	TK-D1,D2	SAMPLING TANK/FEED TANK	TK-L1,L2
CENTRIFUGE	G-E2	L-CELL PACKAGE	TK-L3, E-L4,L5 & L6
FEED TANK	TK-E3,E7		
CENTRIFUGE	G-E4		
CENTRATE RECEIVER	TK-F4		
RECEIVER TANK	TK-F13,F14		
Cs PRODUCT CATCH TANK	TK-F17		
Cs IX WASTE TANK	TK-G3,G4		
LLW RECEIVER	TK-G6		
EXCHANGE COLUMN	T-H2		
CESIUM ION EXCHANGE COLUMNS	T-H3/T-H5		
RECEIVER TANK	TK-J2		
FILTER FEED TANK	TK-J3/J9		
FILTER	F-J4		
FILTRATE RECEIVER	TK-J5		
FILTER	F-J6		
EXCHANGE COLUMN	T-J7		
FILTER FEED TANK	TK-K1/K7		

Figure 6-17. Configuration of Plutonium-Uranium Extraction Plant for Transuranic Extraction Process.



PRELIMINARY

NOT APPROVED FOR CONSTRUCTION

Figure 6-18. Schedule for Completion of Waste Pretreatment Upgrades to the Plutonium-Uranium Extraction Plant.

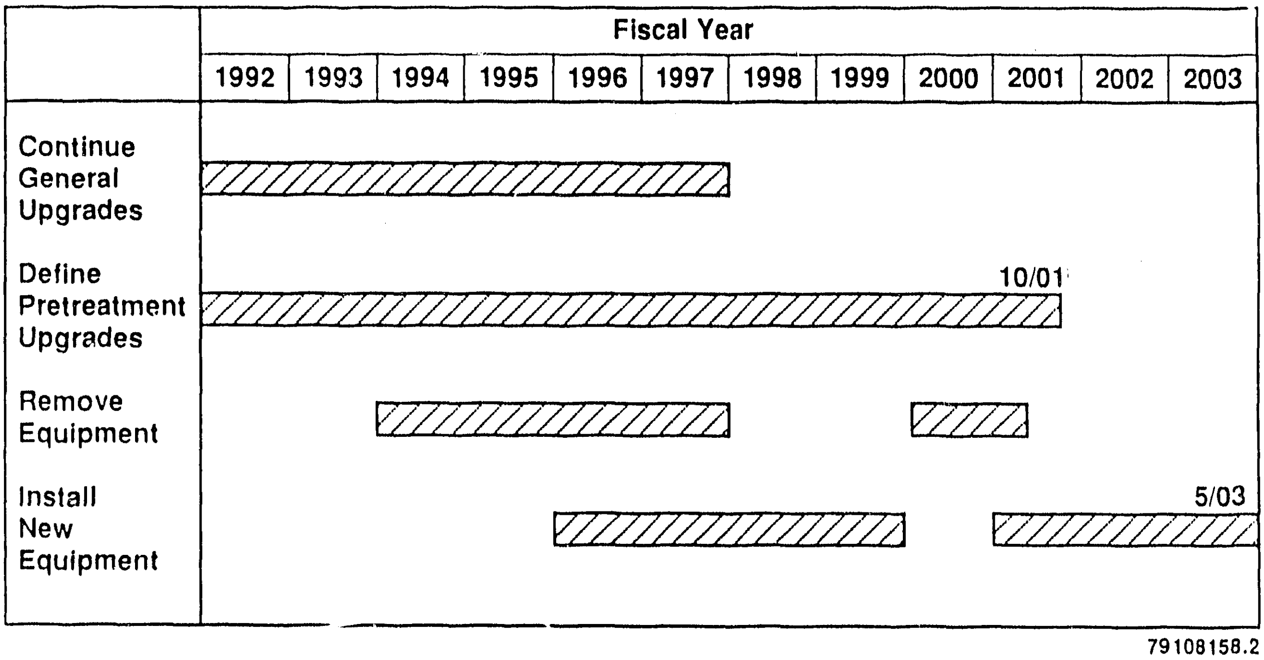


Table 6-7. Estimated Costs of Plutonium-Uranium Extraction Plant Upgrades.

Upgrade description	Estimated cost (millions of FY 1991 $)
General support and regulatory compliance	200 to 400
Pretreatment equipment	250
Sludge wash equipment--no transuranic extraction	230

6.5.2.6.2 Description. Table 6-8 lists important features of three candidate HWVP pretreatment facility alternatives. Two of these alternatives (alternatives 1 and 3) involve installing pretreatment equipment and processes in an expansion of the currently planned HWVP canyon building. Alternative 2 involves installing such pretreatment equipment in a new separate building constructed adjacent to the planned HWVP canyon (HWVP annex). The full set of sludge-washing pretreatment processes would be performed in HWVP alternatives 1 and 2; only filtration and cesium ion exchange operations would be performed in HWVP alternative 3.

Table 6-8. Hanford Waste Vitrification Plant Waste Pretreatment Alternatives.

HWVP alternative[b]	Pretreatment facility	Pretreatment processes performed[a]			
		Solid-liquid separation	Solid washing	Cesium ion exchange	Organic destruction
1	HWVP integrated canyon	X	X	X	X
2	HWVP annex	X	X	X	X
3	HWVP (cesium ion exchange)	X		X	

[a]Blanks indicate pretreatment process not performed.
[b]For identification only.
HWVP = Hanford Waste Vitrification Plant.

In all three HWVP alternatives, all pretreatment operations would be performed in a canyon facility except for lag storage of spent sludge washes and collection of LLW, which would utilize underground DSTs. Also, all HWVP pretreatment alternatives assume that two new DSTs in a new tank farm located near the HWVP will be available for lag storage of DST wastes for feed to the pretreatment process.

Figures 6-19, 6-20, and 6-21 illustrate proposed pretreatment equipment configurations for HWVP alternatives 1, 2, and 3, respectively.

6.5.2.6.3 HWVP Pretreatment Facility Costs. Table 6-9 lists the estimated costs of designing, constructing, and equipping each of the three HWVP pretreatment facility alternatives. The estimated impact to the present hot radioactive startup schedule for vitrification (December 1999) also is shown.

Table 6-9. Estimated Costs and Schedules for Hanford Waste Vitrification Plant Pretreatment Facilities.

Hanford Waste Vitrification Plant alternative[a]	Estimated cost (millions of $) for facility[b]	Hanford Waste Vitrification Plant schedule impacts (months)[c]
1	415	+24
2	660	+24[d]
3	210	+15

[a]See Table 6-8 for description.
[b]Fiscal year 1991 dollars, includes contingency
[c]Impact (months) to December 1999 startup schedule.
[d]Hanford Waste Vitrification Plant vitrification startup remains December 1999; pretreatment annex startup is estimated to occur December 2001 (data are preconceptual).

6.5.2.7 New Pretreatment Facilities.

6.5.2.7.1 Introduction. Construction of a new facility (process facility and supporting buildings) in either the 200 East or 200 West Areas of the Hanford Site would provide maximum flexibility in selection and operation of waste pretreatment operations. Suitably sized, such a facility would permit pretreatment of wastes retrieved from all or a selected number of DSTs and SSTs. Again, by design choice, a new pretreatment facility (NPF) would permit both reference and, if desired or necessary, advanced pretreatment operations (Section 6.4.5) to be performed.

6.5.2.7.2 Description. Table 6-10 lists the characteristics of 10 different candidate NPFs that might be designed and constructed. These 10 choices are sized to accomplish pretreatment of waste, ranging in volume from only 10 DSTs to the total inventory (177 tanks) of DST and SST waste. However, as discussed in Section 6.5.2.2.3, the TRUEX E and SW E facilities are used for comparison purposes in this study as the reference facilities for pretreatment of the 10 DST wastes, and the TRUEX A facility is used as the reference facility for pretreatment of all SST and DST wastes.

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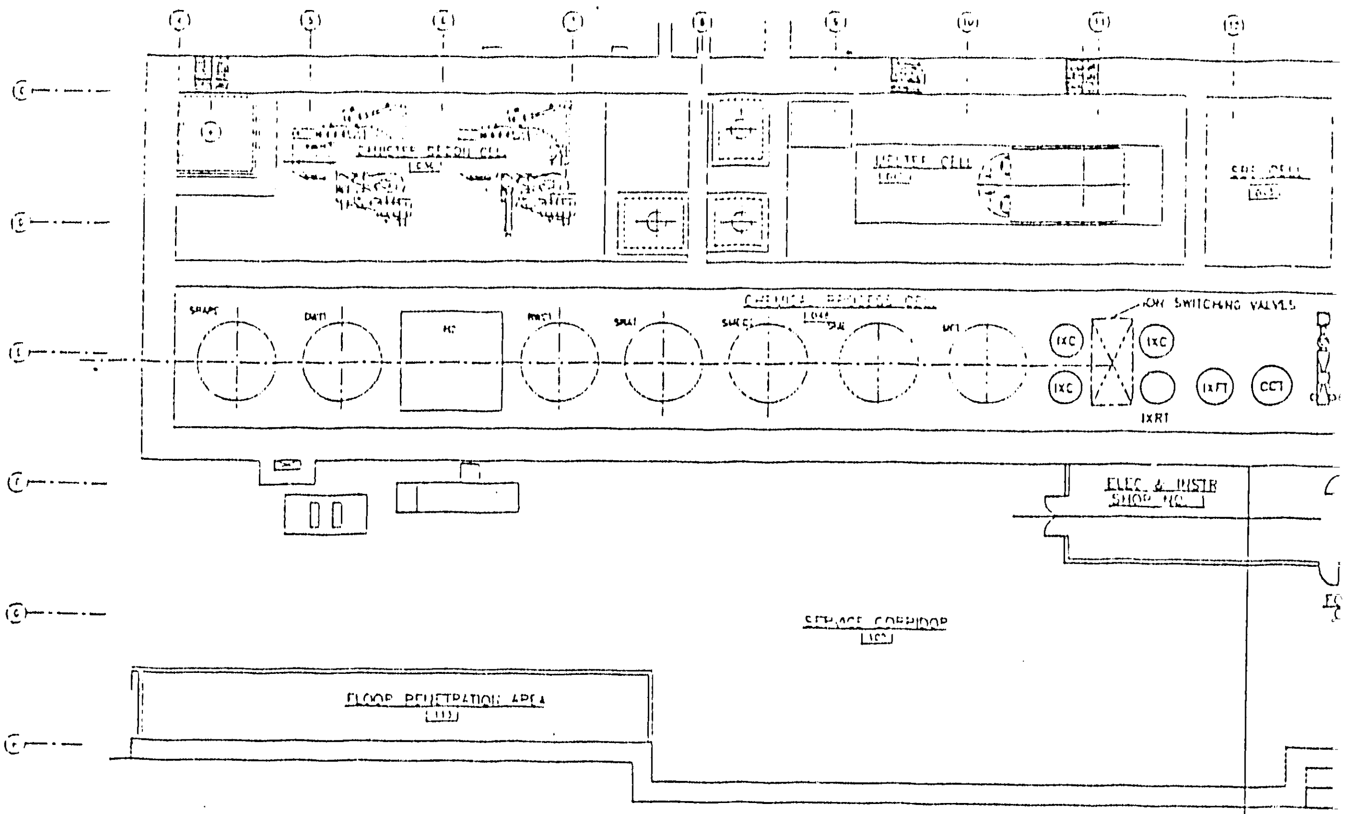


TANK NAMES & SIZES

OOT - ORGANICS DESTRUCTION TANK - 22' DIA. X 19'
WSD - WASH/SETTLE/DECANT TANK - 22' DIA. X 19'
SFT - SLURRY FEED TANK - 16' DIA. X 19'
PFT - PRECOAT FEED TANK - 6' DIA. X 8'-6"
IXFT - ION EXCH[illegible] FEED TANK - 5'-0" DIA. X 6'
CCT - CONCENT[illegible]D CAUSTIC TANK - 3' DIA. X 6'
IXC - ION EXCHANGE COLUMN - 4'-0" DIA. X 21'
SRHT - SPENT RESIN HOLDING TANK - 11' DIA. X 11'
IXRT - ION EXCHANGE REGENERATION TANK - 5' DIA. X 5'
WAT - WASTE ADJUSTMENT TANK - 25' DIA. X 13'
CPST - CESIUM PRODUCT STORAGE TANK - 5'-0" DIA. X 4'
OGE - OFF-GAS EQUIPMENT
SEC - SPENT ELUENT CONCENTRATOR - 8'-0" DIA. X 11'
REC - RECYCLED ELUENT CONCENTRATOR - 12'-0" DIA. X 13'
EMT - ELUENT MAKE-UP TANK - 12'-0" DIA. X 13'

GENERAL NOTES:

1. THE OOT, WSD'S, & SFT'S ARE TO BE FIXED IN PLACE WITH HARD PIPED UTILITY CONNECTIONS. ALL OTHER IN-CELL TANKS ARE TO BE REMOTELY REMOVABLE.
2. OTHER EQUIPMENT REQUIRING REMOTE REMOVAL INCLUDES:
   - VERTICAL TRANSFER & SAMPLE PUMPS
   - TANK AGITATORS
   - FILTERS
   - SWITCHING VALVES
   - ION EXCHANGE COLUMNS
   - TANK HEATING & COOLING COILS
   - SUPERNATANT COOLERS
3. ARRANGEMENT SHOWN IS A NON SEGMENTED CELL W/O COVER BLOCKS
4. EQUIPMENT REMOVAL IS BY OVERHEAD BRIDGE MOUNTED CRANE INTO CPC LAYDOWN AREA.
5. EQUIPMENT SIZING IS BASED ON PRETREATING SUFFICIENT VOLUMES OF DILUTE CC WASTE TO SATISFY 220 LBS/HR HWVP GLASS PRODUCTION AT 25 WT% WASTE OXIDE LOADING
6. TWO EXISTING ONE MILLION GAL TANKS OUTSIDE THE PRETREATMENT FACILITY ARE USED FOR RECEIVING RAW WASTE SLURRY AND FOR HOLDING DECANTED SUPERNATANT
7. PHP FILTERS & SUPERNATANT COOLERS ARE MOUNTED ON TOP OF THE SLURRY FEED TANKS
8. DWG. SK-2-91326 (FIRST FLOOR PLAN) SHOWS THE VARIOUS CPC TANK RELOCATIONS AS A RESULT OF THE PRETREATMENT INTEGRATION. THE WAT AND TANKS HAVE BEEN ENLARGED TO ACCOMMODATE THE COMBINED LLW PRODUCTION FROM BOTH HWVP AND PRETREATMENT OPERATIONS. THE LOW LEVELS OF CONTAMINATION IN THESE TANKS PERMITS THEIR RELOCATION FROM THE CPC TO AN OUT OF CELL AREA NEAR THE WYC. THE CPC SPACE VACATED BY THE WAT TANKS IS NOW BEING USED FOR THE PRETREATMENT ION EXCHANGE SYSTEM
9. LLW IS TRANSFERRED FROM THE WATS TO AN UNDERGROUND WASTE HOLD TANK LOCATED OUTSIDE THE PRETREATMENT FACILITY

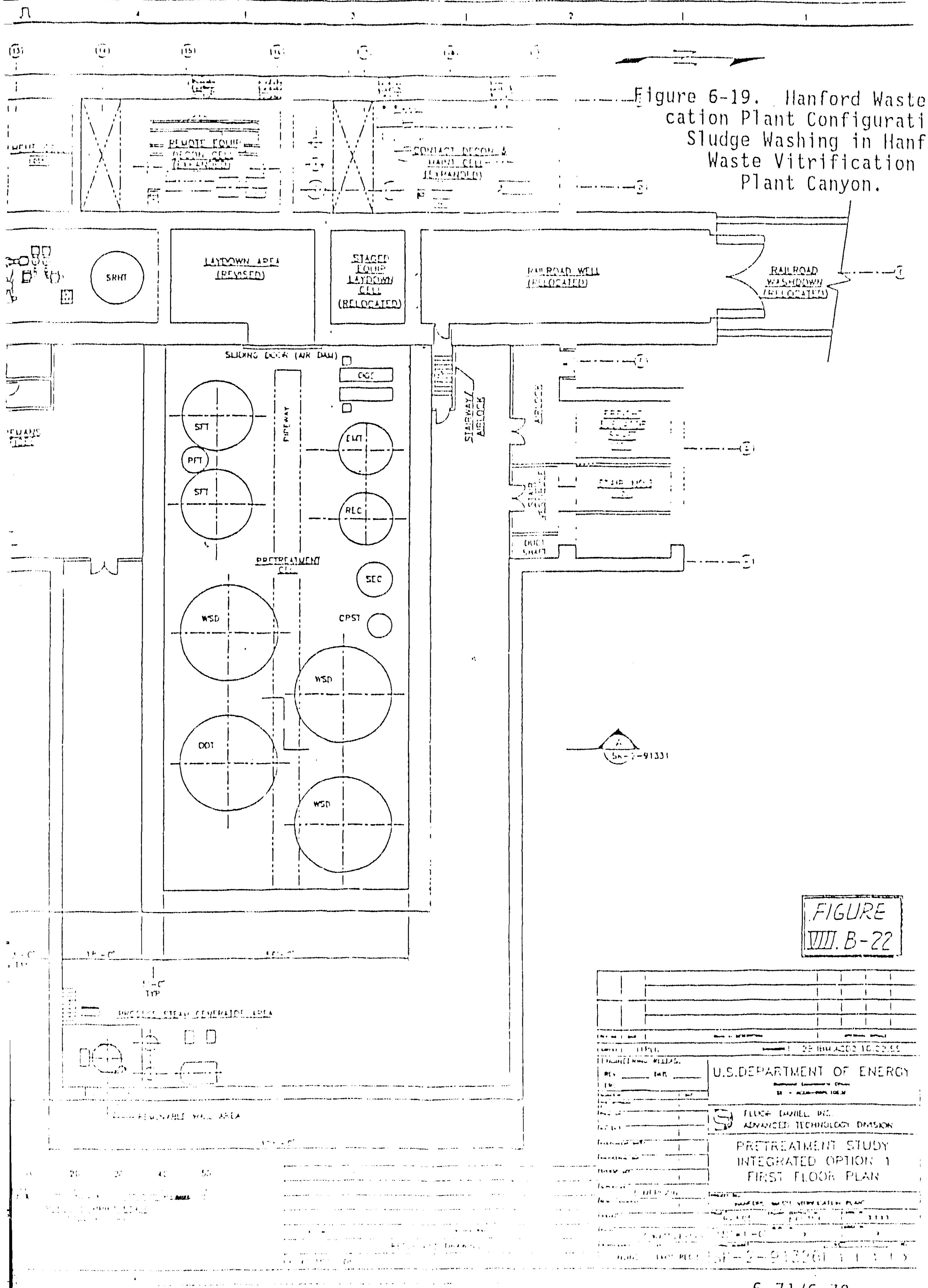
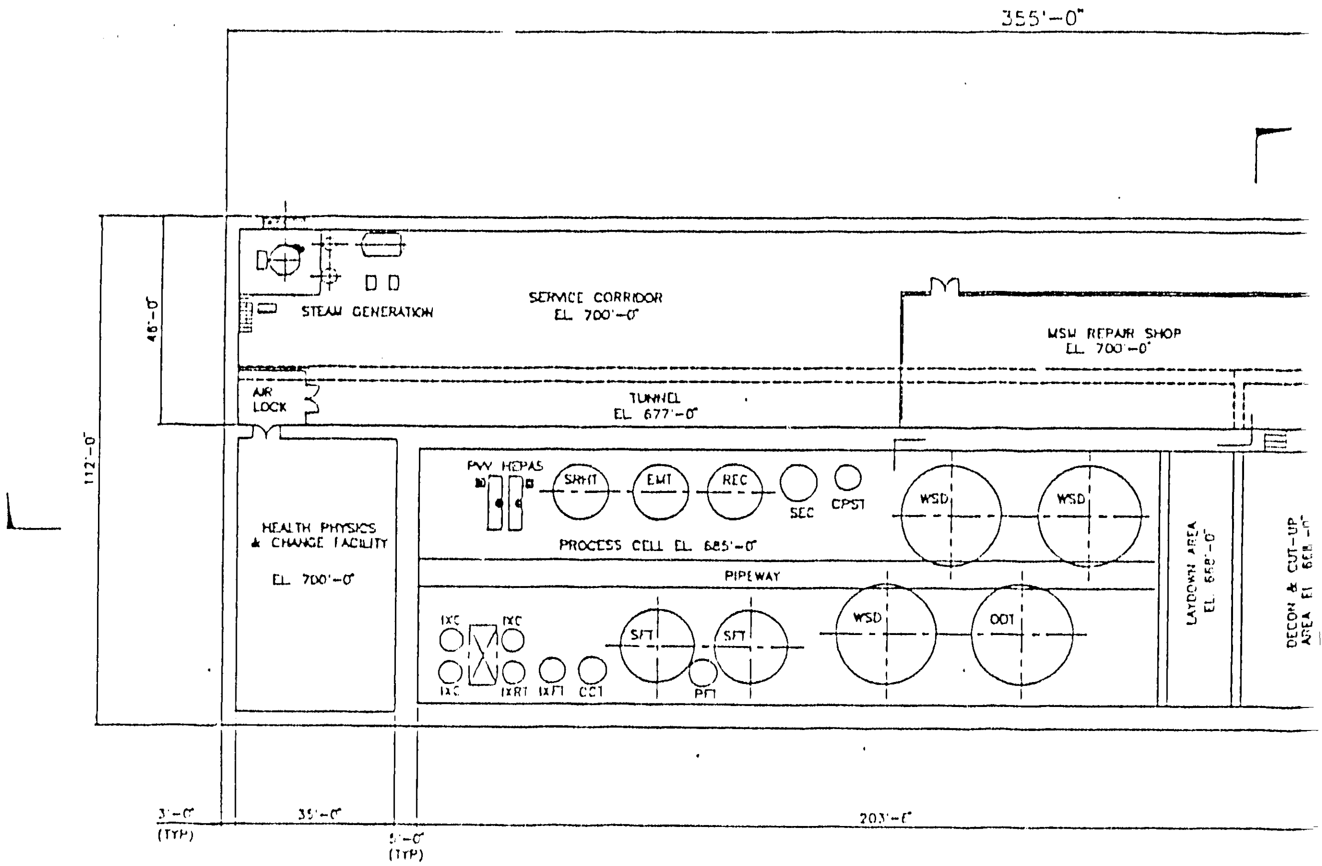


Figure 6-19. Hanford Waste Vitrification Plant Configuration for Sludge Washing in Hanford Waste Vitrification Plant Canyon.

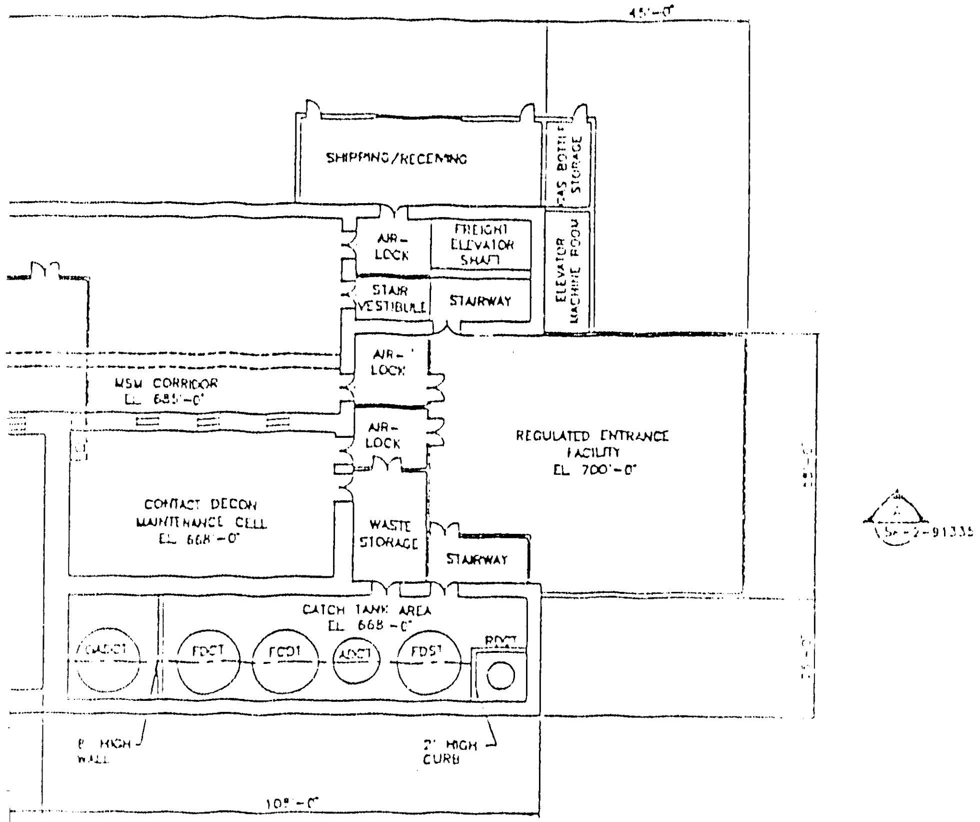


TANK NAMES & SIZES

ODT - ORGANICS DESTRUCTION TANK - 22' DIA. X 19'
WSD - WASH/SETTLE/DECANT TANK - 22' DIA. X 19'
SFT - SLURRY FEED TANK - 16' DIA. X 19'
PFT - PRECOAT FEED TANK - 6' DIA. X 8'-0"
IXFT - ION EXCHANGE FEED TANK - 5'-0" DIA. X 6'
CCT - CONCENTRATED CAUSTIC TANK - 3' DIA. X 6'
IXC - ION EXCHANGE COLUMN - 4'-0" DIA. X 21'
SRHT - SPENT RESIN HOLDING TANK - 11' DIA. X 11'
IXRT - ION EXCHANGE REGENERATION TANK - 5' DIA. X 5'
WAT - WASTE ADJUSTMENT TANK - 25' DIA. X 13'
CPST - CESIUM PRODUCT STORAGE TANK - 5'-0" DIA. X 4'
OGE - OFF-GAS EQUIPMENT
SEC - SPENT ELUENT CONCENTRATOR - 8'-0" DIA. X 11'
REC - RECYCLED ELUENT CONCENTRATOR - 12'-0" DIA. X 12'
EMT - ELUENT MAKE-UP TANK - 12'-0" DIA. X 13'
OADCT - ORGANIC ACID DRAIN CATCH TANK 15' DIA. X 14'
FDCT - FLOOR DRAIN CATCH TANK (2) 18' DIA. X 17'
FDST - FLOOR DRAIN SAMPLING TANK 14' DIA. X 13'
RDCT - REGULATED DRAINS CATCH TANK 5' DIA. X 8'
ADCT - ACID DRAIN CATCH TANK 10' DIA. X 11'

PRETREATMENT BUILDING
BASEMENT & 1ST FLOOR LEVELS

Figure 6-20. Hanford Waste Vitrification Plant Configuration for Sludge Washing in Standalone Annex.



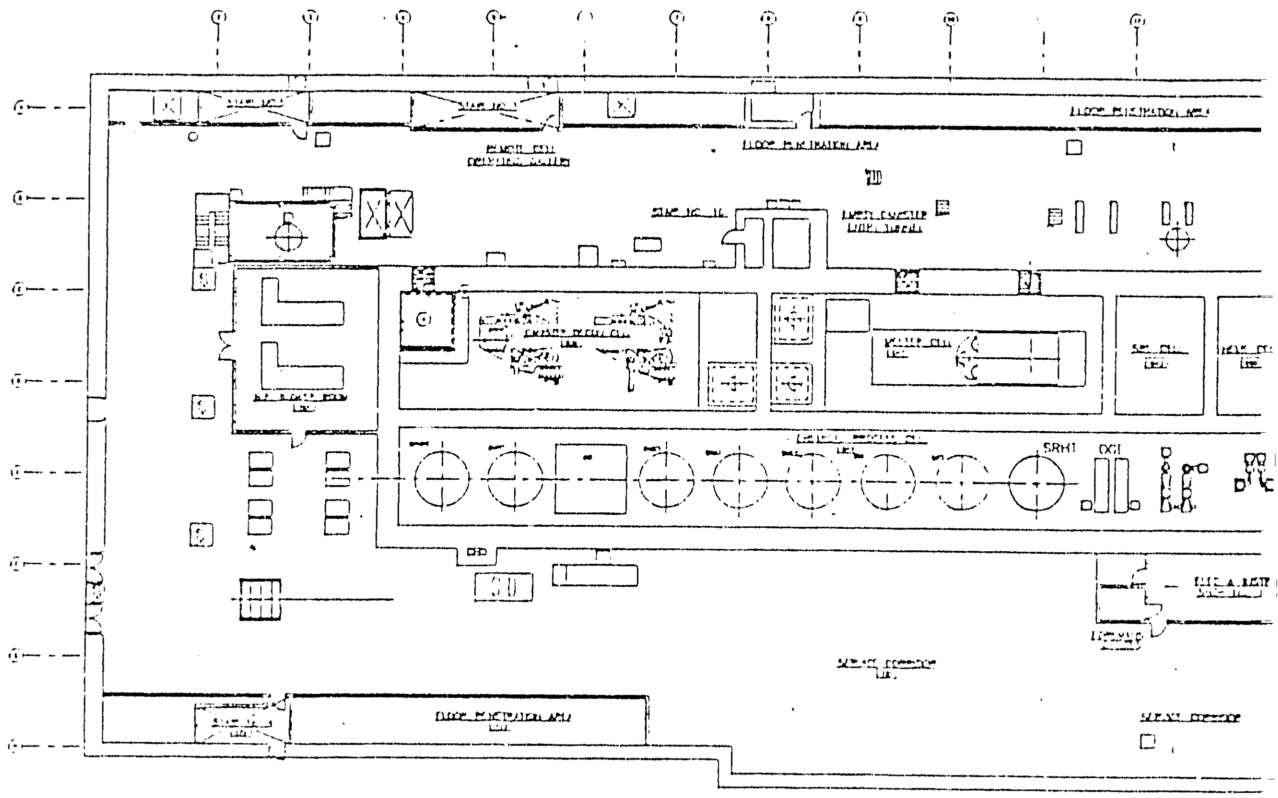
GENERAL NOTES:

1. THE ODT, WSD'S, & SFT'S ARE TO BE FIXED IN PLACE WITH HARD PIPED UTILITY CONNECTIONS. ALL OTHER IN-CELL TANKS ARE TO BE REMOTELY REMOVABLE.
2. OTHER EQUIPMENT REQUIRING REMOTE REMOVAL INCLUDES
   - VERTICAL TRANSFER & SAMPLE PUMPS
   - TANK AGITATORS
   - FILTERS
   - SWITCHING VALVES
   - ION EXCHANGE COLUMNS
   - TANK HEATING & COOLING COILS
   - SUPERNATANT COOLERS
3. ARRANGEMENT SHOWN IS A NON SEGMENTED CELL W/O COVER [illegible]
4. EQUIPMENT REMOVAL IS BY OVERHEAD BRIDGE MOUNTED CRANE [illegible] LAYDOWN AREA
5. EQUIPMENT SIZING IS BASED ON PRETREATING SUFFICIENT VOLUMES OF DILUTE CC WASTE TO SATISFY 220 LBS/HR HWVP GLASS PRODUCTION AT 25 WT% WASTE OXIDE LOADING
6. TWO EXISTING ONE MILLION GAL TANKS OUTSIDE THE PRETREATMENT FACILITY ARE USED FOR RECEIVING RAW WASTE SLURRY AND FOR HOLDING DECANTED SUPERNATANT.
7. [illegible] FILTERS & SUPERNATANT COOLERS ARE MOUNTED ON TOP OF [illegible] SLURRY FEED TANKS
8. [illegible] IS TRANSFERRED FROM THE WAT'S TO AN UNDERGROUND WASTE HOLD TANK LOCATED OUTSIDE THE PRETREATMENT FACILITY

U.S. DEPARTMENT OF ENERGY

FLUOR DANIEL INC.
ADVANCED TECHNOLOGY DIVISION

PRETREATMENT STUDY
ANNEX OPTION 1
BASEMENT & FIRST FLOOR PLAN



TANK NAMES & SIZES

PFT - PRECOAT FEED TANK - 6' DIA. X 8'-6"
IXFT - ION EXCHANGE FEED TANK - 5'-0" DIA. X 6'
CCT - CONCENTRATED CAUSTIC TANK - 3' DIA. X 6'
IXC - ION EXCHANGE COLUMN - 4'-0" DIA. X 21'
SRHT - SPENT RESIN HOLDING TANK - 11' DIA. X 11'
IXRT - ION EXCHANGE REGENERATION TANK - 5' DIA. X 5'
OGE - OFF-GAS EQUIPMENT
SEC - SPENT ELUENT CONCENTRATOR - 8'-0" DIA. X 11'
REC - RECYCLED ELUENT CONCENTRATOR - 12'-0" DIA. X 13'
EMT - ELUENT MAKE-UP TANK - 12'-0" DIA. X 13'
CPST - CESIUM PRODUCT STORAGE TANK - 9'-0" DIA. X 11'
FBT - FILTER BACKWASH TANK - 12'-0" DIA. X 13'
FFT - FILTER FEED TANK - 12'-0" DIA. X 13'

GENERAL NOTES

1. THIS DRAWING SHOWS THE GENERAL IMPACT TO THE HWVP VITRIFICATION BLDG CAUSED BY INCORPORATING THE PRETREATMENT PARTIAL OPTION 2. USE IN CONJUNCTION WITH THE OPTION 2 FUNCTIONAL REQUIREMENTS CHECKLIST SECTION E - PROCESS BLDG. VIT FOR DETERMINING THE TOTAL EXTENT OF BUILDING AND EQUIPMENT MODIFICATIONS REQUIRED.

FIRST FLOOR PLAN - 1/16" = 1'-0"

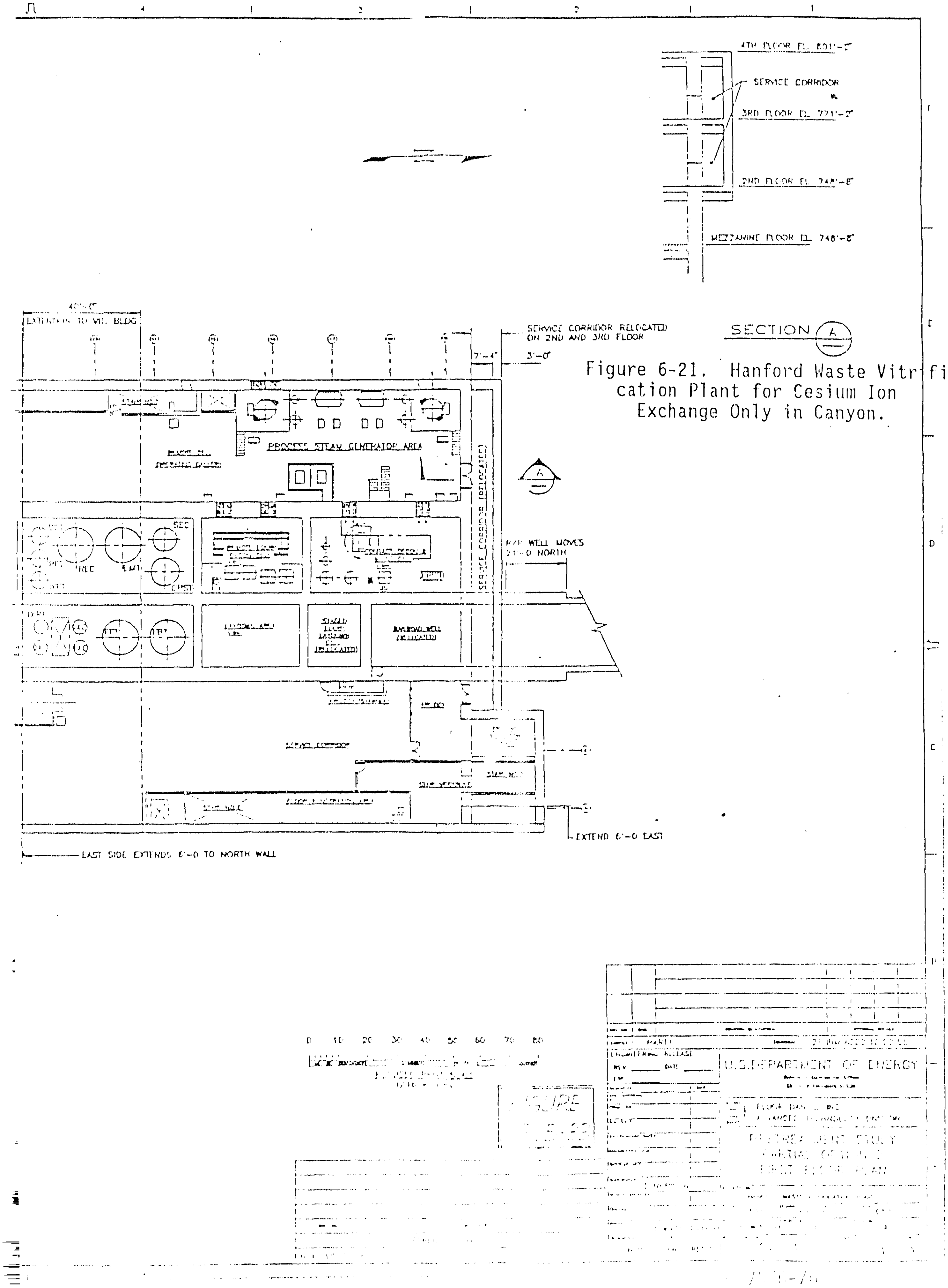


Figure 6-21. Hanford Waste Vitrification Plant for Cesium Ion Exchange Only in Canyon.

Table 6-10. Characteristics of Candidate New Pretreatment Facilities.

NPF designation[a]	Facility length[b] (m)	Number of tanks' waste pretreated		Pretreatment processes used[c,d]				
		DST	SST	Cesium ion exchange	Complexant destruction	Technetium ion exchange	TRUEX process	SREX process
Sludge washing alternative[e]								
SW E	307[g]	10	0	X	X			
SW D	140	10	22	X	X			
SW D'	NA	10	22	X	X	X		
SW B	140	28	149	X	X			
SW C	210	28	149	X	X	X		
TRUEX process alternatives[f]								
TRUEX F	148	28	0	X	X		X	X
TRUEX E'	202	28	0	X	X	X	X	X
TRUEX E	167	28	22	X	X		X	X
TRUEX A	220	28	149	X	X		X	X
TRUEX C	290	28	149	X	X	X	X	X

[a]For identification purposes only.
[b]All NPFs except SW E facility assumed to have the same width.
[c]In all cases, waste pretreatment operations involve solid-liquid separations and sludge washing steps.
[d]Blanks indicate treatment process not performed.
[e]No TRUEX process operation in any of five washing alternatives.
[f]All five TRUEX process alternatives involve operation of the combined TRUEX-SREX process with dissolved waste solids so as to also co-extract ^{99}Tc, ^{90}Sr, and TRU elements.
[g]Single-wide (narrower) canyon than other alternatives.

DST = Double-shell tank
NA = Not available
NPF = New pretreatment facility
SREX = Strontium extraction
SST = Single-shell tank
SW = Sludge wash
TRUEX = Transuranic extraction.

The 10 new facilities are further classified on the basis of the specific waste pretreatment processes that could be performed using either a simple sludge-washing alternative or the more complex TRUEX process alternative. In some cases, the suite of pretreatment processes includes ion exchange removal of ^{99}Tc from alkaline liquid wastes.

In addition to the information in Table 6-10 and in Boomer et al. (1990), the following points concerning the 10 candidate NPFs are worth noting.

- All 10 facilities are capable of separating solids and liquids and washing solids; this capability exceeds any capability in the DSTs.
- With the exception of the SW E facility, all facilities are assumed to have a common layout and width for easy cost comparison. More efficient facility layouts, especially for the smaller plants, are possible, but time limitation in preparing this study didn't allow for optimization of facilities.
- All facilities, with the exception of SW E, consist of a shielded canyon containing a double row of 6.1-m-(20-ft-) wide cells separated by a connecting pipe trench. The SW E facility contains a single row of cells, each 6.1-m (20-ft) wide. Three gallery levels surround the canyons. The bottom gallery contains storage areas and hot shops while the middle gallery contains shielded analytical facilities and some service piping to the canyon. The upper gallery contains the majority of the nonradioactive piping to the canyon and closed loop heating and cooling systems.
- Process control rooms, office areas, changerooms, switchgear rooms, and shops are all located on one side of each facility. The exhaust filters, blowers, and stack are located on the other side of the facility.
- Each facility is provided with six 3.79×10^6 L storage tanks for receipt of waste for pretreatment or for storage of processed wastes.
- Figures 6-22 and 6-23 present preliminary canyon pretreatment layouts for the TRUEX E and SW E facilities. Additional facility layouts for the pretreatment facility alternatives also are shown in Appendix G.

Anion exchange technology (see Section 6.4.5.1) would be used in four of the NPF alternatives (see Table 6-10) to remove ^{99}Tc from alkaline liquid wastes, if deemed necessary or required by new environmental regulations. Sorbed ^{99}Tc would be eluted with a HNO_3 solution. Each of the four NPF alternatives would be outfitted with acid fractionation equipment to recover and recycle HNO_3.

As noted in Table 6-10, in all five TRUEX process alternatives, a combined TRUEX-SREX process would be operated to remove TRU elements, as well as ^{90}Sr, from dissolved sludge fractions.

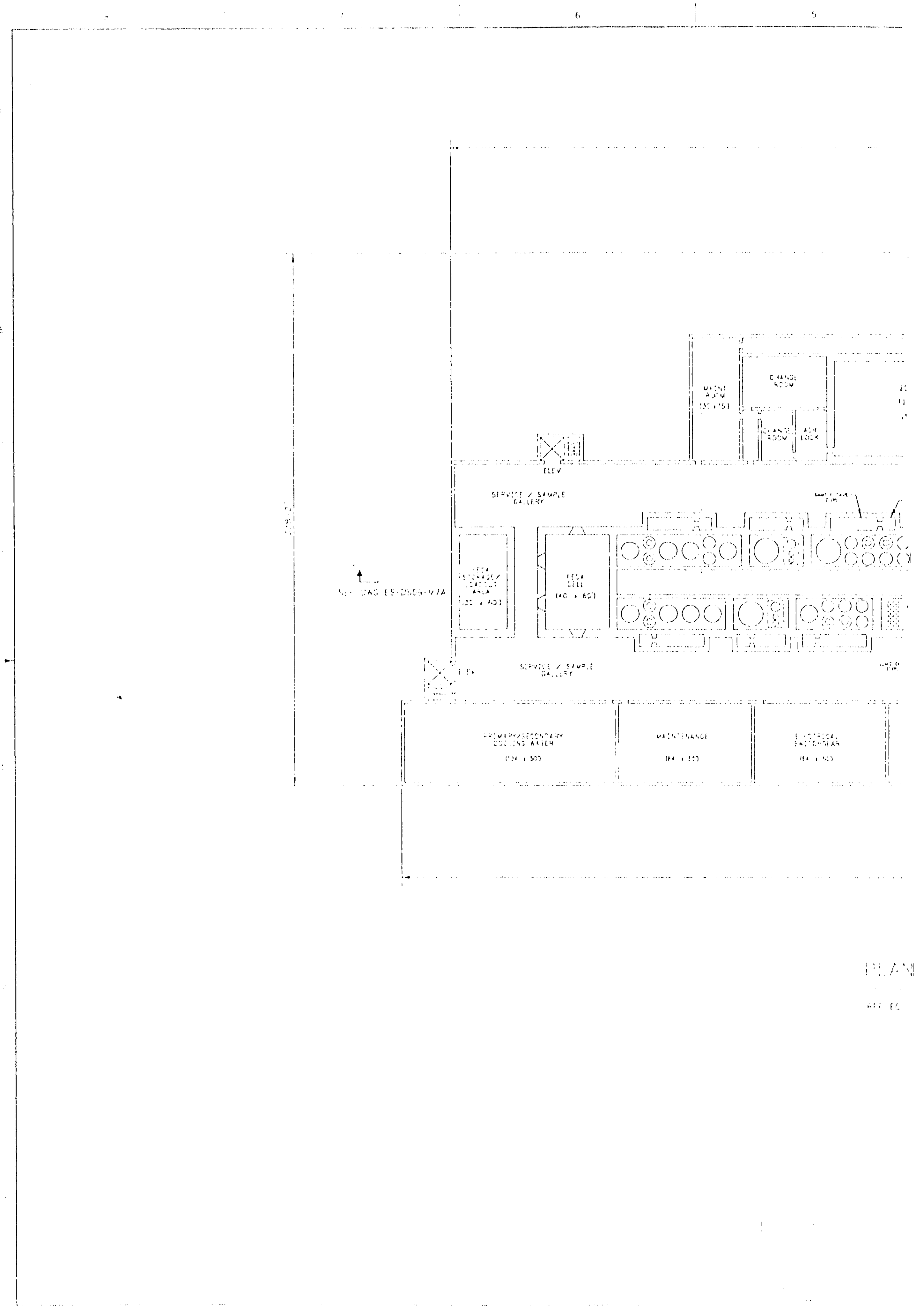
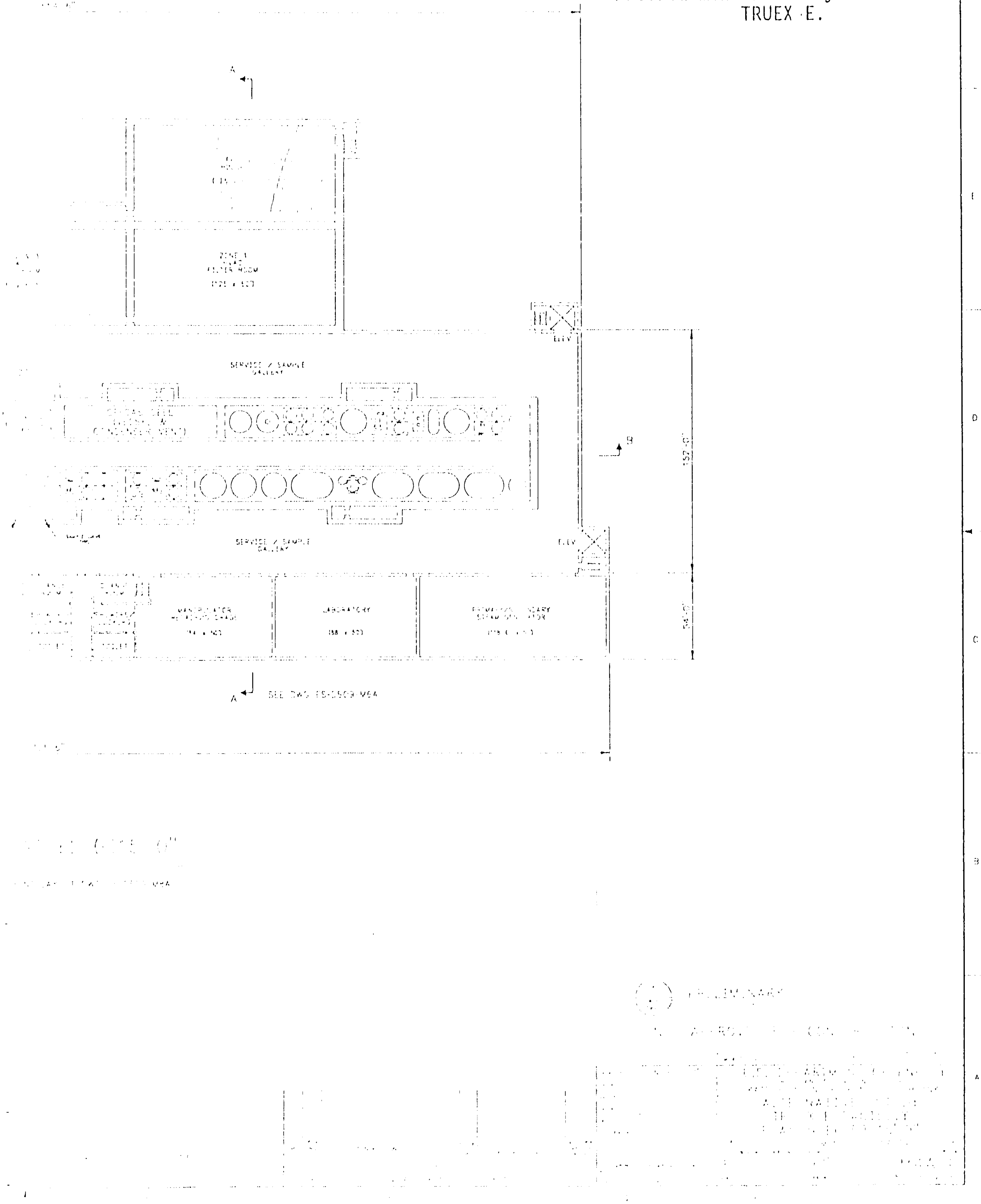
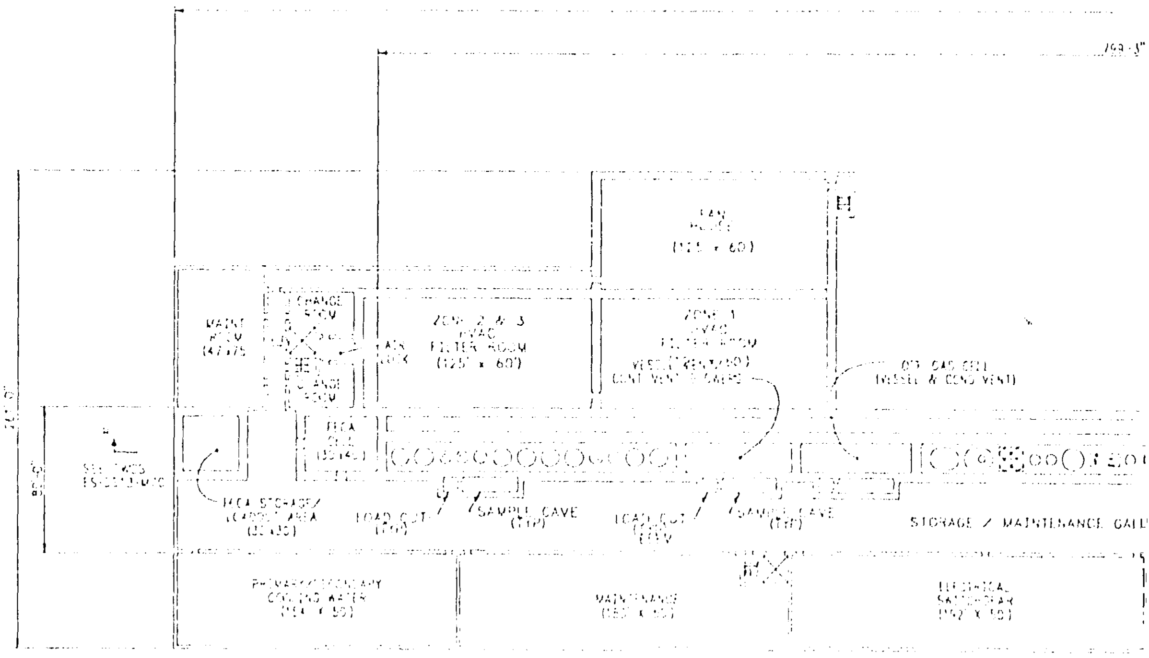

6
5
CHANGE ROOM
CHANGE ROOM
AIR LOCK
ELEV
SERVICE / SAMPLE GALLERY
(40 x 60)
ELEV
SERVICE / SAMPLE GALLERY
PRIMARY/SECONDARY COOLING WATER
MAINTENANCE
ELECTRICAL SWITCHGEAR

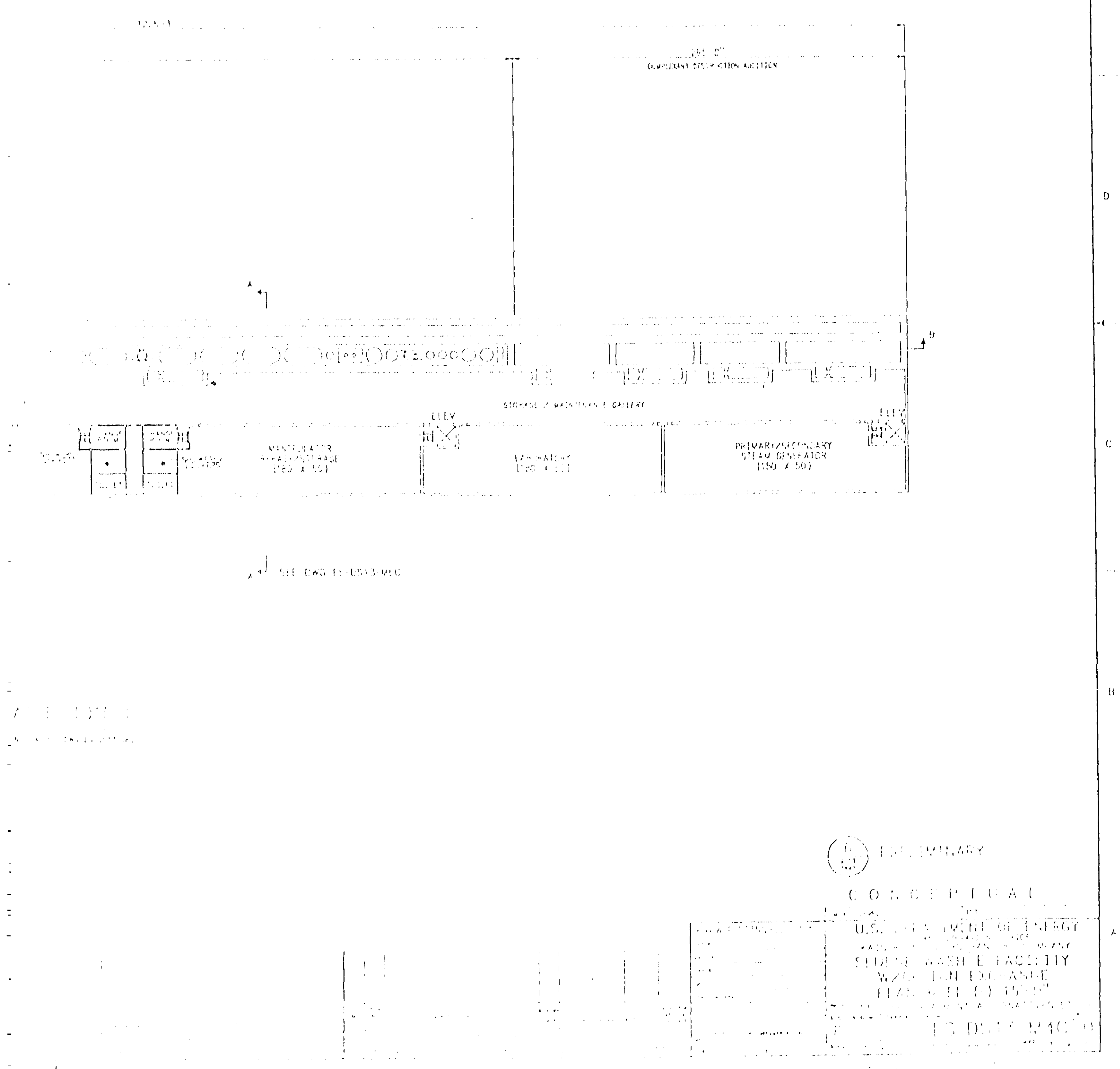
Figure 6-22. Canyon Layout for New Pretreatment Facility Alternative TRUEX E.




CHANGE ROOM
ZONE 2 & 3
HVAC
FILTER ROOM
(125' x 60')
SAMPLE CAVE
(TYP)
STORAGE / MAINTENANCE GALL
ELECTRICAL
SWITCHGEAR

PLAN

Figure 6-23. Canyon Layout for New Pretreatment Alternative Sludge Wash E.



6.5.2.7.3 Costs and Schedules for New Pretreatment Facilities. Table 6-11 summarizes estimated costs of designing, constructing, and equipping the 10 NPF alternatives. These costs are preliminary and do not include those for many auxiliary buildings and systems. Figures 6-24 and 6-25 show preliminary project schedules for TRUEX E and SW E facilities, respectively.

Table 6-11. Estimated Costs of New Pretreatment Facilities.

Facility[a]	Estimated cost (billions of $)[b]
SW E	1.3
SW D	1.4
SW D'	cost not estimated
SW B	1.3
SW C	1.7
TRUEX F	1.5
TRUEX E'	2.0
TRUEX E	1.7
TRUEX A	1.8
TRUEX C	2.5

[a]See Table 6-10 for characteristics of these facilities.
[b]Costs are fiscal year 1991 dollars; includes contingency.
TRUEX = Transuranic extraction.

6.5.2.8 Alternative Pretreatment Facility Design Concepts. Many facility design concepts and features have been used at existing United States and foreign nuclear and/or chemical processing facilities. This section discusses facility design concepts and features that could be used for an NPF.

The design features and concepts used in processing facility designs are based primarily on the maintenance philosophy. The identified maintenance philosophies are (1) crane-remote, (2) manipulator-remote, (3) contact or hands-on maintenance, and (4) minimum maintenance (i.e., inherently reliable design). Both remote maintenance concepts (1 and 2) are principally for installation and removal of equipment in the cells.

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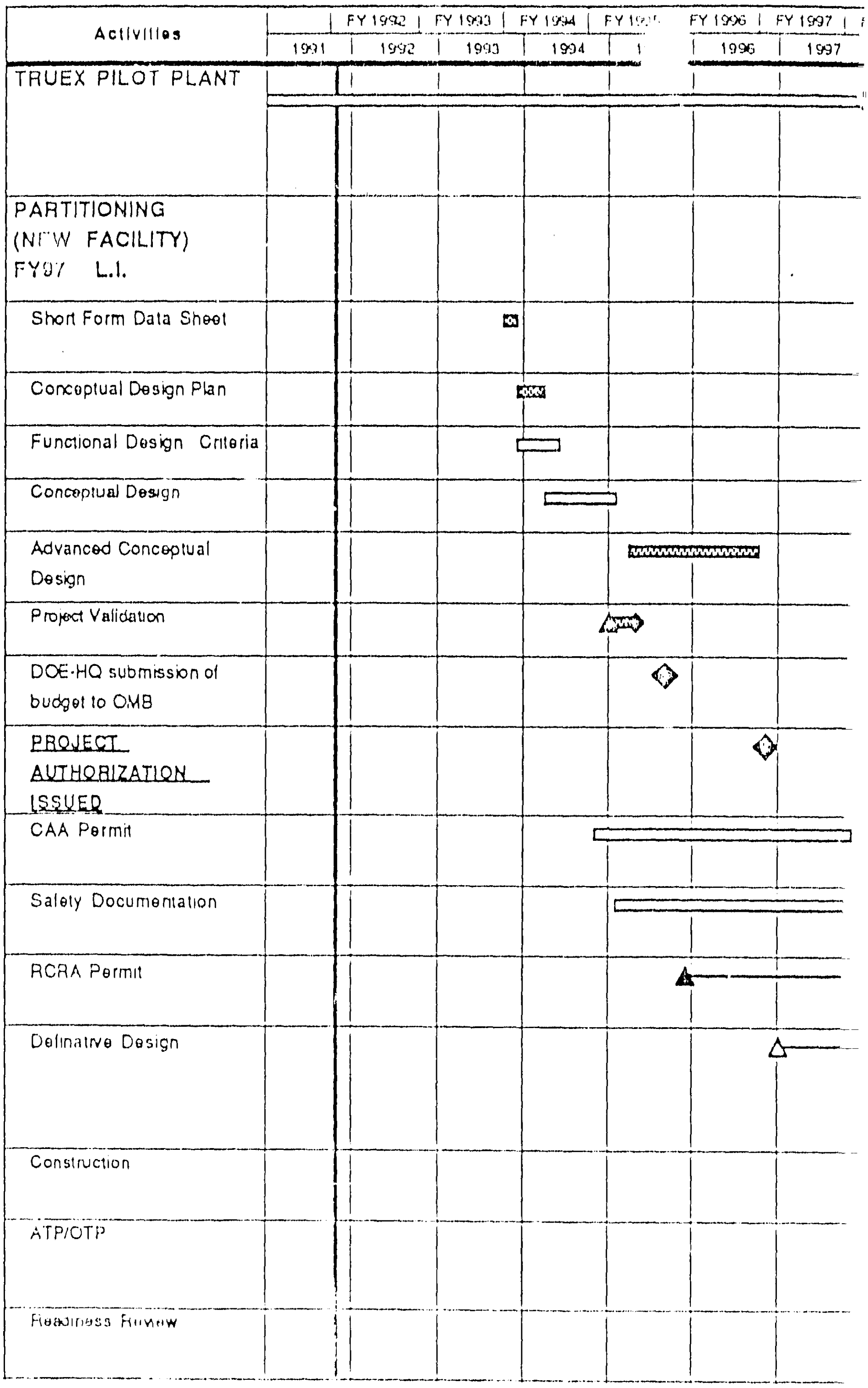
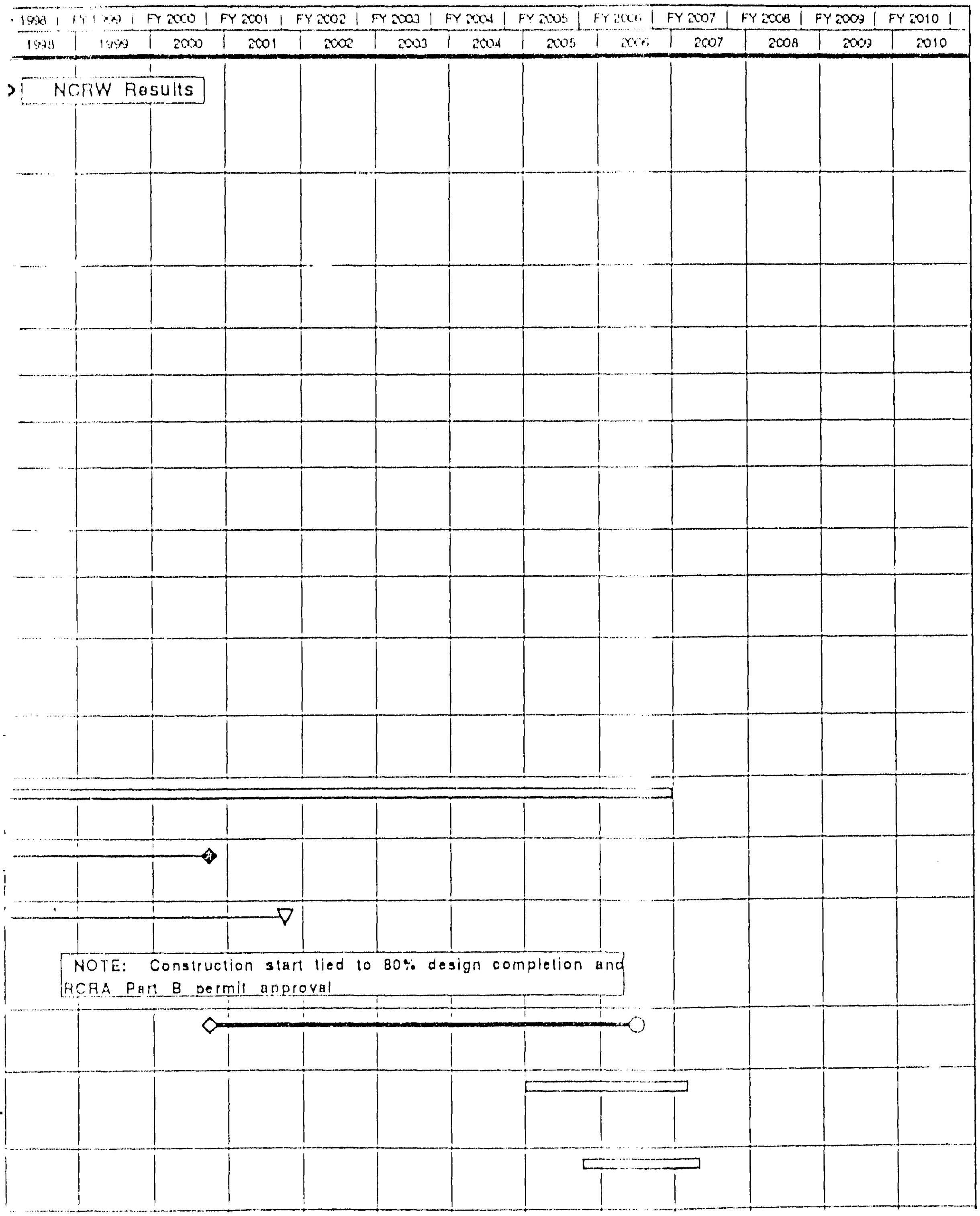

Activities
FY 1992
FY 1993
FY 1994
FY 1996
FY 1997
1991
1992
1993
1994
1996
1997
TRUEX PILOT PLANT
PARTITIONING
(NEW FACILITY)
FY97 L.I.
Short Form Data Sheet
Conceptual Design Plan
Functional Design Criteria
Conceptual Design
Advanced Conceptual Design
Project Validation
DOE-HQ submission of budget to OMB
PROJECT AUTHORIZATION ISSUED
CAA Permit
Safety Documentation
RCRA Permit
Definative Design
Construction
ATP/OTP
Readiness Review

Figure 6-24. Project Schedule for New Pretreatment Facility Alternative TRUEX E.



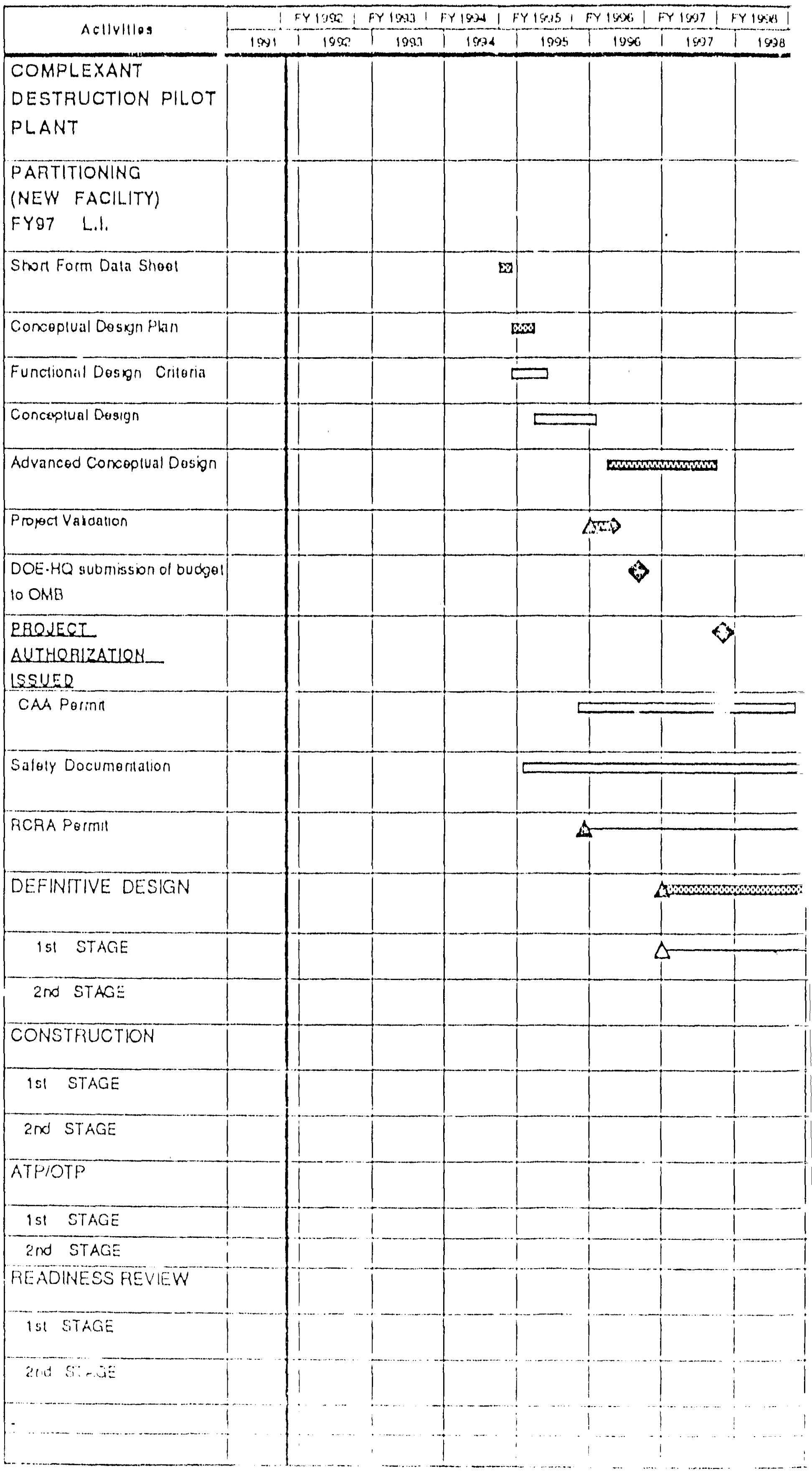
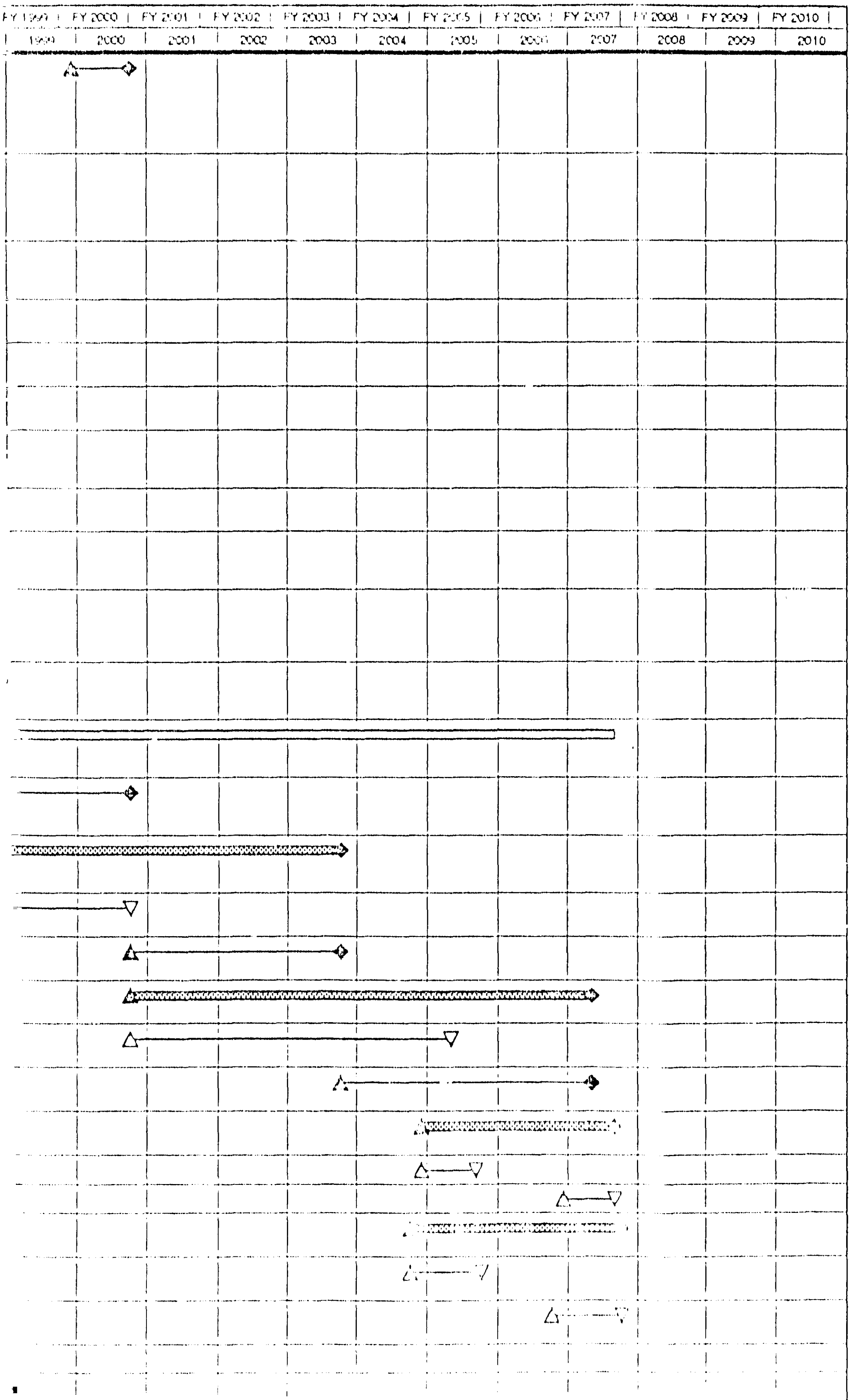

Activities
FY 1992
FY 1993
FY 1994
FY 1995
FY 1996
FY 1997
FY 1998
1991
1992
1993
1994
1995
1996
1997
1998
COMPLEXANT DESTRUCTION PILOT PLANT
PARTITIONING (NEW FACILITY) FY97 L.I.
Short Form Data Sheet
Conceptual Design Plan
Functional Design Criteria
Conceptual Design
Advanced Conceptual Design
Project Validation
DOE-HQ submission of budget to OMB
PROJECT AUTHORIZATION ISSUED
CAA Permit
Safety Documentation
RCRA Permit
DEFINITIVE DESIGN
1st STAGE
2nd STAGE
CONSTRUCTION
1st STAGE
2nd STAGE
ATP/OTP
1st STAGE
2nd STAGE
READINESS REVIEW
1st STAGE

Figure 6-25. Project Schedule for New Pretreatment Facility Alternative Sludge Wash E.



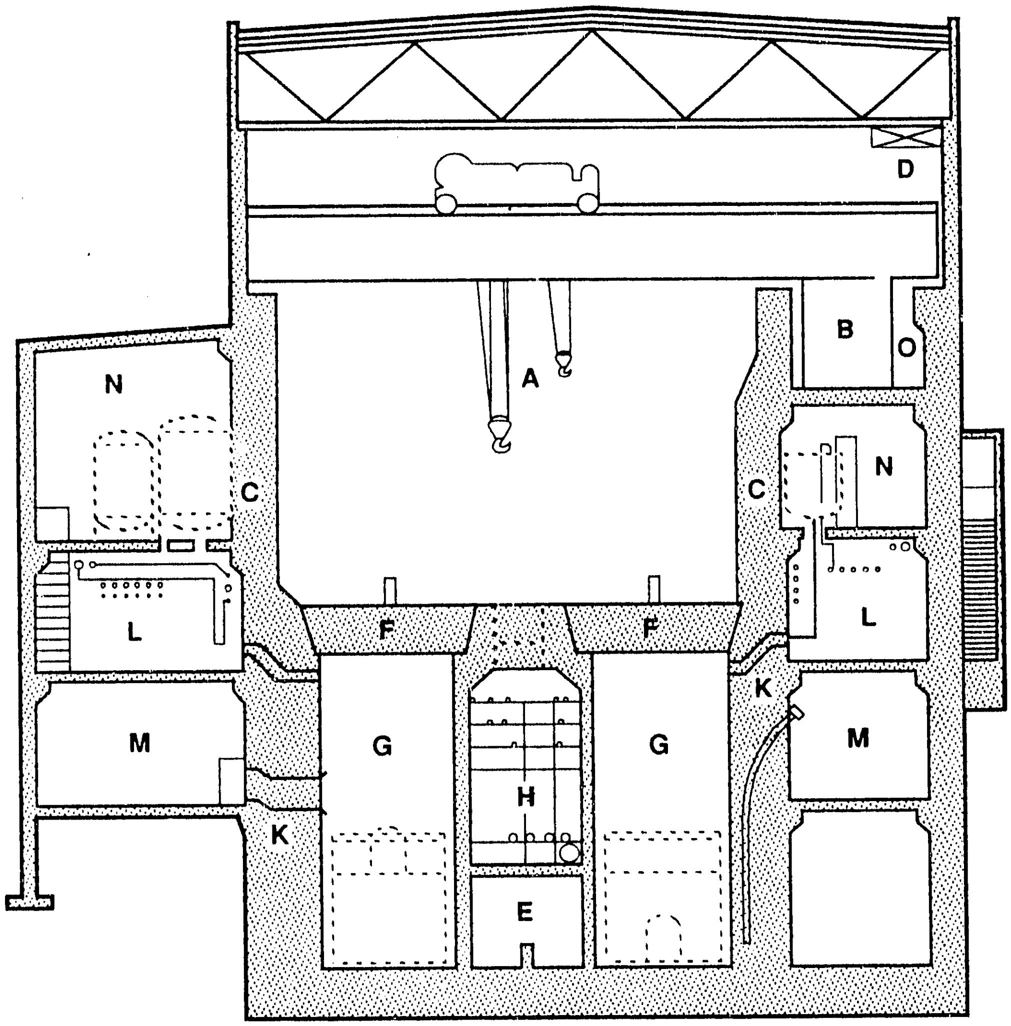
Crane-remote maintenance is characterized by a crane bay located above chemical process cells. Special pipe and electrical connectors and tools are used with a crane to install and remove equipment. In a crane-remote facility, radioactive and nonradioactive piping are located in separate pipeways or galleries parallel to the process cells. Crane-remote facilities have become known as "canyon" facilities.

The original crane-remote facilities (e.g., B Plant) that were developed at the Hanford Site during World War II have a single row of cells located below a crane bay (Figure 6-12). Second generation facilities [e.g., Reduction-Oxidation (REDOX) Plant] have two parallel rows of cells (Figure 6-26) (Yoder et al. 1979), thus reducing the facility length. Both of these facility concepts are very flexible because both equipment and chemistry can be changed to accommodate new and evolving operating requirements. For instance, B Plant has been reconfigured to satisfy three different missions. Contamination control can be a problem because of leakage from the many mechanical pipe connectors. Crane maintenance is a major source of radiation uptake in these facilities. The NPF alternatives discussed in the previous section are crane-remote type facilities.

The processing facilities built at the Savannah River Site (Yoder et al. 1979) in the 1950's are a variation of the original crane-remote facilities built at the Hanford Site (Figure 6-27). The major variation is that these facilities have two parallel crane bays. All other characteristics of the Hanford Site crane-remote facilities were retained. One crane bay (i.e., the hot canyon) contains all the highly radioactive processes. The other bay (i.e., the warm canyon) contains the low activity processes. Because of the low-level radioactivity, the warm canyon doesn't require as much shielding as the hot canyon.

Some processing facilities use manipulators to perform maintenance. The fuel processing plant built by Eurochemic, a European consortium, in Mol, Belgium, is a classic example. All the process equipment is in two large hot cells (one directly above the other). This arrangement will be called a "great room" facility. In this type of facility, the valves, pumps, and other high-maintenance items are located near the walls where manipulators can easily remove and replace them. Highly reliable equipment is in the center of the room; this equipment may require other equipment to be removed or actual entrance into the cell to perform maintenance. A "great room" facility has a low construction cost and results in low radiation exposure of personnel. This concept, however, would have difficulty in satisfying seismic requirements. Implementation would require additional walls or other reinforcement. These changes effectively convert the facility into a more standard hot-cell facility. The Fuel and Materials Examination Facility at the Hanford Site is a small-scale "great room" facility that has been seismically qualified (Figure 6-28). An alternative to the "great room" concept would be to place the equipment in several small hot cells equipped with manipulators. The Hot Fuel Examination Facility--South (Yoder et al. 1979), which is part of the EBR-II complex at Idaho Nuclear Engineering Laboratory, was based on a circular hot cell concept (Figure 6-29).

Figure 6-26. Reduction-Oxidation Plant Cross Section.



A = Crane
B = Crane cab
C = Shielding wall
D = Ventilation air inlet duct
E = Ventilation air exhaust tunnel
F = Cover blocks
G = P· ɔcess cells
H = Pipe tunnel
I = Process equipment
J = Service piping
L = Pipe gallery
M = Sample gallery
N = Operating gallery and aqueous Make-up facilities
O = Crane cab gallery

79110010.3

Figure 6-27. Parallel Canyons (221-F).

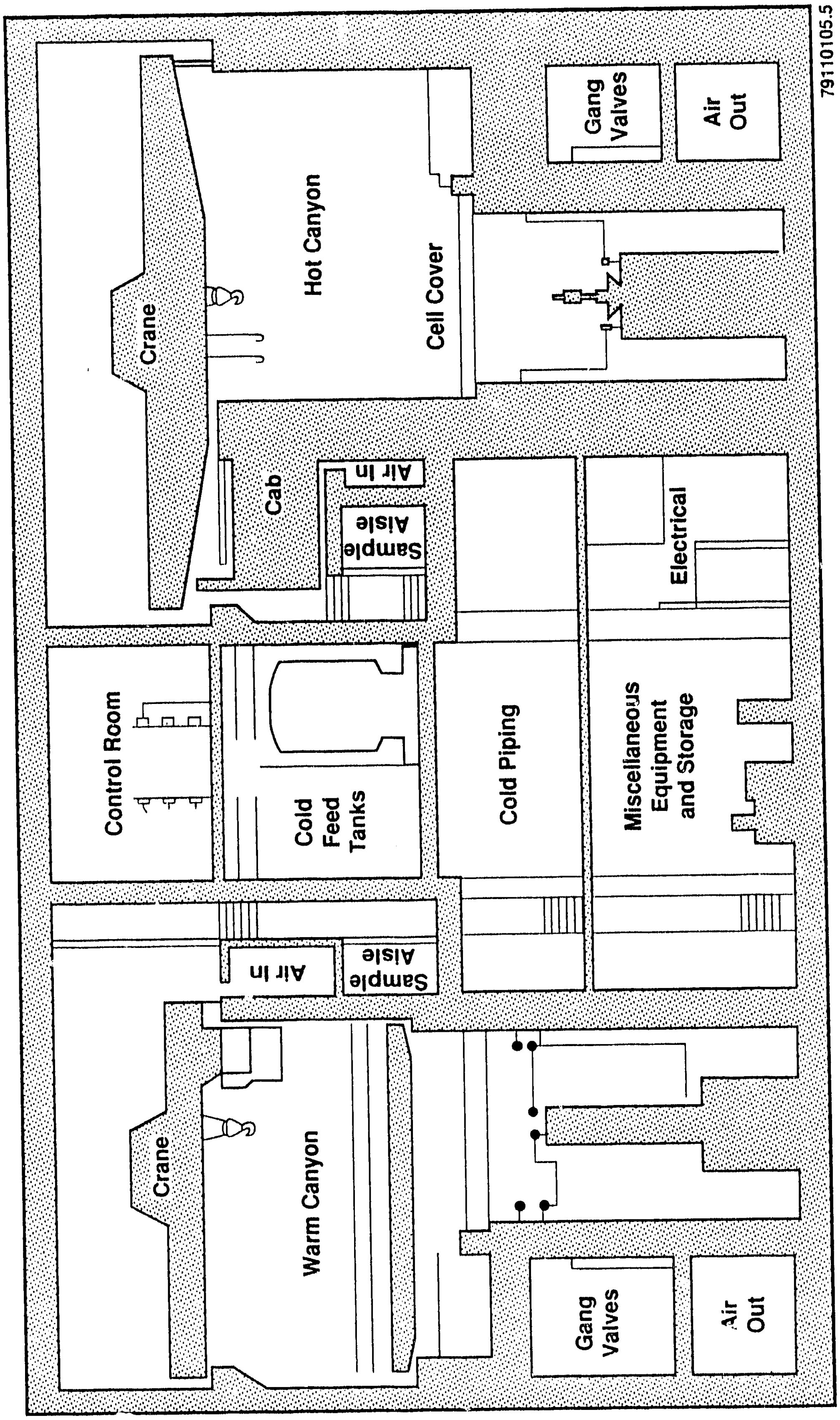


Figure 6-28. Fuel and Material Examination Facility.

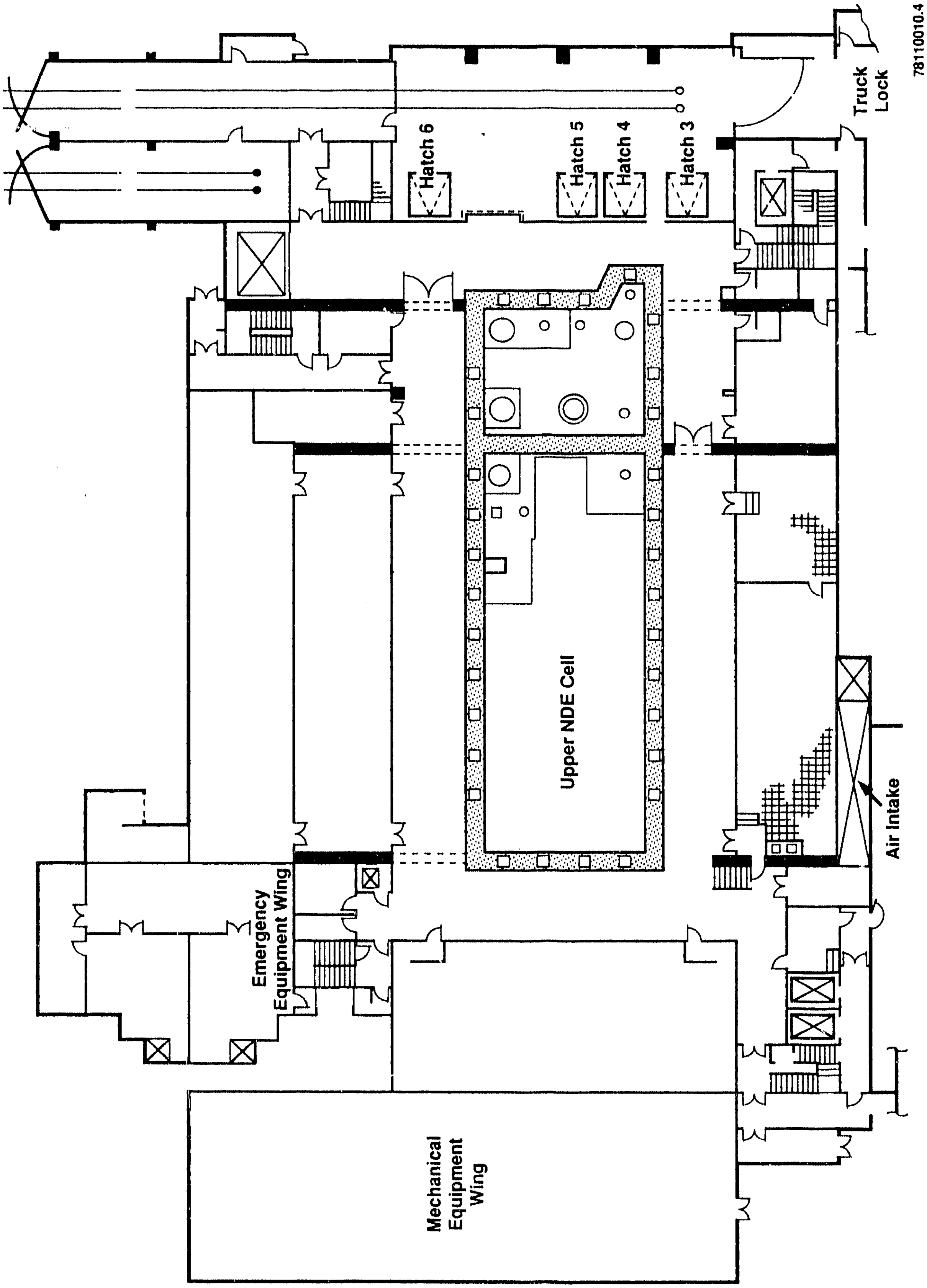
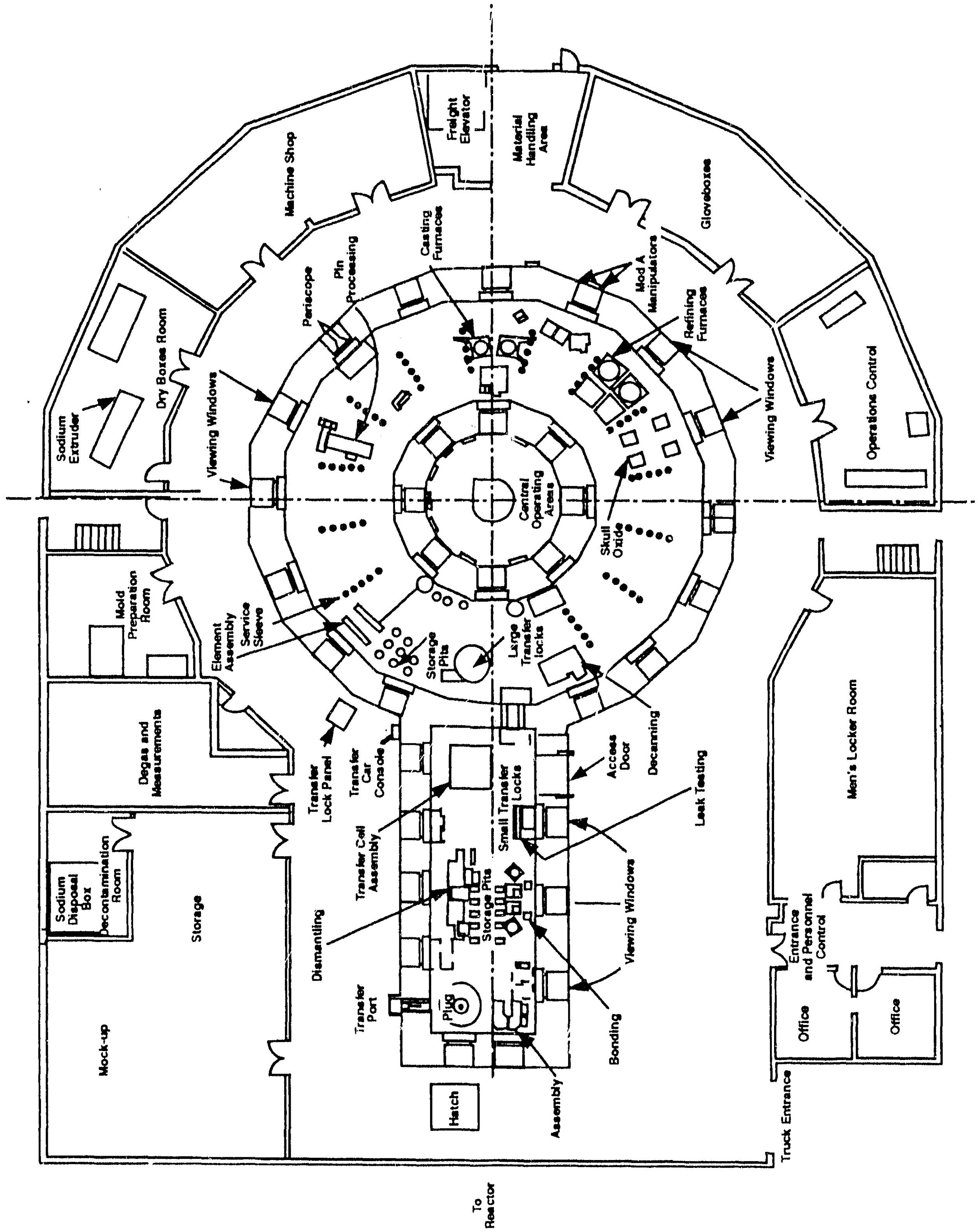


Figure 6-29. Hot Fuel Examination Facility--South.



The original Idaho Chemical Processing Plant at Idaho National Engineering Laboratory used contact maintenance. Process equipment is located in cells that do not have any remote maintenance capability. Cell design provides for easy personnel access. Process equipment must be flushed and the cell decontaminated before personnel can enter the cell for maintenance. Strategically located spray nozzles and stainless steel liners facilitate decontamination. Contact maintenance facilities are less expensive to build than remote maintenance facilities. Flushing and decontamination results in a lower operating efficiency than a comparable remote maintenance facility. Occupational radiation exposure is greater in a contact maintenance facility than in a remote maintenance facility (Yoder et al. 1979).

British Nuclear Fuels Limited uses a minimum maintenance (i.e., inherently reliable) philosophy in British facilities. The objective of this philosophy is to design equipment to last the life of the facility. Key features include minimization of mechanical connectors (i.e., welded construction), extensive use of fluidic devices (i.e., no moving parts), and use of corrosion-resistant materials.

Facilities built in the last 20 yr have not relied on a single maintenance philosophy. Some facilities (e.g., the WESF and the Defense Waste Processing Facility at the Savannah River Site) combine the crane-remote and manipulator maintenance philosophies. The New Waste Calcining Facility at the Idaho Chemical Processing Plant and Thermal Oxide Reprocessing Plant at Sellafield in Great Britain use all four maintenance philosophies depending on the reliability of the equipment. These two facilities differ in that the New Waste Calcining Facility relies more on remote maintenance while the Thermal Oxide Reprocessing Plant relies more on "zero" maintenance.

Available technologies also affect facility design. Examples of some of these technologies follow.

- Power manipulators: Power manipulators provide the horizontal movement and complex movements of the master-slave manipulators and the high lift and the traversing capabilities of a crane. Operators use viewing windows and remote cameras to observe the work.

- Crane and/or manipulator maintenance cells: Some facilities at the Hanford Site and the Idaho Chemical Processing Plant have shielded crane and/or power manipulator maintenance cells. These cells eliminate the need for personnel to enter a potentially high contamination area to perform crane or manipulator maintenance. There is a shield door through which a crane or manipulator can be moved from the process cell to the maintenance area. Temporary rail sections move into place to permit movement through the doorway. The maintenance cell pressure normally is maintained higher than the process cell atmosphere to minimize contamination of the maintenance cell.

- Remotely replaceable HEPA filters: Remotely replaceable HEPA filter designs have been developed in Europe and at the Idaho Chemical Processing Plant to eliminate personnel exposure during periodic filter replacement. The Idaho Chemical Processing Plant design permits filter replacement using either the overhead crane or a power manipulator.

- Modular equipment: British Nuclear Fuels Limited has developed several modular equipment designs (e.g., valves, pumps, and cranes) for use when moving parts could not be eliminated. Modular equipment is designed for ease of removal for repair. The valve and pump designs permit removal of internal parts into a maintenance cask for repair or transportation to a maintenance area. The modular crane provides for easy removal and installation of each module to minimize radiation exposure to personnel. Once removed, the crane modules are taken to a maintenance area for decontamination and repair. The crane can be disassembled for removal easily.

6.6 FACILITY AND PROCESS ALTERNATIVES

From previous discussions, there are five candidate facilities in which one or more of six pretreatment processes could be performed with each of the four DST waste types. The initial task is to identify those facility and process combinations that are most suitable for performing the required pretreatment operations with all DST waste types The final task is to select, using evaluation and comparison criteria from all the identified facility and process combinations, the combination most capable of and reliable for meeting all the objectives of a revised Hanford Site defense waste remediation program strategy.

6.6.1 Selection of Alternatives

The possible combinations of process and facility alternatives were initially assessed with respect to accomplishing the objectives of the revised program strategy stated in Section 3.4, most specifically:

- Implementing the HDW-EIS (DOE 1987) and the ROD (DOE 1988)
- Providing pretreated feed for HWVP startup in December 1999
- Being cost-effective by minimizing HWVP standby time and the number of glass canisters to be produced.

The alternatives selected involved the use of sludge washing and/or ^{137}Cs removal by ion exchange; these are mature, proven technologies, and they provide early feed to the HWVP. More advanced technologies, such as the TRUEX process, which only has been demonstrated in laboratory-scale tests, will provide more effective separation but require time for development. These advanced technologies are appropriate for the cost-effective disposal of later feeds to the HWVP. When only mature and advanced technologies are applied to the four DST waste types (i.e., NCRW, NCAW, CC waste, and PFP waste) to be pretreated, the result is either significant gaps in feed to the HWVP or an increase in the number of canisters to be produced (this results in a substantial increase in cost). Hence, intermediate technologies need to be developed; intermediate technologies would be based on known chemical processes, reduce the penalty in canisters, and provide continuous feed to the HWVP. These intermediate technologies are directed at the removal of constituents that limit the glass composition (i.e., aluminum, chromium, and zirconium).

Existing facilities would appear to be useful in providing feed for early HWVP operations. The B Plant was favored for the pretreatment mission because several of the planned processes are similar to those previously performed there and B Plant conceivably could support the December 1999 milestone for hot startup of the HWVP. The 244-AR Vault, when used in conjunction with B Plant, was seen as minimizing gaps in HWVP feed continuity. The PUREX Plant became a candidate pretreatment facility because of a decision to prepare an environmental impact statement before remaining N Reactor fuels were processed, hence its potential availability for a pretreatment mission. The use of these existing canyon-type facilities has been questioned because of concerns about each facility's ability to comply with today's regulations.

In-tank sludge washing of selected tank wastes is possible if the potential for uncontrolled steam venting (tank bump) can be eliminated or a new DST, specifically designed for this purpose, could be made available. The use of a DST for sludge washing (to avoid using B Plant) defers the removal of cesium from NCAW supernatant. If there is insufficient tank space available to separately store the supernatant until an NPF is operational, the limited use of B Plant for cesium removal might be necessary.

An NPF could be sized to pretreat wastes at rates consistent with HWVP glass production and designed to meet all the requirements of DOE orders and environmental regulations. However, an NPF would not be available in time to supply feed for the start of HWVP operations. As the schedule in Figure 6-24 shows, a TRUEX process NPF would not be available until fiscal year 2007, at the earliest. As a result, consideration was given to design and construction of pretreatment processes within the HWVP. While such design additions would delay the start of plant operations, the HWVP annex could be available several years before an NPF.

6.6.2 Description of Selected Facility and Process Alternatives

The constraints and limitations noted in Section 6.6.1 provide a satisfactory basis for designation of 16 pretreatment facility and process combinations (Table 6-12) for detailed evaluation and comparison. As noted in Table 6-12, most of the 16 facility and process alternatives involve performing pretreatment processes in more than one facility. Some of these combinations are further classified on the basis of whether or not the TRUEX process is part of the pretreatment operations.

Table 6-13 provides information concerning pretreatment of each of the four types of DST waste in the 16 candidate facility and process combinations. The matrix given in Table 6-13 is a convenient and concise way of specifying in which of the 16 facility and process combinations each of the required pretreatment processes unit operations for each DST waste type can be

Table 6-12. Selected Facility and Process Alternatives.

Alternative	Designation
1	244-AR Vault/B Plant with TRUEX
2	DST/B Plant with TRUEX
3	DST/B Plant without TRUEX
4	DST/NPF with TRUEX
5	DST/Intermediate processing/NPF with TRUEX
6	DST/NPF without TRUEX
7	DST/Intermediate processing/NPF without TRUEX
8	DST/PUREX Plant with TRUEX
9	DST/PUREX Plant without TRUEX
10	DST/HWVP without TRUEX
11	DST/B Plant (limited)/NPF with TRUEX
12	DST/B Plant (limited)/NPF without TRUEX
13	DST/HWVP (limited)/NPF with TRUEX
14	DST/Intermediate processing/HWVP (limited)/NPF with TRUEX
15	DST/HWVP (limited)/NPF without TRUEX
16	NPF with TRUEX

NOTE: Limited means limited pretreatment capabilities, which includes cesium ion exchange and sludge washing only.

DST = Double-shell tank
HWVP = Hanford Waste Vitrification Plant
NPF = New pretreatment facility
PUREX = Plutonium-Uranium Extraction
TRUEX = Transuranic extraction.

Table 6-13. Unit Operations for 16 Facility and Process Alternatives. (sheet 1 of 2)

Processing case-step	1 244-AR Vault/ B Plant with TRUEX	2 DST/ B Plant with TRUEX	3 DST/ B Plant no TRUEX	4 DST/NPF with TRUEX	5 DST/Int. Proc./NPF with TRUEX	6 DST/NPF no TRUEX	7 DST/Int. Proc./ NPF no TRUEX	8 DST/PUREX Plant with TRUEX	9 DST/PUREX Plant no TRUEX	10 DST/HWVP no TRUEX
NCAW wash	244-AR Vault (DST)	(DST)	(DST)	(DST)	(DST)	(DST)	(DST)	(DST)	(DST)	(DST)
NCAW filtration	B Plant	B Plant	B Plant	TRUEX NPF	TRUEX NPF	SW NPF	SW NPF	PUREX	PUREX	HWVP
NCAW cesium removal	B Plant	B Plant	B Plant	TRUEX NPF	TRUEX NPF	SW NPF	SW NPF	PUREX	PUREX	HWVP
NCAW strontium removal										
NCAW TRUEX										
NCRW TRUEX	B Plant	B Plant		TRUEX NPF	TRUEX NPF			PUREX		
NCRW wash			B Plant			SW NPF	SW NPF		PUREX	HWVP
PFP TRUEX	B Plant	B Plant		TRUEX NPF	TRUEX NPF			PUREX		
PFP wash			DST			DST			DST	DST
PFP chromium leach					DST		DST			
CC Wash (tank 241-AY-101)					DST					
CC TRUEX	B Plant	B Plant		TRUEX NPF	TRUEX NPF			PUREX		
CC cesium removal	B Plant	B Plant	B Plant	TRUEX NPF	TRUEX NPF	SW NPF	SW NPF	PUREX	PUREX	HWVP
CC organic destruction	B Plant	B Plant	B Plant	TRUEX NPF	TRUEX NPF	SW NPF	SW NPF	PUREX	PUREX	HWVP
CC chromium leach							SW NPF			
Blending							SW NPF			

Table 6-13. Unit Operations for 16 Facility and Process Alternatives. (sheet 2 of 2)

Processing case-step	11 DST/B Plant (limited)/NPF with TRUEX	12 DST/B Plant (limited)/NPF no TRUEX	13 DST/HWVP (limited)/NPF with TRUEX	14 DST/Int. Proc./HWVP (limited)/NPF with TRUEX	15 DST/HWVP (limited)/NPF no TRUEX	16 NPF with TRUEX
NCAW wash	(DST)	(DST)	(DST)	(DST)	(DST)	
NCAW filtration	B Plant	B Plant	HWVP	HWVP	HWVP	
NCAW cesium removal	B Plant	B Plant	HWVP	HWVP	HWVP	TRUEX NPF
NCAW strontium removal						TRUEX NPF
NCAW TRUEX						TRUEX NPF
NCRW TRUEX	TRUEX NPF		TRUEX NPF	TRUEX NPF		TRUEX NPF
NCRW wash		SW NPF			SW NPF	
PFP TRUEX	TRUEX NPF		TRUEX NPF	TRUEX NPF		TRUEX NPF
PFP wash		DST			DST	
PFP chromium leach				DST		
CC wash (241-AY-101)				DST		
CC TRUEX	TRUEX NPF	SW NPF	TRUEX NPF	TRUEX NPF		TRUEX NPF
CC cesium removal	TRUEX NPF	SW NPF	TRUEX NPF	TRUEX NPF	SW NPF	TRUEX NPF
CC organic destruction	TRUEX NPF	SW NPF	TRUEX NPF	TRUEX NPF	SW NPF	TRUEX NPF
CC chromium leach						
Blending						

NOTE: Limited means limited pretreatment capabilities, which includes cesium ion exchange and sludge washing only.
CC = Complexant concentrate
DST = Double-shell tank
HWVP = Hanford Waste Vitrification Plant
NCAW = Neutralized current acid waste
NCRW = Neutralized cladding removal waste
NPF = New pretreatment facility
PFP = Plutonium Finishing Plant
PUREX = Plutonium-Uranium Extraction
SW NPF = New pretreatment facility using sludge washing approach (no TRUEX)
TRUEX = Transuranic extraction
TRUEX NPF = New pretreatment facility that uses TRUEX process.

performed. Table 6-14, an expanded version of Table 6-13, further indicates (in narrative fashion) exactly which pretreatment operations will be performed in each facility.

Figure 6-11 provides a condensed summary of the information in Tables 6-13 and 6-14. Figure 6-11 also indicates which facility-process combinations are suitable and/or required for pretreating wastes from varying numbers of DSTs and, in some cases, SSTs. For example, to provide feed to the HWVP in an early timeframe, wastes retrieved from one or two DSTs could simply be washed in an existing DST; alternatively, after separation of solid and liquid phases, the solids could be washed and ^{137}Cs removed from the supernatant liquid in B Plant or in an extension to the HWVP. Larger and more elaborate facilities (e.g., PUREX Plant or an NPF) are required to conduct more extensive pretreatment (i.e., TRUEX process operations, destruction of organic materials, removal of ^{90}Sr and/or ^{99}Tc) of wastes retrieved from 10 or more DSTs and, especially, from any SSTs.

6.7 PRETREATMENT FEED ALTERNATIVES

One of the important objectives of a revised strategy for disposal of Hanford Site tank wastes is to support, if fully justified, the currently-planned December 1999 startup of the HWVP. There are, of course, strong economic incentives to avoid operating the HWVP in a routine "startup-shutdown" mode with long down times between operating periods. Thus, to support the December 1999 startup and continuous operation thereafter, an adequate, continuous feed supply must be available. Ensurance of an adequate supply of HWVP feed must account for the campaign nature of DST waste pretreatment and the unavoidable turnaround times between pretreatment campaigns.

Washed NCAW sludge is considered to be the most suitable DST feed for a December 1999 HWVP startup. At currently assumed HWVP glass production rates, approximately 2 yr will be required to vitrify the current inventory of NCAW sludge; additional time would be required to vitrify NCAW sludge produced in future PUREX Plant operations. Approximately 580 canisters of glass will result from vitrification of the current inventory of NCAW sludge. But direct vitrification of this waste, after washing, avoids the need to install and operate equipment to solubilize NCAW sludge and remove TRU elements and, possibly, ^{90}Sr from resulting aqueous dissolver solution. All of the candidate pretreatment facilities are suitable for washing NCAW and other types of DST waste solids. However, to ensure sufficiently washed NCAW sludge is available by December 1999 only DSTs are considered viable sludge washing facilities.

Once the inventory of washed NCAW solids has been vitrified, the HWVP can vitrify either other washed DST sludges or undissolved solids and radionuclide fractions from additional pretreatment of other DST wastes (i.e., sludge dissolution, TRUEX process). Washed sludges from tank 241-C-106 (SST) as well as 241-AY-101 (DST) also appear to be viable supplementary sources of HWVP feed, which would support continuity of HWVP operation before advanced pretreatment processes become available.

Table 6-14. Summary of Facility and Process Alternatives. (sheet 1 of 8)

1. 244-AR Vault-B Plant with TRUEX (Baseline)

   - 244-AR Vault

     - NCAW Solids: Sludge wash, settle-decant, solids feed to HWVP

   - B Plant

     - NCAW Supernatant: Filtration, cesium ion exchange, solids and cesium to HWVP

     - NCRW: Solids wash, acid dissolution, TRUEX, undissolved solids, and TRU feed to HWVP

     - PFP Solids: Acid dissolution, TRUEX, undissolved solids and TRU feed to HWVP

     - CC: Cesium ion exchange, acidification, TRUEX, complexant destruction, TRU solids and cesium to HWVP

2. DST-B Plant with TRUEX

   - DST In-Tank Processing

     - NCAW Solids: Sludge wash, settle-decant, solids to HWVP

   - B Plant

     - NCAW Supernatant: Filtration, cesium ion exchange, solids and cesium to HWVP

     - NCRW: Sludge wash, acid dissolution, TRUEX, TRU, and undissolved solids to HWVP

     - PFP: Acid dissolution, TRUEX, TRU and undissolved solids to HWVP

     - CC: Cesium ion exchange, acidification, TRUEX, complexant destruction; cesium, TRU, and undissolved solids to HWVP

Table 6-14. Summary of Facility and Process Alternatives. (sheet 2 of 8)

3. DST-B Plant without TRUEX

- DST In-Tank Processing
  - NCAW Solids: Sludge wash, settle-decant, solids feed to HWVP

PFP Solids: Sludge wash, settle-decant, feed to HWVP

- B Plant
  - NCAW Supernatant: Filtration, cesium ion exchange, solids and cesium feed to HWVP
  - NCRW: Sludge wash, solid-liquid separation, solids feed to HWVP
  - CC Supernatant: Cesium ion exchange, complexant destruction, TRU solids and cesium feed to HWVP

4. DST-New Pretreatment Facility with TRUEX

- DST In-Tank Processing
  - NCAW Solids: Sludge wash, settle-decant, solids feed to HWVP
- NPF with TRUEX
  - NCAW Supernatant: Filtration, cesium ion exchange, solids and cesium feed to HWVP
  - NCRW: Solids wash, acid dissolution, TRUEX, undissolved solids and TRU feed to HWVP
  - PFP Solids: Acid dissolution, TRUEX, undissolved solids, and TRU feed to HWVP
  - CC: Cesium ion exchange, TRUEX, complexant destruction, TRU solids, and cesium feed to HWVP

5. DST-Intermediate Processing-NPF with TRUEX

- DST In-Tank Processing
  - NCAW Solids: Sludge wash, settle-decant, solids to HWVP
  - CC (241-AY-101): Sludge wash, settle-decant, solids to HWVP
- DST Intermediate Processing
  - PFP (55%): Chromium leach, settle-decant, solids to HWVP

Table 6-14. Summary of Facility and Process Alternatives. (sheet 3 of 8)

- NPF with TRUEX
  - NCAW Supernatant: Filtration, cesium ion exchange, solids and cesium to HWVP
  - NCRW: Solids wash, acid dissolution, TRUEX, TRU and undissolved solids to HWVP
  - PFP (45%): Acid dissolution, TRUEX, TRU and undissolved solids to HWVP
  - CC: Cesium ion exchange; acidification; TRUEX; complexant destruction; cesium, TRU, and undissolved solids to HWVP

6. DST-NPF without TRUEX

- DST In-Tank Processing
  - NCAW Solids: Sludge wash, settle-decant, solids feed to HWVP
  - PFP Solids: Sludge wash, settle-decant, solids feed to HWVP
- NPF (without TRUEX)
  - NCAW Supernatant: Filtration, cesium ion exchange, solids and cesium feed to HWVP
  - NCRW: Sludge wash, solid-liquid separation, solids feed to HWVP
  - CC: Cesium ion exchange, complexant destruction, TRU solids and cesium feed to HWVP

7. DST-Intermediate Processing-NPF without TRUEX

- DST In-Tank Processing
  - NCAW Solids: Sludge wash, settle-decant, solids to HWVP
  - CC (241-AY-101): Sludge wash, settle-decant, solids to HWVP
- DST Intermediate Processing
  - PFP (60%): Chromium leach, settle-decant, solids to HWVP
- NPF Intermediate Processing without TRUEX
  - NCAW Supernatant: Filtration, cesium ion exchange, blending, solids and cesium feed to HWVP
  - NCRW: Sludge wash, solid-liquid separation, blending, solids to HWVP

Table 6-14. Summary of Facility and Process Alternatives. (sheet 4 of 8)

- PFP (40%): Chromium leach, solid-liquid separation, blending, solids to HWVP
- CC: Cesium ion exchange, complexant destruction, blending, cesium and solids to HWVP

8. DST-PUREX Plant with TRUEX

- DST In-Tank Processing
  - NCAW Solids: Sludge wash, settle-decant, solids feed to HWVP
  - Optional: Possible tank 241-C-106 solids or tank 241-AY-101 solids washing, feed to HWVP
- PUREX Plant with TRUEX
  - NCAW Supernatant: Filtration, cesium ion exchange, solids and cesium feed to HWVP
  - NCRW: Solids wash, acid dissolution, TRUEX, undissolved solids and TRU feed to HWVP
  - PFP Solids: Acid dissolution, TRUEX, undissolved solids and TRU feed to HWVP
  - CC: Cesium ion exchange, acidification, TRUEX, complexant destruction, TRU solids and cesium feed to HWVP

9. DST-PUREX Plant without TRUEX

- DST In-Tank Processing
  - NCAW Solids: Sludge wash, settle-decant, solids feed to HWVP
  - PFP Solids: Sludge wash, settle-decant, solids feed to HWVP
- PUREX Plant without TRUEX
  - NCAW Supernatant: Filtration, cesium ion exchange, solids and cesium feed to HWVP
  - NCRW: Sludge wash, solids liquid separation, solids feed to HWVP
  - CC Supernatant: Cesium ion exchange, complexant destruction, TRU solids and cesium feed to HWVP

Table 6-14. Summary of Facility and Process Alternatives. (sheet 5 of 8)

10. DST-HWVP without TRUEX

- DST In-Tank Processing
  - NCAW Solids: Sludge wash, settle-decant, solids to HWVP
  - PFP Solids: Sludge wash, settle-decant, solids to HWVP
- HWVP without TRUEX
  - NCAW Supernatant: Filtration, cesium ion exchange, solids and cesium feed to HWVP
  - NCRW: Sludge wash, solids-liquid separation, TRU solids feed to HWVP
  - CC: Cesium ion exchange, complexant destruction, TRU solids and cesium feed to HWVP

11. DST-B Plant (Limited)-NPF with TRUEX

- DST In-Tank Processing
  - NCAW Solids: Sludge wash, settle-decant, solids feed to HWVP
- B Plant
  - NCAW Supernatant: Filtration, cesium ion exchange, solids and cesium feed to HWVP
- NPF with TRUEX
  - NCRW: Solids wash, acid dissolution, TRUEX, undissolved solids and TRU feed to HWVP
  - PFP Solids: Acid dissolution, TRUEX, undissolved solids and TRU feed to HWVP
  - CC: Cesium ion exchange, acidification, TRUEX, complexant destruction, TRU solids and cesium feed to HWVP

12. DST-B Plant (Limited)-NPF without TRUEX

- DST In-Tank Washing
  - NCAW Solids: Sludge wash, settle-decant, solids feed to HWVP
  - PFP Solids: Sludge wash, settle-decant, solids feed to HWVP

Table 6-14. Summary of Facility and Process Alternatives. (sheet 6 of 8)

- B Plant
  - NCAW Supernatant: Filtration, cesium ion exchange, solids and cesium feed to HWVP
- NPF without TRUEX
  - NCRW: Sludge wash, solids-liquid separation, solids feed to HWVP
  - CC Supernatant: Cesium ion exchange, complexant destruction, TRU solids and cesium feed to HWVP

13. DST-HWVP (Limited)-NPF with TRUEX

- DST In-Tank Washing
  - NCAW Solids: Sludge wash, settle-decant, solids to HWVP
  - Required for Continuity: Tank 241-AY-101 solids and tank 241-C-106 (SST) solids washing, feed to HWVP
- HWVP (cesium ion exchange only)
  - NCAW Supernatant: Filtration, cesium ion exchange, solids and cesium to HWVP
- NPF with TRUEX
  - NCRW: Solids wash, acid dissolution, TRUEX, undissolved solids and TRU feed to HWVP
  - PFP Solids: Acid dissolution, TRUEX, undissolved solids and TRU feed to HWVP
  - CC: Cesium ion exchange, acidification, TRUEX, complexant destruction, TRU solids and cesium feed to HWVP

14. DST-Intermediate Processing-HWVP (Limited)-NPF with TRUEX

- DST In-Tank Processing
  - NCAW Solids: Sludge wash, settle-decant, solids to HWVP
  - CC (241-AY-101): Sludge wash, settle-decant, solids to HWVP
  - 241-C-106: Sludge wash, settle-decant, solids to HWVP
- DST Intermediate Processing
  - PFP (23%): Chromium leach, settle-decant, solids to HWVP

Table 6-14. Summary of Facility and Process Alternatives. (sheet 7 of 8)

- HWVP (Limited)
  - NCAW Supernatant: Filtration, cesium ion exchange, solids and cesium to HWVP
- NPF with TRUEX
  - NCRW: Solids wash, acid dissolution, TRUEX, TRU and undissolved solids to HWVP
  - PFP (77%): Acid dissolution, TRUEX, TRU and undissolved solids to HWVP
  - CC: Cesium ion exchange; TRUEX; complexant destruction; cesium, TRU, and undissolved solids to HWVP

15. DST-HWVP (Limited)-NPF without TRUEX

- DST In-Tank Processing
  - NCAW Solids: Sludge wash, settle-decant, solids feed to HWVP
  - PFP Solids: Sludge wash, settle-decant, solids to HWVP
- HWVP (cesium ion exchange only)
  - NCAW Supernatant: Filtration, cesium ion exchange, solids and cesium feed to HWVP
- NPF without TRUEX
  - NCRW Solids: Sludge wash, solid-liquid separation, solids to HWVP
  - CC Supernatant: Cesium ion exchange, complexant destruction, TRU solids and cesium feed to HWVP

16. NPF with TRUEX

  - NCAW Solids: Solids wash, acid dissolution, TRUEX, SREX, undissolved solids, TRU, and strontium feed to HWVP
  - NCAW Supernatant: Filtration, cesium ion exchange, solids and cesium feed to HWVP
  - NCRW: Solids wash, acid dissolution, TRUEX, undissolved solids and TRU feed to HWVP

Table 6-14. Summary of Facility and Process Alternatives. (sheet 8 of 8)

- PFP Solids: Acid dissolution, TRUEX, undissolved solids and TRU feed to HWVP
- CC: Cesium ion exchange, acidification, TRUEX, complexant destruction, TRU solids and cesium feed to HWVP
- CC: Cesium ion exchange, acidification, TRUEX, complexant destruction, TRU solids and cesium feed to HWVP

NOTE: Limited means limited pretreatment capabilities, which includes cesium ion exchange and sludge washing only.

CC = Complexant concentrate
DST = Double-shell tank
HWVP = Hanford Waste Vitrification Plant
NCAW = Neutralized current acid waste
NCRW = Neutralized cladding removal waste
NPF = New pretreatment facility
PFP = Plutonium Finishing Plant
PUREX = Plutonium-Uranium Extraction
SREX = Strontium extraction
TRU = Transuranic
TRUEX = Transuranic extraction.

Sludge in tank 241-C-106 contains the solids remaining from previous (1970's) ^{90}Sr removal operations performed on NCAW-type wastes from selected SSTs. This sludge still contains relatively high concentrations of ^{90}Sr and thus generates large amounts of radiolytic decay heat energy. Also, because the solids in tank 241-C-106 are already known not to be readily soluble in HNO_3, they are not particularly attractive feedstock to the TRUEX process.

The solids in tank 241-AY-101 are known, from analyses, to contain large amounts of siliceous material. Thus, the solids are an excellent candidate for direct vitrification after washing and are not desirable feedstock to aqueous pretreatment processing such as the TRUEX process. Because they apparently originated from CC waste, the solids in tank 241-AY-101 likely contain some organic complexing agents and their degradation products.

Potential availability and suitability of sludges in tanks 241-C-106 and 241-AY-101 can provide sufficient feed to the HWVP to permit nearly continuous operation while various other DST wastes are pretreated before vitrification. An economic penalty, in terms of an increased number of canisters of glass that must be made and disposed of, will be incurred by direct vitrification of washed sludges from tanks 241-C-106 and 241-AY-101 as opposed to TRUEX treatment of these wastes. These costs must be balanced against the costs of operating the HWVP in a "stop-and-go" fashion. However, as stated previously, these wastes are not good candidates for the TRUEX pretreatment process.

As mentioned in Section 6.4.3, wastes generated from intermediate processing also can provide feed to support continuous HWVP operations.

6.8 REFERENCES

Atomic Energy Act of 1954, 42 USC 2001, et seq.

Bernero, R. M. 1989, Letter, U.S. Nuclear Regulatory Commission, Washington, D. C., to A. J. Rizzo U.S. Department of Energy, Field Office, Richland, Washington, September 26.

Boomer, K. D., J. S. Garfield, K. A. Giese, B. A. Higley, J. S. Layman, A. L. Boldt, N. R. Croskrey, C. E. Goldberg, L. J. Johnson, and R. J. Parazin, 1990, *Functional Requirements Baseline for the Closure of Single-Shell Tanks*, WHC-EP-0338, DRAFT, Westinghouse Hanford Company, Richland, Washington.

Boomer, K. D., S. K. Baker, A. L. Boldt, M. D. Britton, L. E. Engelsman, J. D. Galbraith, J. S. Garfield, K. A. Giese, C. E. Golberg, B. A. Higley, K. J. Hull, L. J. Johnson, R. P. Knight, J. S. Layman, R. A. Marusich, R. J. Parazin, M. G. Piepho, E. J. Slaathaug, T. L. Waldo, and C. E. Worcester, 1991, *Systems Engineering Study for the Closure of Single-Shell Tanks*, WHC-EP-0405, Vol. 1 and 2, Westinghouse Hanford Company, Richland, Washington.

Corcoran, C. L., and K. M. Weingardt, 1991, *B Plant Secondary Containment System Description and Analysis*, WHC-SD-HWV-TI-017, Rev. 1, Westinghouse Hanford Company, Richland, Washington.

DOE, 1987, *Final Environmental Impact Statement, Disposal of Hanford Defense High-Level, Transuranic and Tank Wastes, Hanford Site, Richland, Washington*, DOE/EIS-0113, Vol. 1 through 5, U.S. Department of Energy, Washington, D.C.

DOE, 1988, "Final Environmental Impact Statement for the Disposal of Hanford Defense High-Level, Transuranic, and Tank Wastes, Hanford Site, Richland, Washington; Record of Decision," *Federal Register*, Vol. 53, No. 72, pp. 12449-12453, U.S. Department of Energy, Washington, D.C.

DOE, 1989a, *Hazardous and Radioactive Mixed Waste Program*, DOE Order 5400.3, U.S. Department of Energy, Washington, D.C.

DOE, 1989b, *General Design Criteria*, DOE Order 6430.1A, U.S. Department of Energy, Washington, D.C.

DOE, 1990a, *Radioactive Waste Management*, DOE Order 5820.2A, U.S. Department of Energy, Washington, D.C.

DOE, 1990b, *Radiation Protection of the Public and the Environment*, DOE Order 5400.5, U.S. Department of Energy, Washington, D.C.

DOE-OCRWM, 1986, *Waste Acceptance Preliminary Specifications for the Defense Waste Processing Facility High-Level Waste Form*, OGR/B-8, U.S. Department of Energy, Office of Civilian Radioactive Waste Management, Washington, D.C.

Ecology, 1991, "Dangerous Waste Regulations," *Washington (State) Administrative Code*, WAC 173-303, Washington State Department of Ecology, Olympia, Washington.

Ecology, EPA, and DOE, 1990, *Hanford Federal Facility Agreement and Consent Order*, Vol. 1 and 2, Washington State Department of Ecology, U.S. Environmental Protection Agency, and U.S. Department of Energy, Olympia, Washington.

EPA, 1990a, "Identification and Listing of Hazardous Waste," *Code of Federal Regulations*, 40 CFR 261, U.S. Environmental Protection Agency, Washington, D.C.

EPA, 1990b, "Land Disposal Restrictions," *Code of Federal Regulations*, 40 CFR 268, U.S. Environmental Protection Agency, Washington, D.C.

EPA, 1991, "Land Disposal Restrictions," *Code of Federal Regulations*, 40 CFR 268, U.S. Environmental Protection Agency, Washington, D.C.

Hendrickson, D. W., 1990, *Grout Treatment Facility Land Disposal Restriction Management Plan*, WHC-SD-WM-PLN-005, Rev. 0, Westinghouse Hanford Company, Richland, Washington, September 1990.

Horwitz, E. P., and W. W. Schulz, 1985, "Solvent Extraction and Recovery of Transuranium Elements for Waste Solutions Using the TRUEX Process," *Solvent Extraction and Ion Exchange in the Nuclear Fuel Cycle*, p. 137, Ellis Horwood, Ltd., Chichester, England.

Horwitz, E. P., and W. W. Schulz, 1986, "Applications of the TRUEX Process to the Decontamination of Nuclear Waste Streams," in *Proceedings ISEC 86*.

Horwitz, E. P., and W. W. Schulz, 1987, "The TRUEX Process: Removal/Recovery of TRU Elements from Acidic Waste Solutions," *Proceedings Extraction '87-The Recovery of High Value Materials*, p. 245, Institute of Chemical Engineers, London, England, Symposium Series No. 03.

Horwitz E. P., M. L. Dietz, and D. E. Fisher, 1991, "SREX: A New Process for the Extraction and Recovery of Strontium from Acidic Nuclear Waste Solutions," *Solv. Ex. Ion Exch.*, Vol. 9, pp. 1-26.

Lowe, S. S., 1991, *Preliminary Material Balances for Pretreatment of NCAW, NCRW, PFP, and CC Wastes*, WHC-SD-WM-TI-492, Westinghouse Hanford Company, Richland, Washington.

Ludowise, J. D., 1989, *Assessment of the Compliance of B Plant to DOE Order 6430.1A and Other Codes, Standards and Regulations*, WHC-SD-WM-TI-383, Westinghouse Hanford Company, Richland, Washington.

Lutton, T. W., W. W. Schulz, D. M. Strachan, and L. J. Bollyky, 1980, *Ozonation of Hanford Defense Nuclear Waste*, RHO-SA-98, Rockwell Hanford Operations, Richland, Washington.

Miller, W. C., D. W. Hamilton, L. K. Holton, and J. W. Bailey, 1991, *Hanford Waste Vitrification Systems Risk Assessment-Final Report*, WHC-EP-0421, Rev. 0, Westinghouse Hanford Company, Richland, Washington.

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

Newland, 1991, *U.S. Spent Fuel and Radioactive Waste Inventories, Projections, and Characteristics*, DOE/RW-0006, Rev. 6, Prepared for the DOE Office of Civilian Radioactive Waste Management by Oak Ridge National Laboratory, Oak Ridge, Tennessee.

Nord, T. L., 1991, "Petition for Equivalency for PUREX Secondary Containment," (letter to S. H. Wisness, Hanford Site Project Manager), U.S. Department of Ecology, Washington, D.C. (July 9).

NRC, 1982, "Licensing Requirements for Land Disposal of Radioactive Waste," *Code of Federal Regulations*, 10 CFR 61, U.S. Nuclear Regulatory Commission, Washington, D.C.

NRC, 1990a, "Design Criteria for the Waste Package: Criteria for the waste package and its components, high-level-waste package design in general," *Code of Federal Regulations*, 10 CFR 60.135(a)(2), U.S. Nuclear Regulatory Commission, Washington, D.C.

NRC, 1990b, "Licensing Requirements for Land Disposal of Radioactive Waste," *Code of Federal Regulations*, 10 CFR 61, U.S. Nuclear Regulatory Commission, Washington, D.C.

Resource Conservation and Recovery Act of 1976, 42 USC 6901, et seq.

Rizzo, A. J. U.S. Department of Energy, Field Office, Richland, 1989, Letter to R. M. Bernero, U.S. Nuclear Regulatory Commission, Washington, D.C. (March 6).

Schulz, W. W., 1980, *Cyclohexanone Solvent Extraction of $^{99}TcO_4$ from Alkaline Nuclear Waste Solutions*, RHO-SA-113, Rockwell Hanford Operations, Richland, Washington.

Schulz, W. W., and L. A. Bray, 1987, "Solvent Extraction of ^{137}Cs and ^{90}Sr from HNO_3 Solutions - A Technology Review and Assessment," *Sep. Sci. and Tech.*, Vol. 22, pp. 191-214.

Schulz, W. W., and M. J. Kupfer, 1991, *Candidate Reagents and Procedures for Dissolution of Hanford Site Single-Shell Tank Sludges*, WHC-EP-0451, Westinghouse Hanford Company, Richland, Washington.

Swanson, J. L., 1991a, *Initial Studies of Pretreatment Methods for Neutralized Cladding Removal Waste (NCRW) Sludge*, PNL-7716, Pacific Northwest Laboratory, Richland, Washington.

Swanson, J. L., 1991b, *Use of the TRUEX Process for the Pretreatment of Neutralized Cladding Removal Waste (NCRW) Sludge - Results of a Design Basis Experiment*, PNL-7734, Pacific Northwest Laboratory, Richland, Washington.

Swanson, J. L., 1991c, *Use of the TRUEX Process for the Pretreatment of Neutralized Cladding Removal Waste (NCRW) Sludge - Results of FY 1990 Studies*, PNL-7780, Pacific Northwest Laboratory, Richland, Washington.

WHC, 1990a, *Assessment of Double-Shell Tank Waste Pretreatment Options*, WHC-SP-0464, Rev. 1, Westinghouse Hanford Company, Richland, Washington.

WHC, 1990b, *Environmental Compliance Manual*, WHC-CM-7-5, Westinghouse Hanford Company, Richland, Washington.

WHC, 1991, *Independent Safety Evaluation Review of B Plant Viability Study*, WH-005-00, Westinghouse Hanford Company, Richland, Washington.

Yoder, R. A., et al., 1979, *Study of the Cost Impact of Remote Maintenance on Fuel Reprocessing, Task 1, Current State-of-the-Art Relative to the Design of Existing and Conceptual Reprocessing Plants*, ORNL/SUB-79/31066/3, SAI-002-78-RI, Oak Ridge National Laboratory, Oak Ridge, Tennessee (August).

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ACRONYMS

DSSF	double-shell slurry feed
DST	double-shell tank
DWPF	Defense Waste Processing Facility
ES&H	environmental, safety, and health
FY	fiscal year
HDW-EIS	*Final Environmental Impact Statement, Disposal of Hanford Defense High-Level, Transuranic and Tank Wastes, Hanford Site, Richland, Washington*
HLW	high-level waste
HWVP	Hanford Waste Vitrification Plant
LLW	low-level waste
MAU	multiattribute utility
NCAW	neutralized current acid waste
NCRW	neutralized cladding removal waste
NPF	new pretreatment facility
PFP	Plutonium Finishing Plant
PUREX	Plutonium-Uranium Extraction
RCRA	*Resource Conservation and Recovery Act of 1976*
ROD	record of decision
SEIS	supplemental environmental impact statement
SREX	strontium extraction
SST	single-shell tank
Tri-Party Agreement	*Hanford Federal Facility Agreement and Consent Order*
TRUEX	transuranic extraction
TRUEX NPF	a new pretreatment facility that uses the transuranic extraction process
VERT	venture evaluation and review technique
WESF	Waste Encapsulation and Storage Facility
Westinghouse Hanford	Westinghouse Hanford Company

7.0 COMPARATIVE ANALYSIS OF ALTERNATIVES

A multiattribute utility (MAU) analysis approach was used to quantify the merits of the 16 alternatives for each of the attributes of major concern to the stakeholders (Section 5.0). The attributes were divided into three sets:

- Environment, safety, health, and compliance
- Technology and integration
- Cost and schedule.

These categories were chosen because similar technical expertise would be required to understand and estimate the performance of the alternatives within each group of attributes. One team of technical experts was assembled to provide quantitative measures of the alternatives for each group of attributes.

All attributes are defined in Appendix C. Attributes scored by the technical expert assessment teams are measurable assessments (on a direct or constructed scale) of the stakeholder objectives. It is important that each attribute is absolute and unambiguous, and that each one measures an objective only once to ensure that bias is not introduced by inadvertently capturing the effects of any objective more than once.

Attribute scales were defined to correspond to the values reflected in the objectives identified by the stakeholder groups. Specific, measurable scales were constructed. For some attributes, these scales were directly measured values such as total cost, number of high-level waste (HLW) canisters, or milestone completion dates [i.e., Hanford Waste Vitrification Plant (HWVP) startup]. Other attributes were measured by proxies. For example, the number of grout vaults required was used as a proxy for some aspects of the potential long-term environmental impact of the pretreatment strategies. Other attributes were scored using constructed scales. These scales were generally 0-to-100-point scales with qualitatively defined points. For example, a constructed scale was used to describe the technical maturity of the processes for each alternative. Sections 7.1, 7.2, and 7.3 describe the results of the three scoring teams.

In Section 7.4, the attribute scores are combined with the stakeholder weights to yield a composite measure of the relative utility, or value, of each alternative. To derive the overall scores for the alternatives, the attribute scores were normalized to correspond with the units and scales used to derive attribute weights. The MAU analysis results provided a measure of the relative value of the alternatives and also indicated which attributes are most critical to the results.

A series of sensitivity analyses are performed in Section 7.5 using the MAU model to examine how the relative merits of, and preferences for, the alternatives change as either the attribute weights or attribute scores are allowed to change. These results indicated the stability of the final results and their sensitivity to variations in stakeholder values or uncertain performance measures.

7.1 ENVIRONMENTAL, SAFETY, AND HEALTH

The environmental, safety, and health (ES&H) impacts portion of the evaluation measured four individual attributes:

- Public health
- Environmental impacts
- Worker safety
- Compliance with regulations.

These attributes were broken down further to 16 specific measurements of the ES&H impacts.

The first major attribute, public health, was used to estimate the impact of the facility and process alternatives on the general population. Impacts resulting from the construction, routine operations, transportation, and accident situations were measured relative to the other alternatives. The second attribute, environmental impacts, was used to measure the impacts to the environment. Impacts were considered over the operating life of the double-shell tank (DST) mission. The measurements for assessing environmental impacts were as follows:

- Routine and nonroutine effluents
- Amount of solid waste generated
- Number of grout vaults required for disposal of low-level waste (LLW)
- Number of glass canisters required
- Land requiring restricted use at the completion of the mission
- Potential incremental single-shell tank (SST) leakage resulting from the timing of the alternatives.

The third major attribute, worker safety, was used to measure the occupational health and safety impacts to the work force resulting from routine work and accidents. The fourth attribute, compliance with regulations, was used to measure the probability of obtaining compliance for each of the alternatives.

The team assembled for the expert evaluation process was able to develop direct measurements for the majority of the attributes. Only two attributes required the construction of scales to measure the scores for the alternatives. A summary of the attribute scores for each of the 16 alternatives is presented in Tables 7-1 through 7-4. The team consisted of highly experienced personnel representing the disposal, environmental, safety, and regulatory aspects. Health and safety impacts were assessed using

Table 7-1. Environmental, Safety, and Health Expert Evaluation Matrix--Public Health Attributes.

		Maximum and other credible accidents		Transportation (fatalities)		
Alternative	Description	Radiological risk (probable fatalities)	Chemical impact (probability of fatalities to maximum exposed individual)	Radiological dose (normal shipments)	Radiological dose (accidents)	Vehicular accidents
1	244-AR Vault/B Plant with TRUEX	5.0 E-05	7.39 E-03	3.9 E-04	7.5 E-05	1.9 E-03
2	DST/B Plant with TRUEX	5.0 E-05	7.39 E-03	3.9 E-04	7.5 E-05	1.9 E-03
3	DST/B Plant without TRUEX	3.4 E-05	1.35 E-05	3.0 E-03	5.8 E-04	1.4 E-02
4	DST/NPF with TRUEX	4.0 E-05	6.45 E-03	3.9 E-04	7.5 E-05	1.8 E-03
5	DST/Intermediate processing/NPF with TRUEX	3.8 E-05	5.37 E-03	6.0 E-04	1.2 E-04	2.8 E-03
6	DST/NPF without TRUEX	4.0 E-05	3.83 E-05	3.0 E-03	5.8 E-04	1.4 E-02
7	DST/Intermediate processing/NPF without TRUEX	4.0 E-05	3.83 E-05	1.2 E-03	2.3 E-04	5.5 E-03
8	DST/PUREX Plant with TRUEX	3.7 E-05	7.07 E-03	3.9 E-04	7.5 E-05	1.8 E-03
9	DST/PUREX Plant without TRUEX	3.8 E-05	3.95 E-05	3.0 E-03	5.8 E-04	1.4 E-02
10	DST/HWVP without TRUEX	4.1 E-05	4.19 E-05	3.0 E-03	5.8 E-04	1.4 E-02
11	DST/B Plant (limited)/NPF with TRUEX	4.0 E-05	6.45 E-03	3.9 E-04	7.5 E-05	1.8 E-03
12	DST/B Plant (limited)/NPF without TRUEX	4.0 E-05	3.83 E-05	3.0 E-03	5.8 E-04	1.4 E-02
13	DST/HWVP (limited)/NPF with TRUEX	4.0 E-05	6.45 E-03	3.9 E-04	7.5 E-05	1.8 E-03
14	DST/Intermediate processing/HWVP (limited)/NPF with TRUEX	3.8 E-05	5.37 E-03	5.1 E-04	9.9 E-05	2.4 E-03
15	DST/HWVP (limited)/NPF without TRUEX	4.0 E-05	3.83 E-05	3.0 E-03	5.8 E-04	1.4 E-02
16	NPF with TRUEX	4.3 E-05	8.06 E-03	2.6 E-04	5.1 E-05	1.2 E-03

NOTE: Limited means limited pretreatment capabilities, which includes cesium ion exchange and sludge washing only.
DST = Double-shell tank
HWVP = Hanford Waste Vitrification Plant
NPF = New pretreatment facility
PUREX = Plutonium-Uranium Extraction
TRUEX = Transuranic extraction.

Table 7-2. Environmental, Safety, and Health Expert Evaluation Matrix--Environmental Impact Attributes.

Alternative	Description	Routine and nonroutine effluents	Solid waste x 1,000 m^3 (x 1,000 ft^3)	Number of grout vaults (DSTs)	Number of glass canisters (DSTs)	Incremental land use (acres)	Potential incremental leakage to the environment (SSTs)
1	244-AR Vault/B Plant with TRUEX	0	4.4 (155)	50	1,340	90	0
2	DST/B Plant with TRUEX	40	3.8 (135)	50	1,340	90	0
3	DST/B Plant without TRUEX	20	5.1 (180)	41	10,380	72	0
4	DST/NPF with TRUEX	80	0.68 (24)	38	1,340	78	2
5	DST/Intermediate processing/NPF with TRUEX	80	0.76 (27)	38	2,090	80	2
6	DST/NPF without TRUEX	60	2.5 (89)	38	10,380	78	2
7	DST/Intermediate processing/NPF without TRUEX	60	1.1 (39)	38	4,080	80	2
8	DST/PUREX with TRUEX	40	2.9 (103)	50	1,340	90	0
9	DST/PUREX without TRUEX	20	4.9 (173)	41	10,380	72	0
10	DST/HWVP without TRUEX	60	2.49 (88)	38	10,380	68	2
11	DST/B Plant (limited)/NPF with TRUEX	60	0.9 (32)	38	1,340	78	2
12	DST/B Plant (limited)/NPF without TRUEX	40	2.95 (104)	38	10,380	78	2
13	DST/HWVP (limited)/NPF with TRUEX	80	0.595 (21)	38	1,340	78	2
14	DST/Intermediate processing/HWVP (limited)/ NPF with TRUEX	80	0.74 (26)	38	1,770	80	2
15	DST/HWVP (limited)/NPF without TRUEX	60	2.66 (93)	38	10,380	78	2
16	NPF with TRUEX	100	0.595 (21)	38	905	78	3

NOTE: Limited means limited pretreatment capabilities, which includes cesium ion exchange and sludge washing only.
DST = Double-shell tank
HWVP = Hanford Waste Vitrification Plant
NPF = New pretreatment facility
PUREX = Plutonium-Uranium Extraction
SST = Single-shell tank
TRUEX = Transuranic extraction.

Table 7-3. Environmental, Safety, and Health Expert Evaluation Matrix--Worker Safety Attributes.

Alternative	Description	Routine radiological dose to workers (construction, operations, and transportation) (fatalities)	Accidents		
			Chemical hazard (probability of fatality to maximum exposed individual)	Radiological risk (rem)	Nonradiological (construction, operations, transportation) (fatalities)
1	244-AR Vault/B Plant with TRUEX	1.3	1.99 E-01	0.10	6.7
2	DST/B Plant with TRUEX	1.3	1.99 E-01	0.10	6.5
3	DST/B Plant without TRUEX	1.8	6.13 E-04	0.10	8.4
4	DST/NPF with TRUEX	1.2	1.74 E-01	0.13	10.0
5	DST/Intermediate processing/NPF with TRUEX	1.2	1.45 E-01	0.13	10.1
6	DST/NPF without TRUEX	1.8	1.74 E-03	0.13	11.3
7	DST/Intermediate processing/NPF without TRUEX	1.3	1.74 E-03	0.13	9.5
8	DST/PUREX Plant with TRUEX	1.4	1.90 E-01	0.10	7.1
9	DST/PUREX Plant without TRUEX	2.0	1.79 E-03	0.10	9.0
10	DST/HWVP without TRUEX	1.6	1.90 E-03	0.13	8.8
11	DST/B Plant (limited)/NPF with TRUEX	1.3	1.74 E-01	0.13	10.1
12	DST/B Plant (limited)/NPF without TRUEX	1.9	1.74 E-03	0.13	11.5
13	DST/HWVP (limited)/NPF with TRUEX	1.2	1.74 E-01	0.13	10.4
14	DST/Intermediate processing/HWVP (limited)/ NPF with TRUEX	1.2	1.45 E-01	0.13	10.4
15	DST/HWVP (limited)/NPF without TRUEX	1.8	1.74 E-03	0.13	11.7
16	NPF with TRUEX	1.1	2.17 E-01	0.13	10.4

NOTE: Limited means limited pretreatment capabilities, which includes cesium ion exchange and sludge washing only.
DST = Double-shell tank
HWVP = Hanford Waste Vitrification Plant
NPF = New pretreatment facility
PUREX = Plutonium-Uranium Extraction
TRUEX = Transuranic extraction.

Table 7-4. Environmental, Safety, and Health Expert Evaluation Matrix--Compliance Attributes

Alternative	Description	Compliance attribute
1	244-AR Vault/B Plant with TRUEX	0
2	DST/B Plant with TRUEX	25
3	DST/B Plant without TRUEX	25
4	DST/NPF with TRUEX	75
5	DST/Intermediate processing/NPF with TRUEX	75
6	DST/NPF without TRUEX	75
7	DST/Intermediate processing/NPF without TRUEX	75
8	DST/PUREX Plant with TRUEX	25
9	DST/PUREX Plant without TRUEX	25
10	DST/HWVP without TRUEX	75
11	DST/B Plant (limited)/NPF with TRUEX	50
12	DST/B Plant (limited)/NPF without TRUEX	50
13	DST/HWVP (limited)/NPF with TRUEX	75
14	DST/Intermediate processing/HWVP (limited)/NPF with TRUEX	75
15	DST/HWVP (limited)/NPF without TRUEX	75
16	NPF with TRUEX	100

NOTE: Limited means limited pretreatment capabilities, which includes cesium ion exchange and sludge washing only.
DST = Double-shell tank
HWVP = Hanford Waste Vitrification Plant
NPF = New pretreatment facility
PUREX = Plutonium-Uranium Extraction
TRUEX = Transuranic extraction.

techniques from the *Final Environmental Impact Statement*, *Disposal of Hanford Defense High-Level*, *Transuranic and Tank Wastes*, *Hanford Site*, *Richland*, *Washington* (HDW-EIS) (DOE 1987). At this time, there is little applicable risk information on potential DST remediation facilities and operations. Comprehensive risk analyses have not been performed for these operations. For this reason, the risk values shown in Appendix D are considered very preliminary and should not be taken as the absolute risks of any of the DST remediation facilities (see Appendix D).

The definition and scoring rules for each technical attribute as well as a discussion of the evaluation by the team is contained in the sections that follow.

7.1.1 Public Health

This attribute measured the impact of the strategy alternatives on the health of the general population. Impacts resulting from radiological and chemical accidents and the transportation of canisters of vitrified waste were judged to be the most significant subattributes to measure. The impacts were measured for each alternative relative to the other alternatives. Traffic accidents resulting from the transportation of HLW canisters of vitrified waste had the most impact on number of fatalities. Because alternatives using the transuranic extraction (TRUEX) process result in the least number of canisters, these alternatives were measured as more favorable.

The maximum and other credible radiological accidents were identified for each of the alternatives. The risk was measured as a function of (1) the time that waste remained in the SST before retrieval and pretreatment and (2) pretreatment and vitrification operations length for DST waste for each alternative. The maximum credible accident was judged to be a ferrocyanide explosion in an SST. The radiological risk was measured in expected fatalities resulting from the postulated accident(s). This was calculated as the product of the estimated probability of each accident times the estimated fatality resulting from the accident. There were no significant differences among the alternatives. They all ranged from 3.4×10^{-5} to 5.0×10^{-5} expected fatalities over the life of the program.

The expected fatalities resulting from the effects of a chemical accident to the maximum exposed offsite individual were measured to identify any significant differences among the alternatives. For those alternatives using the TRUEX process for DST waste, the fatalities were measured at 10^{-3} because of the use of more hazardous chemicals in the TRUEX process. The alternatives that did not use the TRUEX process resulted in 10^{-5} expected fatalities to the maximum exposed individual.

The risk to the public resulting from potential transportation impacts was measured in expected fatalities from: (1) the radiological dose from routine shipments, (2) the radiological dose from accidents, and (3) the nonradiological accidents resulting during offsite rail shipments. The scoring measured the probability of the event times the consequences to produce a population risk integrated over the total number of shipments. The greatest risk in this category is from a nonradiological accident resulting from offsite rail shipments. Alternatives using the TRUEX process result in fewer canisters of vitrified waste. These alternatives result in 10^{-3} expected fatalities, which were an order of magnitude less than alternatives that use sludge washing or intermediate processes. For all alternatives, expected nonradiological accident fatalities were at least an order of magnitude greater than radiological derived accident fatalities.

7.1.2 Environmental Impacts

This attribute measured the potential impact of the alternatives on the environment. Impacts resulting from routine and nonroutine effluents, the amount of solid waste generated, the number of grout vaults and canisters of vitrified waste required, the incremental land use, and the potential leakage from SSTs resulting from the timing of the alternatives were judged to be the most significant measures. The alternatives using the TRUEX process resulted in only 13 percent as many canisters of vitrified waste. Regardless of the process selected, the minimum number of grout vaults (38) occurs when using new facilities. The use of existing facilities results in 3 additional vaults for sludge washing and 12 more for TRUEX processing. The number of grout vaults and new facilities are the most significant factors in measuring the incremental land requiring restricted use at the completion of the mission. The alternatives not using the TRUEX process would delay the start of SST pretreatment for 5 yr, increasing the potential for additional leakage from SSTs.

The first measurement of environmental impact was the potential for effluents to affect the environment. Routine effluents are a part of normal operations and pose negligible environmental hazard. However, the alternatives that minimize effluents are more desirable. A nonroutine effluent occurs when a routine effluent is above the instantaneous release limit, but when monitored over an annual time period. The release limits would not be exceeded. Nonroutine effluents are defined as occurring as the result of cooling coil failures, retention basin overflow, tube bundle failure, stack release, or operator error. A scale was constructed to measure the ability of the alternatives to (1) provide additional barriers above standards for higher safety factors in areas of high risk (e.g., if the prime mechanism for release is through a gaseous pathway, mitigation can be provided through the use of localized high-efficiency particulate air filtration), (2) minimize the potential for operator error by including human factors engineering, (3) reduce the potential for nonroutine releases by minimizing the quantity of routine releases, and (4) minimize the complexity of operation as a function of the number of facilities used. This portion of the scoring rule also measures the ability of the facility alternatives to recycle process and steam condensates and provide equipment decontamination. Existing facilities continue to operate whether or not processing occurs; cooling water, steam, and process condensate systems at a new facility would use closed-loop systems, thereby reducing effluents from these sources to an estimated less than 10 percent of an existing facility (total Hanford Site discharge is not a discriminator other than identified previously). This attribute was scored as follows.

Points	Measurement
100	Able to provide additional engineered barriers, human factors can be designed in, routine effluents are low, and minimum number of facilities are used.
80	Same as above except higher number of facilities are used.
60	Able to accommodate the preferred capabilities, but the routine effluents are higher than preferred.

40 Unable to accommodate one of the preferred capabilities, and routine effluents are higher than preferred.

20 Unable to accommodate one or two of the preferred capabilities and routine effluents are significantly higher than other alternatives.

0 Alternative has a fatal flaw and cannot meet minimum standards.

A distinguishing factor for all things being equal is the duration of operation from retrieval to vitrification (longer is worse). This is reflected in the alternatives without TRUEX capabilities, because these alternatives result in significantly more processing time; thus, facility aging becomes a factor.

The second measure of environmental impact was the quantity of LLW generated over the duration of the alternative from retrieval to vitrification. The LLW totals included the solid waste generated during facility retrofit, which was required for conversion to a pretreatment mission, and during operation. Solid waste generated during facility conversion primarily would be failed or no-longer-required equipment consisting of vessels, pumps, agitators, and jumpers. During operation, solid waste is typically personal protective clothing, tape, wood, and failed equipment. Solid waste is buried onsite. The additional land required for solid waste disposal is included in a later measurement. The total solid waste for the alternatives ranged from 590 m^3 over 6.5 yr to 5,100 m^3 over 34 yr.

A third measure of the environmental impact was the number of grout vaults required to dispose of the DST LLW. The measurements were based on the flowsheets and material balances. No significant change would occur in actinide levels across the various processing alternatives. During the dissolution cycle in TRUEX processing, non-TRU radionuclides (e.g., strontium) will dissolve and become part of the TRUEX feedstream. These non-TRU radionuclides are not removed and become part of the LLW used in grout. Using the TRUEX process results in 3.5 times more strontium in the LLW. Strontium extraction (SREX) can be included in a new pretreatment facility (NPF). Existing facilities would not have sufficient space to accommodate the SREX process. Table 7-5 provides a radionuclide balance, showing the distribution of curies for key radionuclides between LLW, HLW, and TRU wastes for sludge washing versus TRUEX process alternatives. This table also shows the volume of LLW, HLW, and TRU that results from each process alternative. Twelve additional grout vaults (a total of 50) are required for those alternatives using the TRUEX process in an existing facility over those alternatives that use a new facility. The difference between the use of existing and new facilities is a result of separations inefficiencies in existing facilities. New facilities can be designed to optimally accommodate the flowsheets.

The number of canisters containing vitrified waste required for storing HLW was also included in this scoring, although there is not a direct correlation to environmental impacts. The number of canisters of vitrified waste was important in determining the HWVP operating life and transportation impacts. Because the glass heat load would not significantly change with the

Table 7-5. Radionuclide Distribution for Pretreated Double-Shell Tank Waste (ci)[a].

Double-shell tank waste	^{137}Cs	^{90}Sr	^{99}Tc	Transuranic	Volume (L)	
					NPF	B Plant/ PUREX Plant
Sludge Washing						
Low-level waste	2.2 E+06	4 E+05	3.2 E+03	1.5 E+03	6.9 E+07	7.8 E+07
High-level waste and transuranic	3.4 E+07	2.6 E+07	2.9 E+03	7.1 E+05	2.4 E+07	2.8 E+07
Grout vaults					38	41
TRUEX Process						
Low-level waste	2.2 E+06	1.4 E+06	3.2 E+03	2.4 E+03	6.6 E+07	1.13 E+08
High-level waste and transuranic	3.4 E+07	2.5 E+07	2.9 E+03	7.1 E+05	1.5 E+07	1.9 E+07
Grout vaults					38 vaults	50 vaults

[a]Radionuclide distributions are based on Lowe (1991). The actual radionuclide distribution between low-level waste and high-level waste fractions depends on specific design and operation of the waste pretreatment facility.

NPF = New pretreatment facility
PUREX = Plutonium-Uranium Extraction
TRUEX = Transuranic extraction.

number of canisters, no additional repository space is required for additional canisters. Alternatives that do not use the TRUEX process result in as much as a 10-fold increase in canisters, to 10,380. Alternatives that use intermediate processing resulted in 2 to 4 times as many canisters as the best TRUEX alternative, which results in 905 canisters.

A fifth measure of the environmental impact was the amount of land requiring restricted use at the completion of the DST mission. Restricted land use was defined as an underground disposal requiring a permanent barrier or a processing facility, which at the completion of decontamination and decommissioning is left abovegrade. The minimum land use resulted from expanding HWVP to accommodate sludge washing (68 acres). Alternatives that use the TRUEX process in existing facilities (added grout vaults) resulted in the greatest use of land (90 acres). Additional land would be required for those alternatives using intermediate processing because of the need for four additional DSTs.

The last measure of the environmental impact was the reduced potential for leakage of SSTs resulting from the timing of the various facility alternatives. The risk from continued SST storage was reduced for those alternatives that use existing facilities for pretreatment; these alternatives provide an opportunity to accelerate SST waste pretreatment from 2011 to 2006. All tanks will be interim stabilized in the mid-1990's. An interim-stabilized tank contains 114 m^3 (30,000 gal) of drainable, but not pumpable, liquid. The likelihood is that these leaks would not migrate to the water table, according to data from monitoring past leaks. Based upon past leaks of interim stabilized tanks, one new leaking SST would be predicted for each 2 yr of delay.

7.1.3 Worker Safety

This attribute measured the impact of the facility and process alternatives on worker safety. The occupational health and safety impacts of the alternatives were measured over the period of construction, transportation, and operation. The preferred alternatives are those that minimize the occupational risks. Scoring is influenced by the amount of construction required, age of the infrastructure, types of processes used, danger of materials being handled, and as low as reasonably achievable considerations. The measurements for assessing worker safety were the number of fatalities resulting from the following:

1. The routine radiological dose to workers during construction, operations, and transportation

2. Accidents exposing workers to hazardous chemicals

3. Nonradiological industrial accidents.

The radiological risk (in rems) was calculated as the dose received by the maximum exposed individual times the probability of the accident. This measurement was determined to be a nondiscriminator. The most significant impact to worker safety resulted from industrial accidents.

There were no significant differences in expected fatalities resulting from the routine radiological dose during construction, operation, and transportation between any of the alternatives. Alternatives that do not use the TRUEX process resulted in slightly higher fatalities. Expected worker fatalities resulting from exposure to routine radiological dose ranged from 1.1 to 2.2. A preliminary evaluation of fatalities resulting from routine exposure to chemicals was also performed. The team concluded that these impacts were significantly less than the other measures; therefore, no direct measurement of expected fatalities resulting from routine exposure to chemicals was provided.

The impact to the work force as a result of chemical hazards during accidents was measured in the expected fatalities to the maximum exposed individual as a result of accidental exposure to the chemicals used in the pretreatment process. The period of interest was the duration of the pretreatment operations. Although the TRUEX process uses more hazardous chemicals, the relatively small inventory results in approximately 10^{-1} expected fatalities. For alternatives using sludge washing, the expected fatalities are reduced to approximately 10^{-3}.

A calculation of the worker health effects was not possible for the radiological consequences to workers (worker population onsite is not well characterized in terms of their locations and emergency evacuation effectiveness). Consequently, the radiological accident consequences to workers was left in units of rem to the maximum exposed individual. This still resulted in a quantitative attribute for comparison purposes, but it was not directly comparable to the public accident risk values. There were minimal differences in exposure between alternatives.

Expected fatalities resulting from industrial accidents during construction, operation, and transportation dominated all other types of worker accidents. The postulated occurrences were based upon an estimate of manpower requirements and occupational fatality rates. The construction fatality incident rate was 0.034 fatalities/100 worker years (NSC 1985). The operations fatality incident rate was 0.0024 fatalities/ 100 worker years (O'Donnell and Hoy 1981). All of the calculations followed the same basic formula:

number of fatalities = (occupational fatality rate) x (manpower required)

The amount of construction and the operating life of the alternative were the major factors in determining the number of fatalities from industrial accidents. The number of fatalities ranged from 6.5 for B Plant (with TRUEX) as the processing facility to 11.7 for limited processing in HWVP and an NPF without TRUEX.

7.1.4 Compliance with Regulations

This attribute measured the difficulty and uncertainty in obtaining compliance with Federal, State, local, and contractor requirements. The requirements have changed significantly in the past few years. More changes are expected before a pretreatment facility becomes operational. It is difficult to retrofit existing facilities and obtain agreement that the facility is compliant. The alternatives that rely on the use of existing facilities present a much higher risk to the program. The ability of an alternative to adapt to the changing environment was scored high. A scale was constructed to measure the difficulty and uncertainty in obtaining compliance. The attribute was scored according to the following.

Points	Measurement
100	All new facility.
75	Use of DSTs with an all new facility.

50 Combination of old and new facilities.

25 Use of existing facilities.

0 Existing facility has a flaw that would preclude obtaining compliance.

New facilities will be subjected to regulatory review before and during construction. Although the DSTs are thought to be compliant, there is some risk that the support systems will need upgrades to be *Resource Conservation and Recovery Act of 1976* (RCRA) compliant. The use of newer facilities increases the likelihood of obtaining compliance.

7.2 TECHNICAL INTEGRATION

The technical integration portion of the expert evaluation process measured seven individual attributes that were collected into two major groups. The first group, contribution to other programs, consisted of four attributes: (1) ability of the alternative to process fuel currently stored at the Hanford Site, (2) ability of the alternative to process and blend the cesium and strontium capsules with other HLW for vitrification, (3) contribution of the alternative to the SST disposal program, and (4) ability of the alternative to contribute to the near-term resolution of the tank safety problems. The second group, technical assurance, consisted of three attributes: (1) maturity, (2) adaptability, and (3) reliability.

Although the seven technical integration attributes did not have unique quantitative data upon which they could be evaluated, qualitative scoring rules with a numerical value for each measure were established and used in the evaluation process. A summary of the scores for each attribute for each of the 16 alternatives is presented in Table 7-6.

Because the technical integration attributes were quite qualitative in nature, the expert evaluation team selected was highly experienced in all aspects of the disposal of tank waste. The team consisted of technical experts from both Westinghouse Hanford Company (Westinghouse Hanford) and Pacific Northwest Laboratory. The range of technical expertise of the team varied from scientist to process designer and included vitrification, chemical separations, waste disposal, and waste management programs.

The definition and scoring rules for each technical attribute as well as a discussion of the evaluation by the team is contained in the following sections.

7.2.1 Process Stored Irradiated Fuel

This attribute measured the potential for an alternative to process the currently stored fuel for eventual disposal. The attribute measured the extent to which an alternative contributed processing and disposal capabilities, such as technology, facilities, and processing capacity. The attribute was scored according to the following.

Table 7-6. Attribute Scoring for Technical Integration.

Alternative	Description	Process stored irradiated fuel	Cesium and strontium	SST mission	Tank safety	Maturity	Adapt	Reliability
1	244-AR Vault/B Plant with TRUEX	100	100	50	0	63	67	56
2	DST/B Plant with TRUEX	100	100	50	0	61	67	56
3	DST/B Plant without TRUEX	100	100	0	0	59	75	57
4	DST/NPF with TRUEX	100	50	100	0	64	98	81
5	DST/Intermediate processing/NPF with TRUEX	100	50	100	0	61	94	78
6	DST/NPF without TRUEX	100	50	0	0	59	94	79
7	DST/Intermediate processing/NPF without TRUEX	100	50	0	0	51	86	75
8	DST/PUREX Plant with TRUEX	0	50	50	0	61	80	61
9	DST/PUREX Plant without TRUEX	0	50	0	0	59	81	64
10	DST/HWVP without TRUEX	100	50	0	0	59	94	79
11	DST/B Plant (limited)/NPF with TRUEX	100	100	100	0	64	94	75
12	DST/B Plant (limited)/NPF without TRUEX	100	100	0	0	59	89	71
13	DST/HWVP (limited)/NPF with TRUEX	100	50	100	0	64	98	81
14	DST/HWVP (limited)/Intermediate processing/NPF with TRUEX	100	50	100	0	61	94	78
15	DST/HWVP (limited)/NPF without TRUEX	100	50	0	0	59	94	79
16	NPF with TRUEX	100	50	100	0	64	96	80

NOTE: Limited means limited pretreatment capabilities, which includes cesium ion exchange and sludge washing only.
DST = Double-shell tank
HWVP = Hanford Waste Vitrification Plant
NPF = New pretreatment facility
PUREX = Plutonium-Uranium Extraction
SST = Single-shell tank
TRUEX = Transuranic extraction.

Points	Measurement
100	Alternative enables stored fuel to be processed with little or no impact.
50	Alternative enables stored fuel to be processed, but with some impact (e.g., time delay).
0	Alternative does not permit stored fuel processing in any facilities used.

Because the Plutonium-Uranium Extraction (PUREX) Plant is the only facility at the Hanford Site that currently possesses fuel processing capability, all alternatives that did not use the PUREX Plant for pretreatment were considered to have the ability to process the stored fuel. These alternatives were considered to maintain that capability fully and thus permit the processing of the stored fuel without any impact. The alternatives that used the PUREX Plant (alternatives 8 and 9) were considered to remove that capability completely and thus could not process stored fuel.

7.2.2 Processing of Cesium and Strontium Capsules

This attribute measured the potential of the alternative to process and vitrify the ^{90}Sr and ^{137}Cs capsules. The attribute measured the extent of the contributions (i.e., facilities, technology, and processing capacity) and is scored according to the following.

Points	Measurement
100	Alternative fully accommodates processing of capsules with little or no impact.
50	Alternative accommodates processing of capsules but with some impact (i.e., availability of feed that will allow blending of high-heat capsules causing a schedule delay).
0	Alternative does not accommodate processing of capsules.

The alternatives that used B Plant as an operating facility were judged to possess the full capability for processing capsules. The alternatives that did not use B Plant as an operating facility were judged to possess the capability but with some impact. For these alternatives, the Waste Encapsulation and Storage Facility (WESF) would be available to process the capsules into a solution for feed, but time would be required to construct a support facility for WESF (to provide services currently rendered by B Plant) and also construct waste transfer lines between the support facility and the HWVP.

7.2.3 Contribution to the Single-Shell Tank Mission

This attribute measured the potential of the alternative to contribute to the final remediation of SSTs. The attribute measured the extent to which the alternative contributed capability or capacity. Again, facilities, technology, and processing capacity were considered. The attribute was scored according to the following.

Points	Measurement
100	Alternative accommodates or can be expanded easily to process all 149 SSTs.
75	Alternative accommodates or can be expanded easily to process up to half (approximately 75) SSTs.
50	Alternative accommodates or can be expanded easily to process up to 25 SSTs.
0	Alternative makes no contribution to the remediation of the SSTs.

Because the TRUEX process is an essential part of the SST remediation program and keeps the overall cost and schedule within reason, the non-TRUEX alternatives were not considered as contributing. For these alternatives, a pretreatment facility containing a TRUEX process would have to be built for the SST remediation program. All alternatives that contained an NPF with a TRUEX process sized to process all SST wastes were considered as fully contributing to the SST remediation program. The alternatives that used B Plant or PUREX Plant with a TRUEX process were expected to be capable of processing up to half of the SST wastes.

7.2.4 Resolution of Near-Term Tank Safety Issues

This attribute measured the relative ability of the alternatives to contribute to the near-term (5-yr) resolution of the tank safety issues. This attribute was scored according to the following.

Points	Measurement
+100	Alternative contributes to the near-term resolution of the tank safety issues.
0	Alternative is neutral to the resolution of tank safety issues.
-100	Alternative impacts the near-term resolution of tank safety issues negatively.

Although many of the alternatives can use solids from SSTs as feed to the HWVP through a sludge-wash-only scenario, none of the alternatives were considered to make a direct, early, significant contribution to the near-term resolution of the tank safety issues. The significant point is that none of the alternatives could process any SST waste before 1997 or 1998. This timing was outside the 5-yr window. Thus, all of the alternatives were scored as being neutral with regard to the near-term resolution of tank safety issues.

7.2.5 Maturity of the Technology

This attribute measured the maturity of the process technologies used in the alternatives and the integration of these processes into the specific facilities. An important aspect for this attribute was to measure the ability of the alternative to ensure hot startup of the HWVP, continuity of feed to the HWVP, and minimization of down time as a result of operating disruptions and process upsets. Technologies that have been used previously either at the Hanford Site or another site received a high score. Technologies that require significant development or scaleup received a lower score. The date the technology for a specific alternative was needed was also given consideration. If time was available within the alternative for development and the chances were high that the technology would mature within that timeframe, credit was given for that capability. In this manner, this attribute gave a measure of technical risk for the alternative.

The remaining three technical integration attributes were scored somewhat differently than the first four. In each attribute, the scoring rule was divided into two portions: a score for each of the basic unit processes and then that score was increased or decreased for a specific facility application. The final score for each alternative was developed from a composite of individual scores for the specific facility and process combination.

The following scoring was used for the maturity attribute.

Basic Process Technology--This portion of the scoring measured the maturity of the basic process technology without regard to implementation within a specific facility. This score evaluated the current process technology without considering future development.

Points	Measurement
100	The process technology is a fully demonstrated process for the waste types of interest. Actual demonstrated experience with full-scale operation at the Hanford Site exists.
80	The process technology is a fully demonstrated process for waste types similar to the waste types of interest. Actual demonstrated experience with full-scale operation at a site other than the Hanford Site exists.
60	The process has been demonstrated on a hot pilot-plant scale. The next step in development is plant design.
40	The process has been demonstrated in a hot bench-scale test. The next step is either a hot pilot plant or to proceed with plant design; if pilot-plant operation is deemed unnecessary.

20	The process has been demonstrated in the laboratory with either hot or simulated waste. Scaleup and hot pilot-plant operation is required.
10	The process has limited demonstration in the laboratory with simulated waste.
0	The process is an idea at the conceptual stage without any laboratory work.

Facility Application and Implementation--This portion of the scoring measured the maturity of the process as it is adapted to a specific facility. This portion also accounted for the ability of the base process technology to mature if used later in the program, as well as, the ability to apply improvements in equipment design. The base process technology score is increased or decreased according to the following.

Points	Measurement
+20	Significant increase in process maturity will be achieved and significant improvement in equipment design can be obtained.
+10	Some minor increase in the maturity of the process technology will be achieved by the time the process is implemented in the specific facility.
0	No improvement in the maturity of the process technology and no issues or concerns arise from the application or implementation in the specific facility.
-10	Some minor technical concerns or issues arise, but are not considered to require significant testing or development to resolve.
-20	A significant technical concern or issue arises out of the implementation of the process in the specific facility. Additional testing and/or development will be required to resolve the issue.

Table 7-7 presents a summary of the final scores for the maturity attribute together with a ranking of the alternatives in descending order of maturity. A review of the scoring for the maturity attribute reveals that there is only a 13-point (out of a possible 100) spread between all the alternatives. The evaluation team agreed that there was not a significant difference between any of the alternatives with regard to maturity. The process technologies used in all alternatives are currently at essentially the same level of maturity. It is important to note that some of the process technologies that would be used in all of the alternatives are quite immature and that development of these required technologies should proceed without delay. Organic destruction and neutralized cladding removal waste (NCRW) sludge washing are in this category.

Table 7-7. Facility and Process Score for Maturity Attribute.

Alternative	Score	Description
4	64	DST/NPF with TRUEX
11	64	DST/B Plant (limited)/NPF with TRUEX
16	64	NPF with TRUEX
13	64	DST/HWVP (limited)/NPF with TRUEX
1	63	244-AR Vault/B Plant with TRUEX
14	61	DST/Intermediate processing/HWVP (limited)/NPF with TRUEX
5	61	DST/Intermediate processing/NPF with TRUEX
8	61	DST/PUREX Plant with TRUEX
2	61	DST/B Plant with TRUEX
9	59	DST/PUREX Plant without TRUEX
6	59	DST/NPF without TRUEX
10	59	DST/HWVP without TRUEX
3	59	DST/B Plant without TRUEX
12	59	DST/B Plant (limited)/NPF without TRUEX
15	59	DST/HWVP (limited)/NPF without TRUEX
7	51	DST/Intermediate processing/NPF without TRUEX

NOTE: Limited means limited pretreatment capabilities, which includes cesium ion exchange and sludge washing only.

DST = Double-shell tank
HWVP = Hanford Waste Vitrification Plant
NPF = New pretreatment facility
PUREX = Plutonium-Uranium Extraction
TRUEX = Transuranic extraction.

Note, that all of the non-TRUEX alternatives ranked lower than the TRUEX alternatives on the maturity attribute. This was surprising and counter to the intuitive feeling of the evaluation team. However, on examination of the alternatives, it was noted that the non-TRUEX alternatives substitute two quite immature alternatives [i.e., NCRW sludge washing and Plutonium Finishing Plant (PFP) sludge washing] for the medium maturity TRUEX. Again, the degree of difference was small and may not be significant, but merely reinforced the need to proceed with the development of the immature processes.

7.2.6 Adaptability

This attribute measured the ability of the alternatives to accommodate changes such as feed composition, feed variability, additional radionuclides or chemical constituent removal, changes in regulatory requirements, additional processing modules, process modifications, and incorporation of new technologies. Facility and process alternatives with a high degree of flexibility and room for expansion would be favored as would facilities that meet regulatory requirements.

Again, as in the case of maturity, the adaptability was scored in two portions.

Basic Process Technology--This portion of the scoring measured basic process technology adaptability to accommodate the following subattributes:

- Ability to accommodate changes in feed composition and type
- Ability to accommodate variable feed and/or process control conditions (i.e., flexibility of the process control)
- Ability to expand or enhance the processes to provide additional radionuclides and/or chemical constituent removal
- Ability to implement or incorporate process modifications and emerging technologies.

Points	Measurement
100	Basic process has all of the desired characteristics.
75	Basic process has three of the desired characteristics.
50	Basic process has two of the desired characteristics.
25	Basic process has one of the desired characteristics.
0	Basic process does not have any of the desired characteristics.

Facility Application and Implementation--This portion of the scoring measured the change in adaptability of the basic process technology as it will be applied or implemented in a specific facility. In particular, the following attributes were evaluated:

- Additional space available within the facility to implement more unit processes
- Ability to make process routing changes
- Ability to implement change outs of unit processes
- Ability to incorporate new process technologies
- Ability to accommodate new regulatory and design requirements.

The basic process technology was scored according to the following.

Points	Measurement
+25	Possesses all subattributes
+10	Possesses ability to accommodate equipment and/or process changes, but is limited or constrained with regard to new regulations and requirements
0	Application or implementation with the facility is essentially neutral
-10	Facility degrades or constrains the flexibility and adaptability of the basic process.

Table 7-8 presents a summary of the final scores for adaptability and a descending ranking of the alternatives. The point spread (31 points out of a total of 100) for the adaptability attribute is considerably larger than for maturity. Also, the ranking and scoring shows a distinct advantage to new facilities that could more readily accommodate expansion and provide future flexibility.

7.2.7 Reliability

This attribute measured the reliability and forgiveness of the process technologies used in the alternatives. This measures the ability of the alternative to provide a continuous feedstream to HWVP and minimize overall system down time caused by equipment failures and/or process upsets. Those process technologies that have demonstrated a high degree of performance score high while those that have a low degree of performance score low. Again, the scoring rule for this attribute is divided into two portions.

Basic Process Technology--This portion of the scoring measured the reliability of the basic process technology irrespective of facility application or implementation. The following subattributes were evaluated:

- Ability of the process to function continuously with a variety of feed conditions
- Ability of the process to be insensitive to human error
- Simplicity of equipment, ease, and reliability of control.

Points	Measurement
100	Basic process has all desired attributes.
50	Basic process has the desired attributes to a lesser degree.
0	Basic process does not have any of the desired attributes.

Table 7-8. Facility and Process Score and Rank for Adaptability Attribute.

Alternative	Score	Description
4	98	DST/NPF with TRUEX
13	98	DST/HWVP (limited)/NPF with TRUEX
16	96	NPF with TRUEX
6	94	DST/NPF without TRUEX
14	94	DST/Intermediate processing/HWVP (limited)/NPF with TRUEX
15	94	DST/HWVP (limited)/NPF without TRUEX
11	94	DST/B Plant (limited)/NPF with TRUEX
5	94	DST/Intermediate processing/NPF with TRUEX
10	94	DST/HWVP without TRUEX
12	89	DST/B Plant (limited)/NPF without TRUEX
7	86	DST/Intermediate processing/NPF without TRUEX
9	81	DST/PUREX Plant without TRUEX
8	80	DST/PUREX Plant with TRUEX
3	75	DST/B Plant without TRUEX
1	67	244-AR Vault/B Plant with TRUEX
2	67	DST/B Plant with TRUEX

NOTE: Limited means limited pretreatment capabilities, which includes cesium ion exchange and sludge washing only.

DST = Double-shell tank
HWVP = Hanford Waste Vitrification Plant
NPF = New pretreatment facility
PUREX = Plutonium-Uranium Extraction
TRUEX = Transuranic extraction.

Facility Application and Implementation--This portion of the scoring measured the change in reliability of the basic process technology as it is applied or implemented in a specific facility. This portion measured the ability of a newer facility to implement state-of-the-art equipment and process control as well as any degradation of reliability that an older facility might contribute. The following subattributes were evaluated:

- Equipment maintainability
- Basic facility reliability

- Inherent facility flexibility that would allow process configuration changes leading to continued operation while equipment repairs were being carried out.

The basic process technology score was measured as follows.

Points	Measurement
+25	Facility significantly improves overall reliability by possessing the desired attributes.
0	Facility does not impact the reliability of the basic process.
-25	Facility significantly degrades reliability of the basic process.

Table 7-9 presents a summary of the final scores for reliability and also provides a descending ranking of the alternatives. Again, as with adaptability, the point spread (25 points out of a total of 100) was significant. New facilities again showed an advantage because new equipment could be used.

7.3 SCHEDULE AND COST

This section provides a comparison of operational schedules and costs for the 16 facility and process alternatives for tank wastes defined in Section 6.2. Cost estimates are preliminary and should be used for comparison only. Evaluation of the alternatives is based on 10 key attributes associated with cost and schedule.

Schedule	Cost
HWVP start date	Life-cycle cost for DST mission
SST closure date	Life-cycle cost for DST and SST mission
DST mission completion	Peak annual cost
HWVP operation continuity	Annual percent cost increase
SST vitrification completion	Community economic impact

Because the attributes for schedule and cost are quantitative in nature, no attempt has been made to rank or to apply scores to the alternatives. The MAU analysis applied weighting factors, based on stakeholder values, to the cost and schedule attributes. These weighting factors for cost and schedule, when added to the qualitative and scored results for the remainder of the attributes, provided rankings for the alternatives.

Table 7-10 summarizes the key cost and schedule attributes for the 16 alternatives. Operational schedules for the alternatives are shown in Figures 7-1 through 7-16.

Table 7-9. Facility and Process Score and Rank for Reliability Attribute.

Alternative	Score	Description
4	81	DST/NPF with TRUEX
13	81	DST/HWVP (limited)/NPF with TRUEX
16	80	NPF with TRUEX
10	79	DST/HWVP without TRUEX
15	79	DST/HWVP (limited)/NPF without TRUEX
6	79	DST/NPF without TRUEX
5	78	DST/Intermediate processing/NPF with TRUEX
14	78	DST/Intermediate processing/HWVP (limited)/NPF with TRUEX
7	75	DST/Intermediate processing/NPF without TRUEX
11	75	DST/B Plant (limited)/NPR with TRUEX
12	71	DST/B Plant (limited)/NPF without TRUEX
9	64	DST/PUREX Plant without TRUEX
8	61	DST/PUREX Plant with TRUEX
3	57	DST/B Plant without TRUEX
1	56	244-AR Vault/B Plant with TRUEX
2	56	DST/B Plant with TRUEX

NOTE: Limited means limited pretreatment capabilities, which includes cesium ion exchange and sludge washing only.

DST = Double-shell tank
HWVP = Hanford Waste Vitrification Plant
NPF = New pretreatment facility
PUREX = Plutonium-Uranium Extraction
TRUEX = Transuranic extraction.

Table 7-10. Cost and Schedule. (sheet 1 of 2)

Alternative	Description	Tri-Party Agreement milestone		Vitrification in HWVP		
		HWVP start date	SST closure date[a]	DST complete (year)	HWVP down time (months)[b]	SST complete (year)
1	244-AR Vault/B Plant with TRUEX	3/03	2025	2015	82	2046
2	DST/B Plant with TRUEX	12/99	2025	2015	122	2046
3	DST/B Plant without TRUEX	12/99	2025	2032	-0-	2063
4	DST/NPF with TRUEX	12/99	2025	2012	84	2043
5	DST/Intermediate processing/NPF with TRUEX	12/99	2025	2011	46	2042
6	DST/NPF without TRUEX	12/99	2025	2032	-0-	2063
7	DST/Intermediate processing/NPF with TRUEX	12/99	2025	2016	39	2049
8	DST/PUREX Plant with TRUEX	12/99	2055	2010	70	2041
9	DST/PUREX Plant without TRUEX	12/99	2025	2032	-0-	2063
10	DST/HWVP without TRUEX	12/01	2025	2034	-0-	2065
11	DST/B Plant (limited)/NPF with TRUEX	12/99	2025	2012	84	2043
12	DST/B Plant (limited)/NPF without TRUEX	12/99	2025	2032	-0-	2063
13	DST/HWVP (limited)/NPF with TRUEX	3/01	2025	2012	74	2043
14	DST/Intermediate processing/HWVP (limited)/NPF with TRUEX	3/01	2025	2011	53	2042
15	DST/HWVP (limited)/NPF without TRUEX	3/01	2025	2033	-0-	2064
16	NPF with TRUEX	10/08	2025	2013	16	2049

Table 7-10. Cost and Schedule. (sheet 2 of 2)

Alternative	Description	Cost			FY 1992 to FY 1996 expense		Community economic impact; reduction from peak labor force
		DST $93(B)	DST and SST $93(B)	Peak $93(M)	Average annual increase (%)	Maximum annual site budget increase (%)	People
1	244-AR Vault/B Plant with TRUEX	9.1	39.1	603	34	8.7	2,640
2	DST/B Plant with TRUEX	9.2	39.2	565	37	10.8	2,570
3	DST/B Plant without TRUEX	13.9	44.9	568	36	11.2	2,420
4	DST/NPF with TRUEX	12.1	38.1	708	37	9.8	3,130
5	DST/Intermediate processing/NPF with TRUEX	12.4	38.4	707	37	9.8	3,070
6	DST/NPF without TRUEX	16.5	47.5	596	37	9.8	2,170
7	DST/Intermediate processing/NPF with TRUEX	12.4	43.4	599	37	9.8	2,550
8	DST/PUREX Plant with TRUEX	10.8	40.8	673	31	9.7	3,420
9	DST/PUREX Plant without TRUEX	16.3	47.3	666	29	9.8	2,830
10	DST/HWVP without TRUEX	14.0	45.0	627	29	8.9	2,710
11	DST/B Plant (limited)/NPF with TRUEX	12.4	38.4	707	26	10.8	3,130
12	DST/B Plant (limited)/NPF without TRUEX	16.9	47.9	601	42	10.8	2,080
13	DST/HWVP (limited)/NPF with TRUEX	12.4	38.4	741	33	11.5	3,300
14	DST/Intermediate processing/HWVP (limited)/NPF with TRUEX	12.5	38.5	707	33	11.5	3,120
15	DST/HWVP (limited)/NPF without TRUEX	16.8	47.8	640	32	12.4	2,430
16	NPF with TRUEX	11.9	37.9	895	28	12.9	4,030

[a]All alternatives can meet 2018 SST closure by accelerating SST ROD to 1996, scheduling residual DST wastes at the end of the partitioning campaign, or by constructing new DSTs (30-50).
[b]The excessive HWVP down time can be reduced 39 months by adding sludge washed tank 241-C-106 waste to the scope.
NOTE: Limited means limited pretreatment capabilities, which includes cesium ion exchange and sludge washing only (alternatives 11-15).

DST = Double-shell tank
FY = Fiscal year
HWVP = Hanford Waste Vitrification Plant
NPF = New pretreatment facility
PUREX = Plutonium-Uranium Extraction
SST = Single-shell tank
Tri-Party Agreement = Hanford Federal Facility Agreement and Consent Order
TRUEX = Transuranic extraction.

Figure 7-1. Operational Schedule for B Plant/244-AR Vault with Transuranic Extraction (Alternative 1).

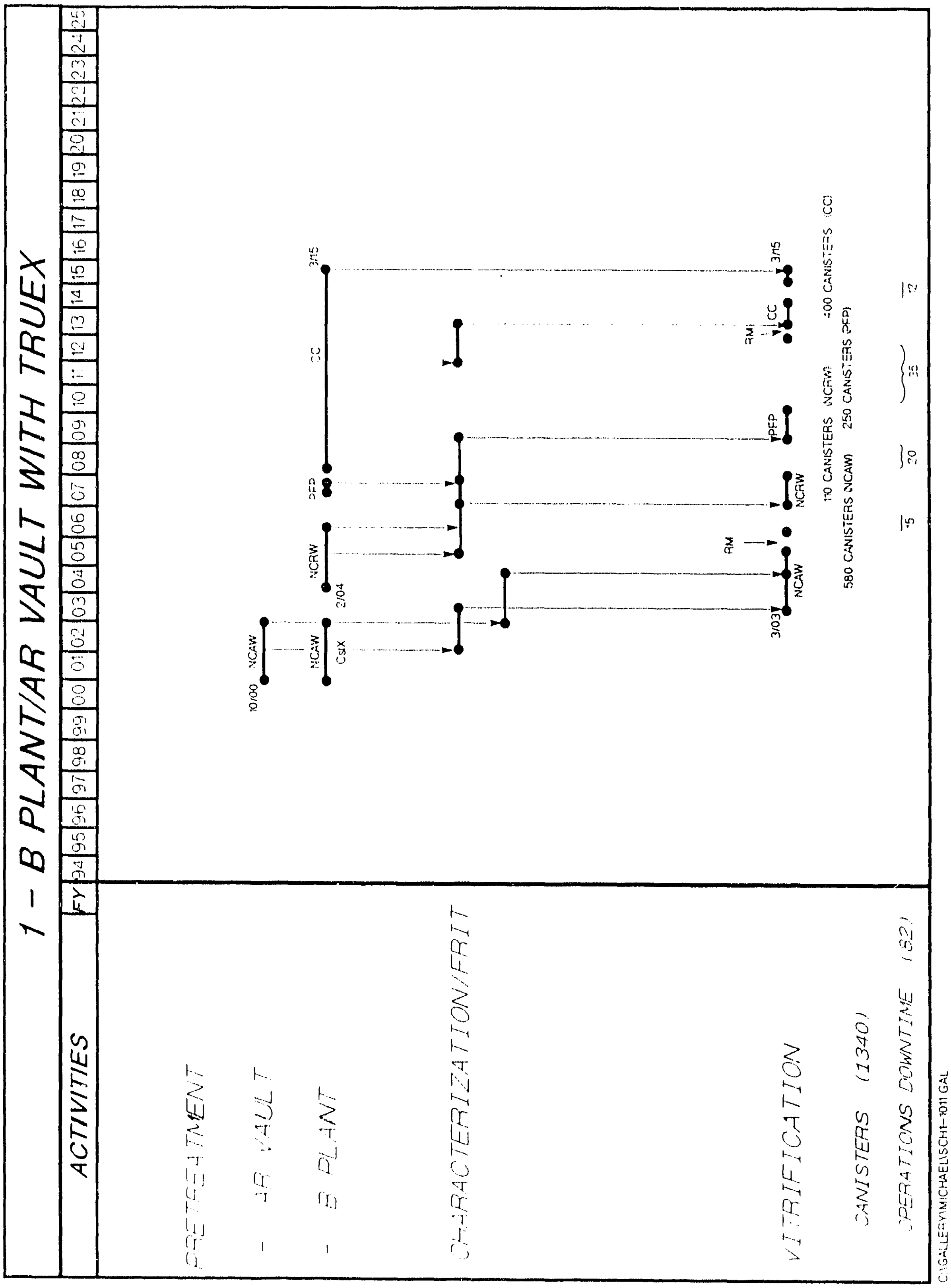


Figure 7-2. Operational Schedule for Double-Shell Tank/
B Plant with Transuranic Extraction (Alternative 2).

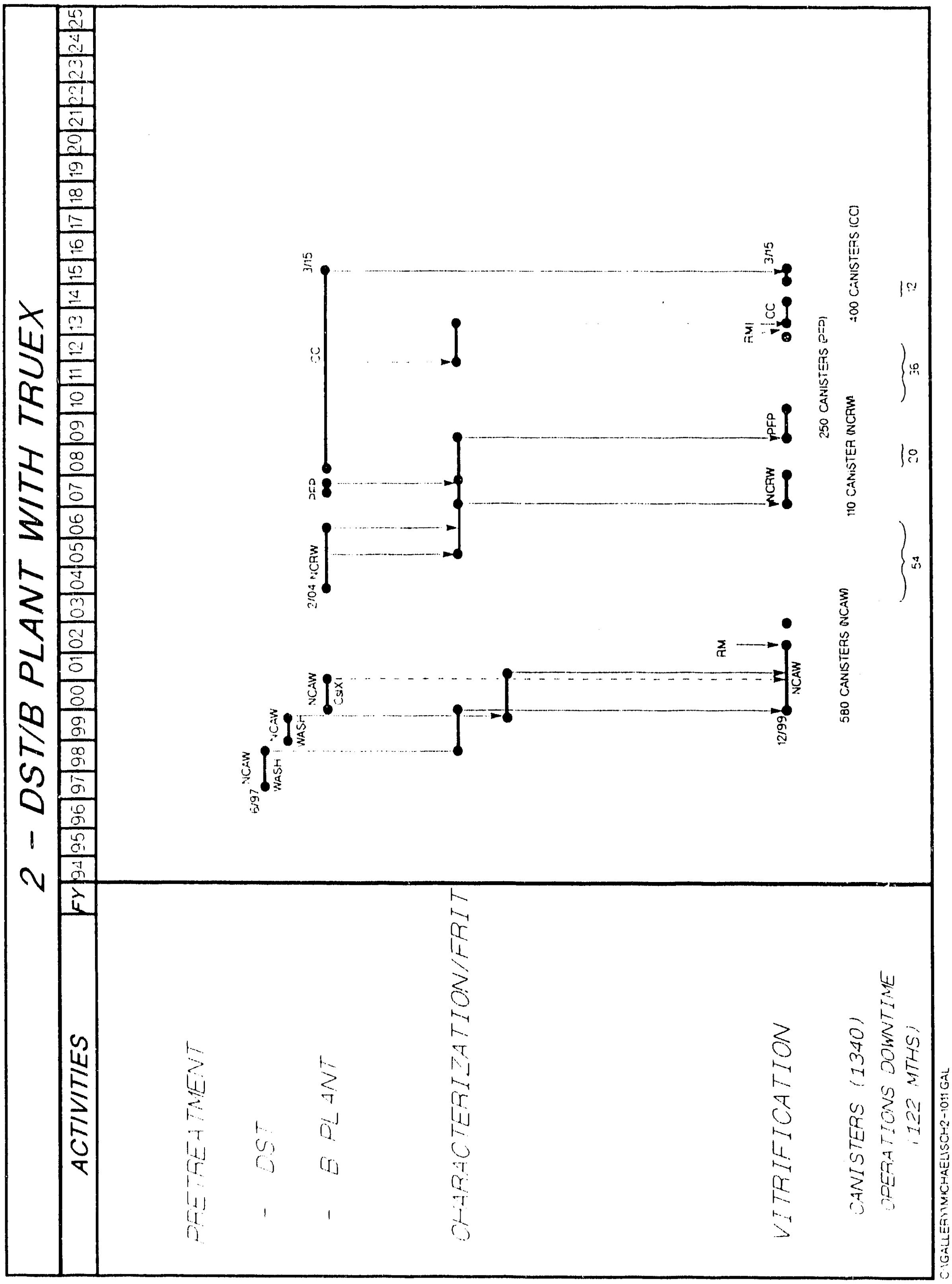


Figure 7-3. Operational Schedule for Double-Shell Tank/B Plant without Transuranic Extraction (Alternative 3).

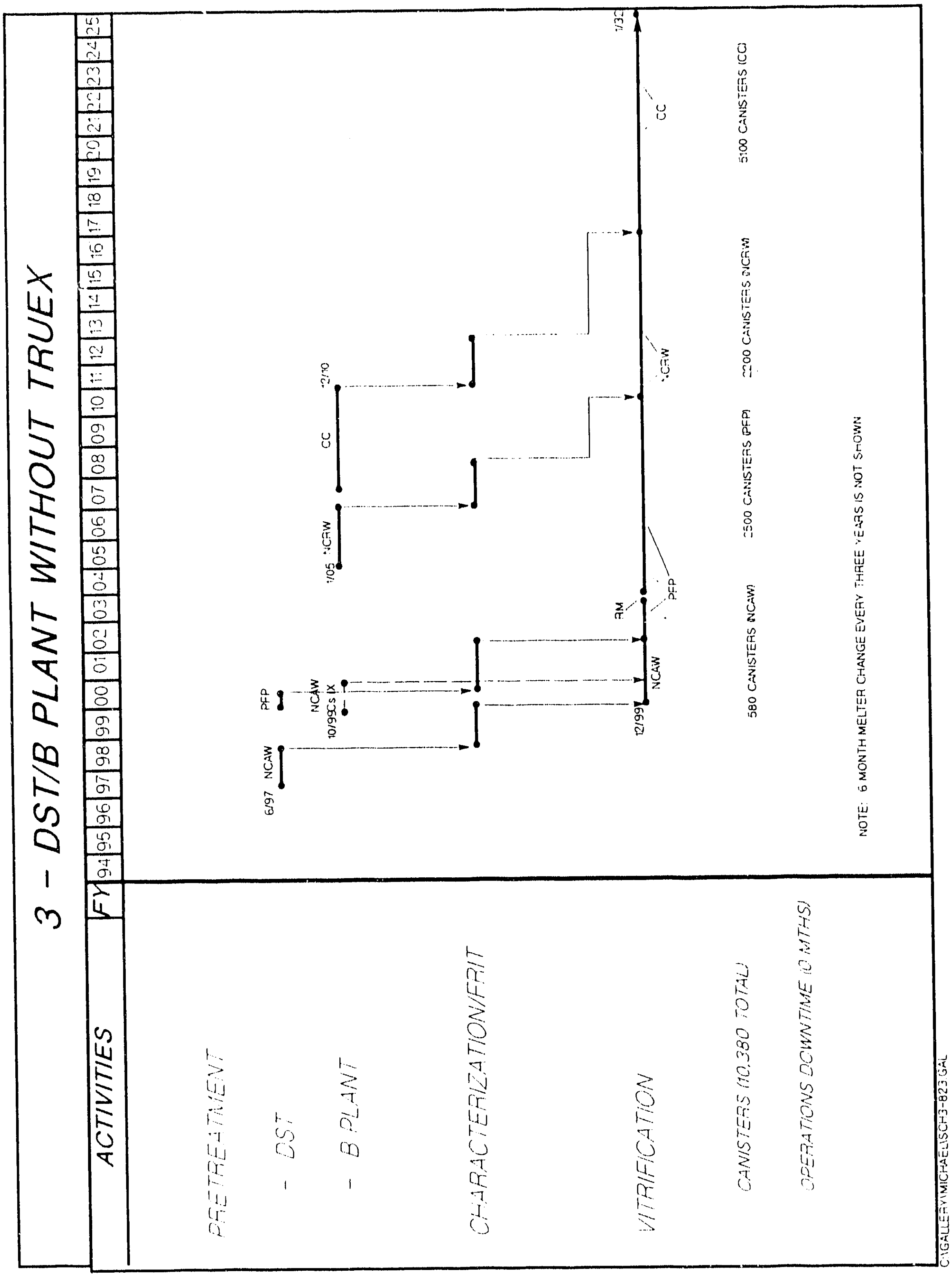


Figure 7-4. Operational Schedule for Double-Shell Tank/New Pretreatment Facility with Transuranic Extraction (Alternative 4).

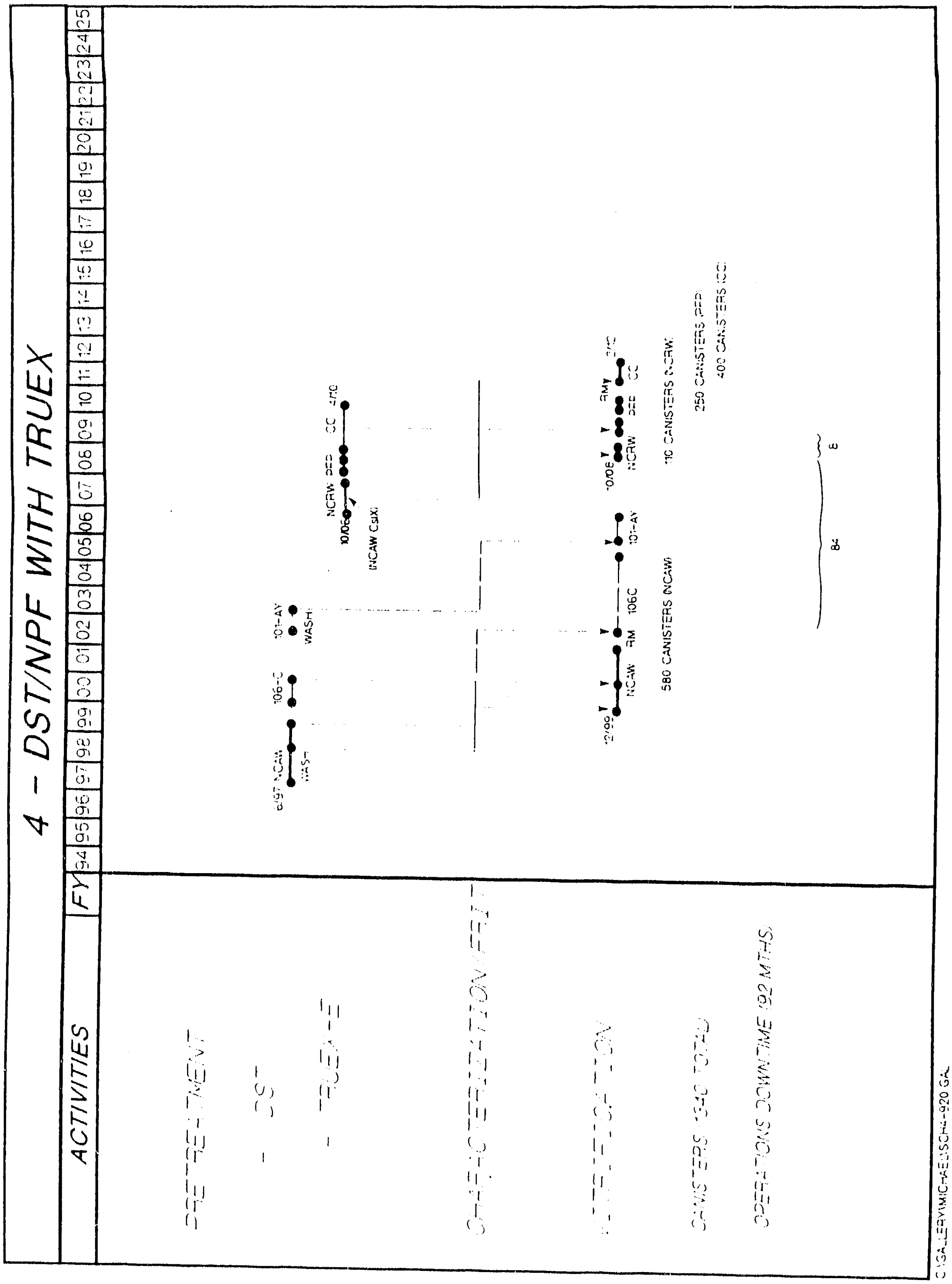


Figure 7-5. Operational Schedule for Double-Shell Tank/Intermediate Processing/New Pretreatment Facility with Transuranic Extraction (Alternative 5).

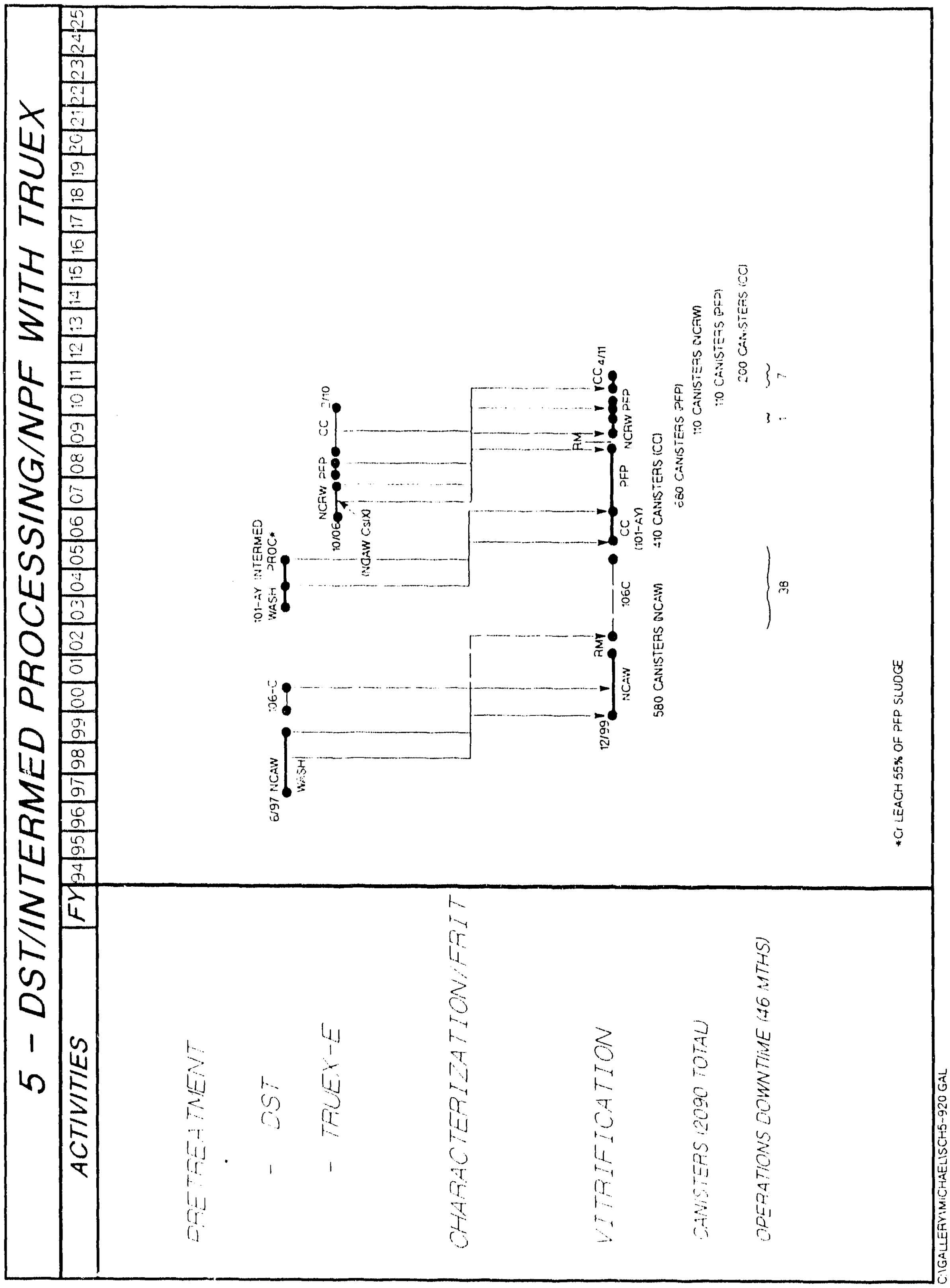


Figure 7-6. Operational Schedule for Double-Shell Tank/New Pretreatment Facility without Transuranic Extraction (Alternative 6).

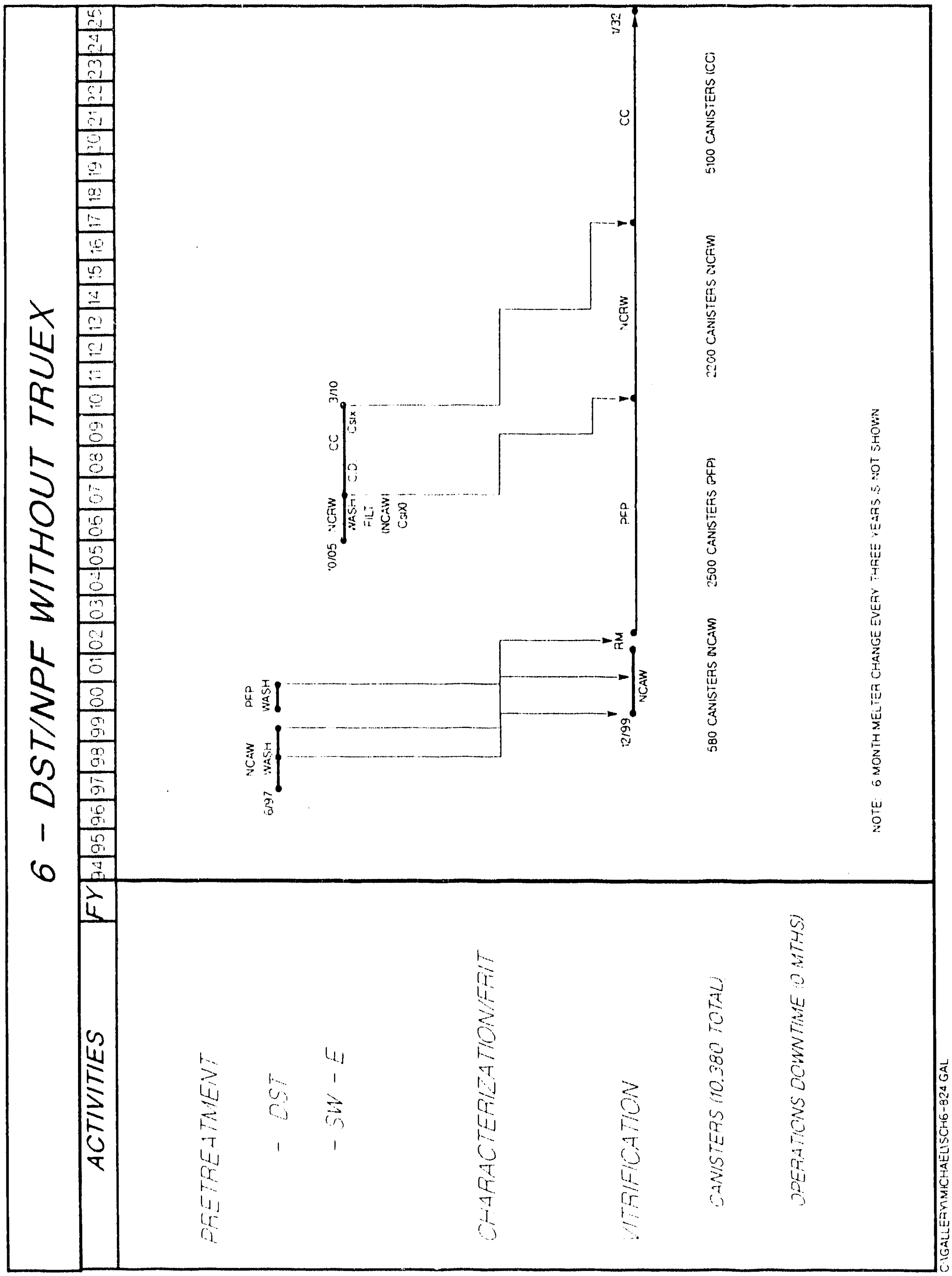


Figure 7-7. Operational Schedule for Double-Shell Tank/Intermediate Processing/New Pretreatment Facility without Transuranic Extraction (Alternative 7).

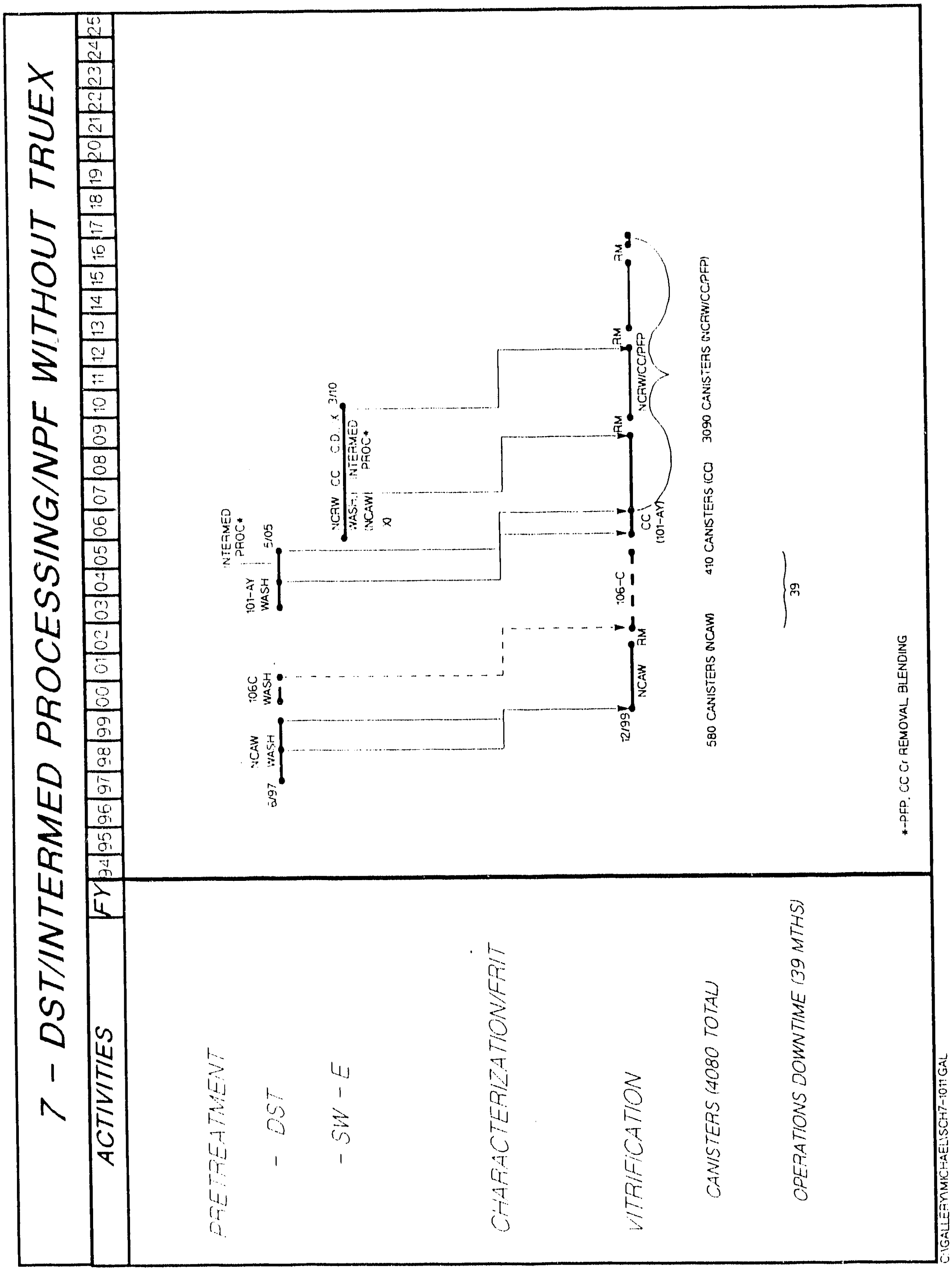


Figure 7-8. Operational Schedule for Double-Shell Tank/Plutonium-Uranium Extraction Plant with Transuranic Extraction (Alternative 8).

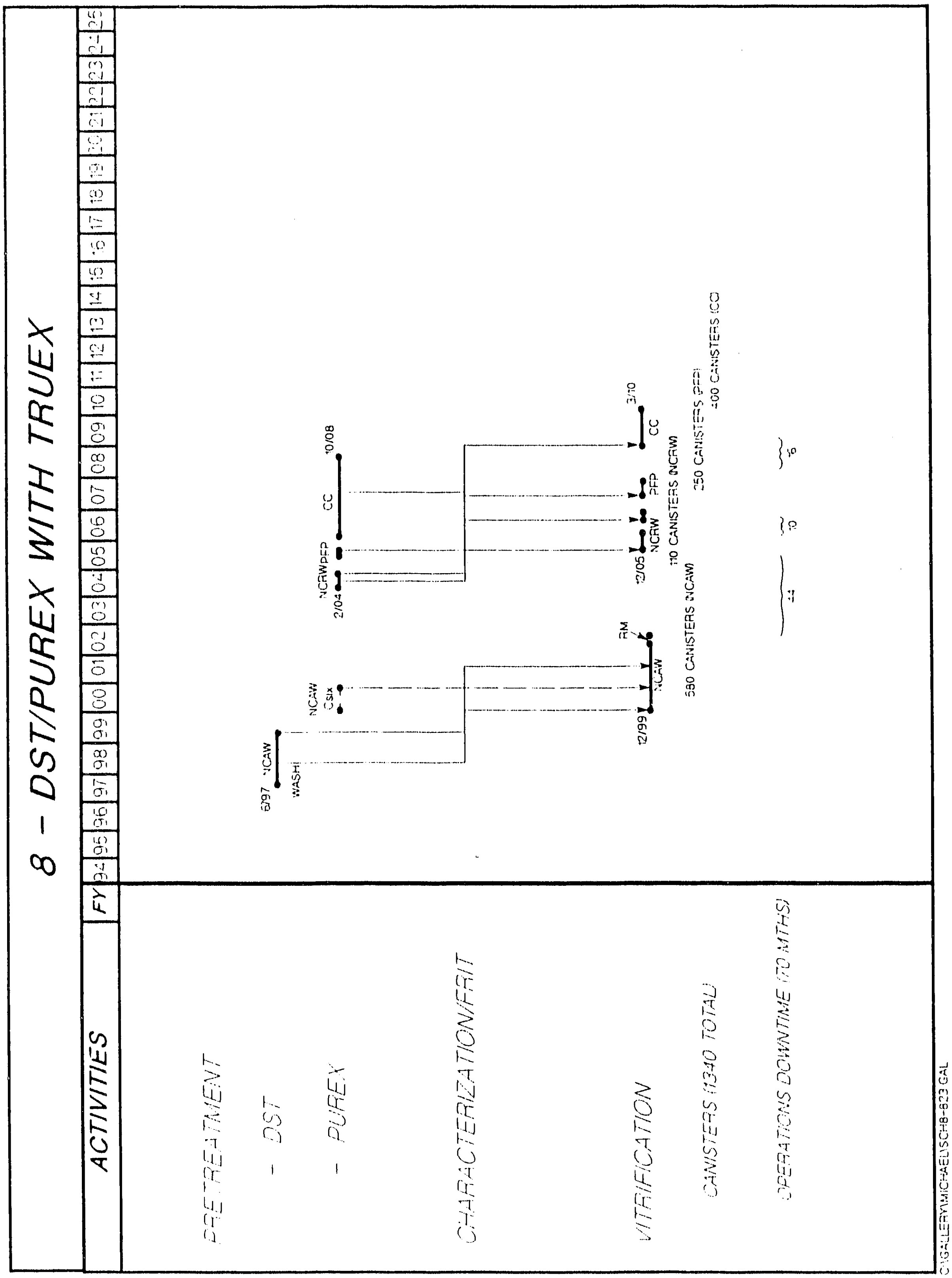


Figure 7-9. Operational Schedule for Double-Shell Tank/Plutonium-Uranium Extraction Plant without Transuranic Extraction (Alternative 9).

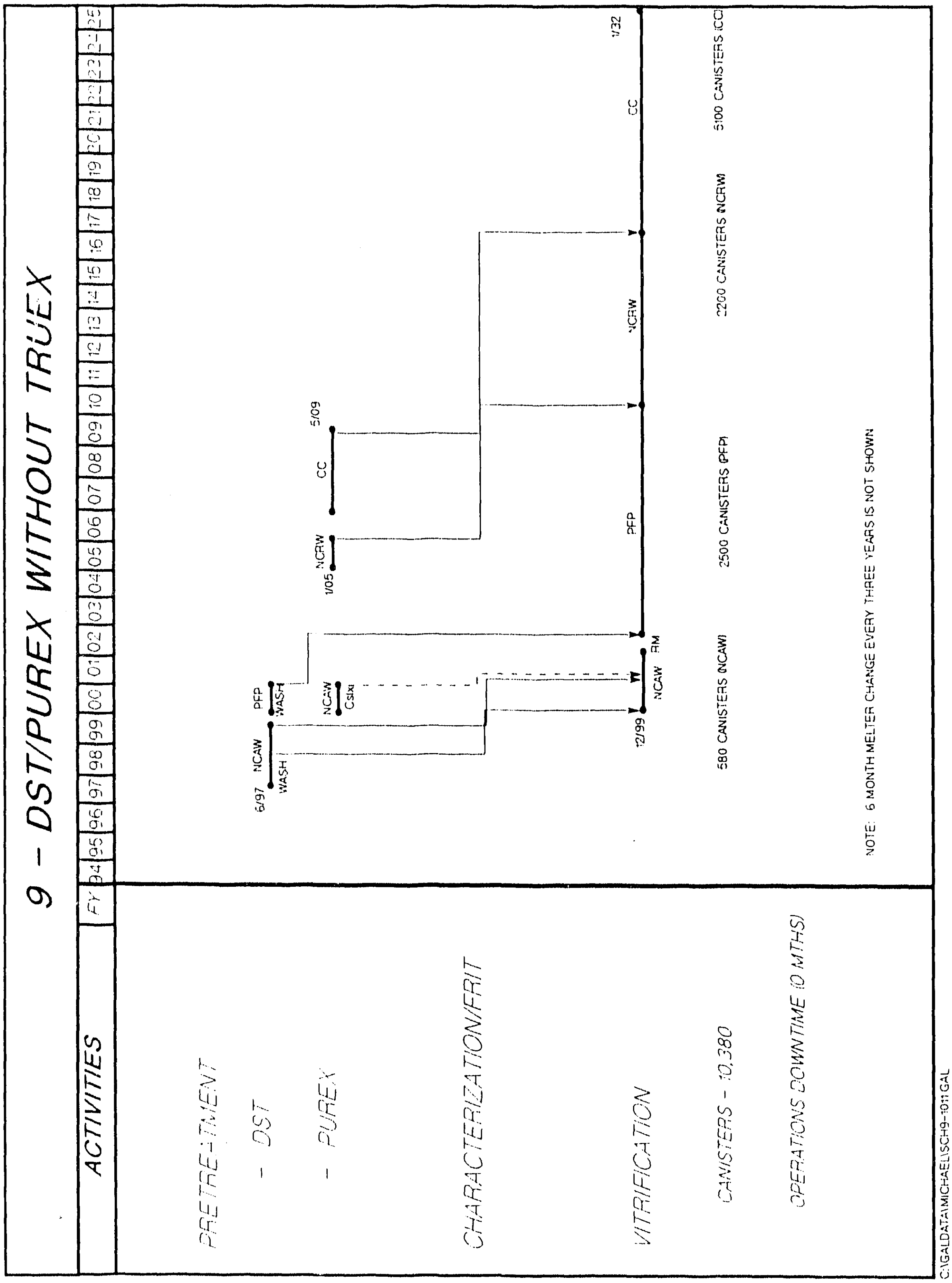


Figure 7-10. Operational Schedule for Double-Shell Tank/Hanford Waste Vitrification Plant without Transuranic Extraction (Alternative 10).

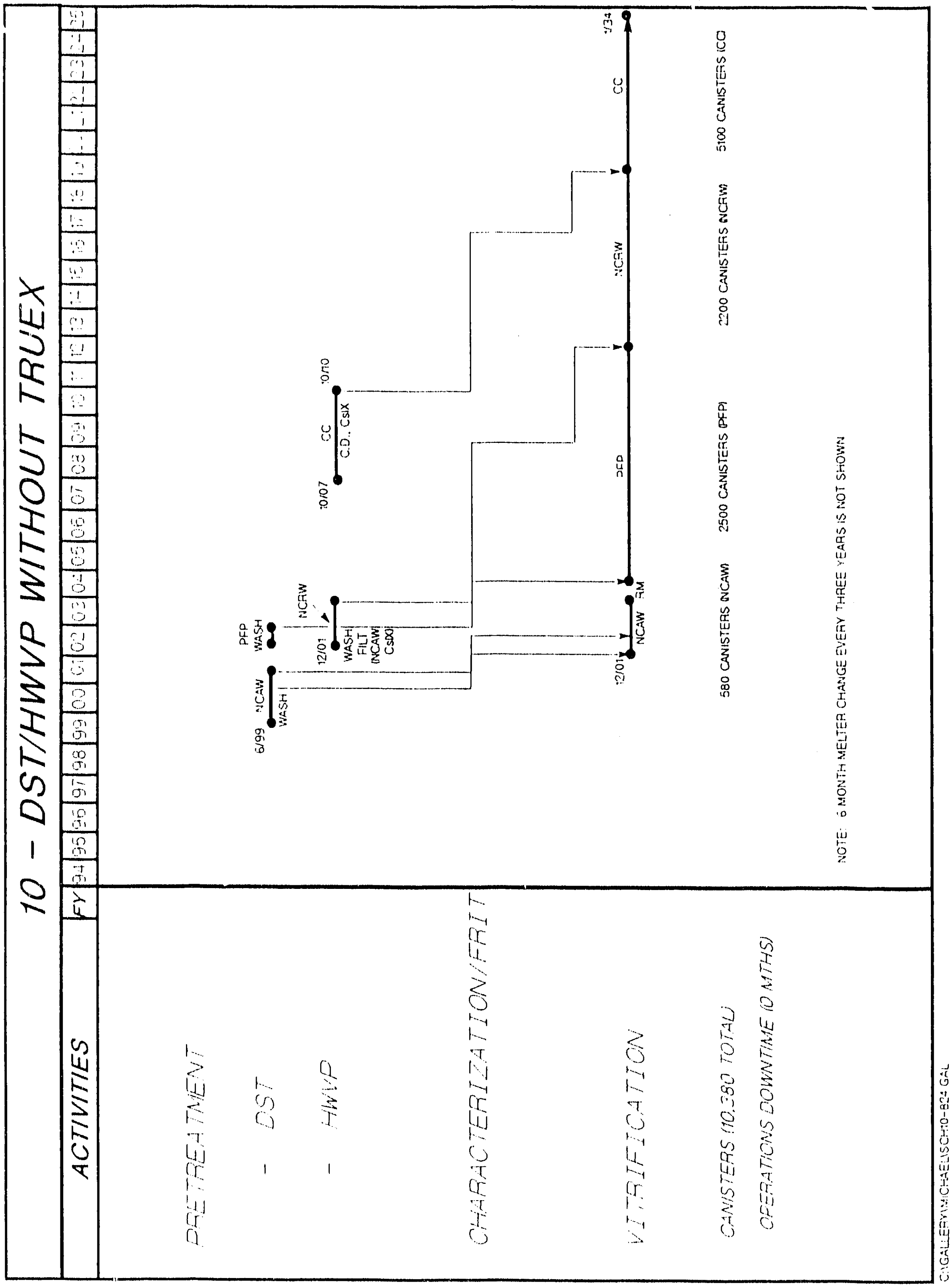


Figure 7-11. Operational Schedule for Double-Shell Tank/ B Plant (Limited)/New Pretreatment Facility with Transuranic Extraction (Alternative 11).

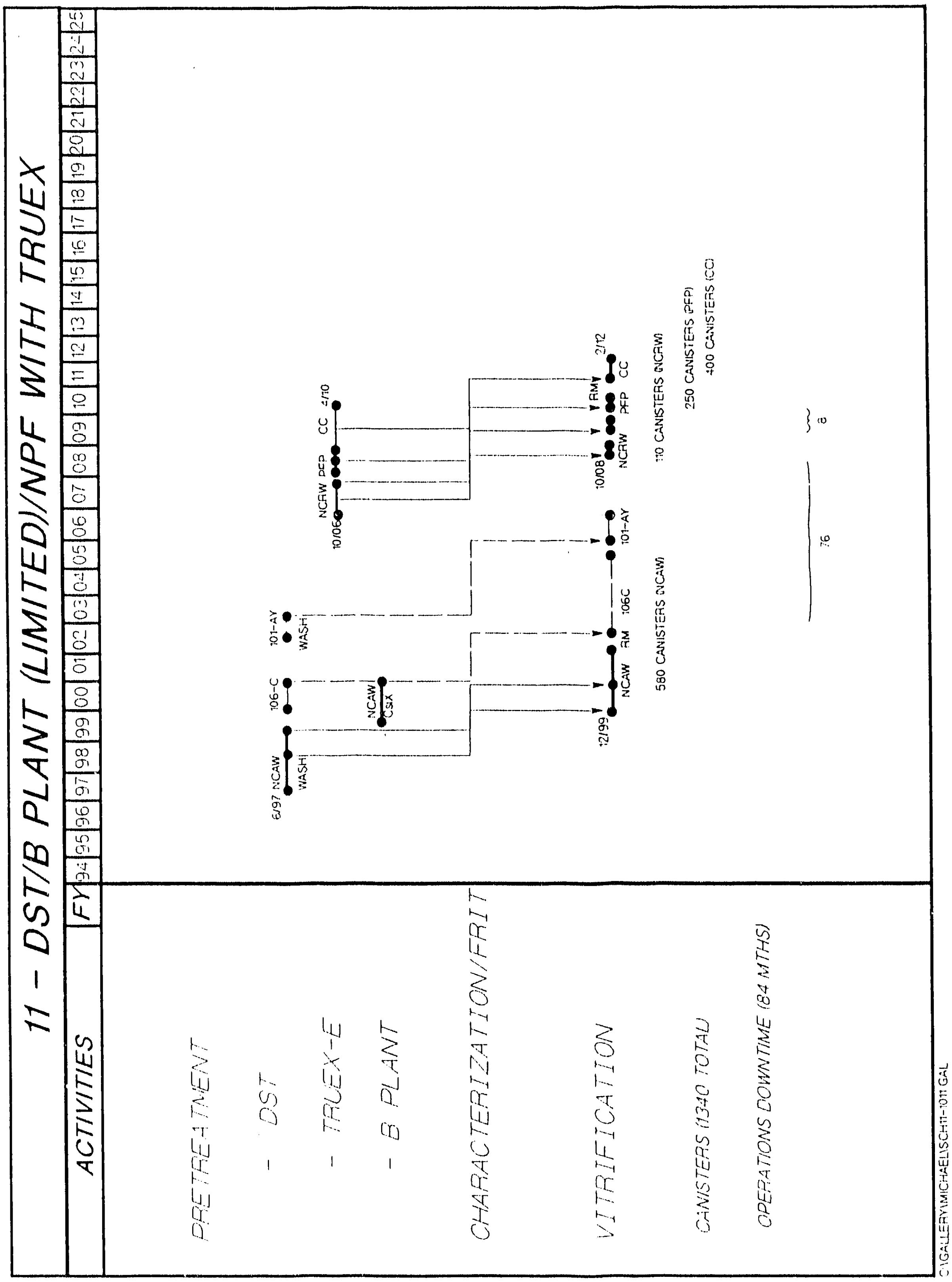


Figure 7-12. Operational Schedule for Double-Shell Tank/ B Plant (Limited)/New Pretreatment Facility without Transuranic Extraction (Alternative 12).

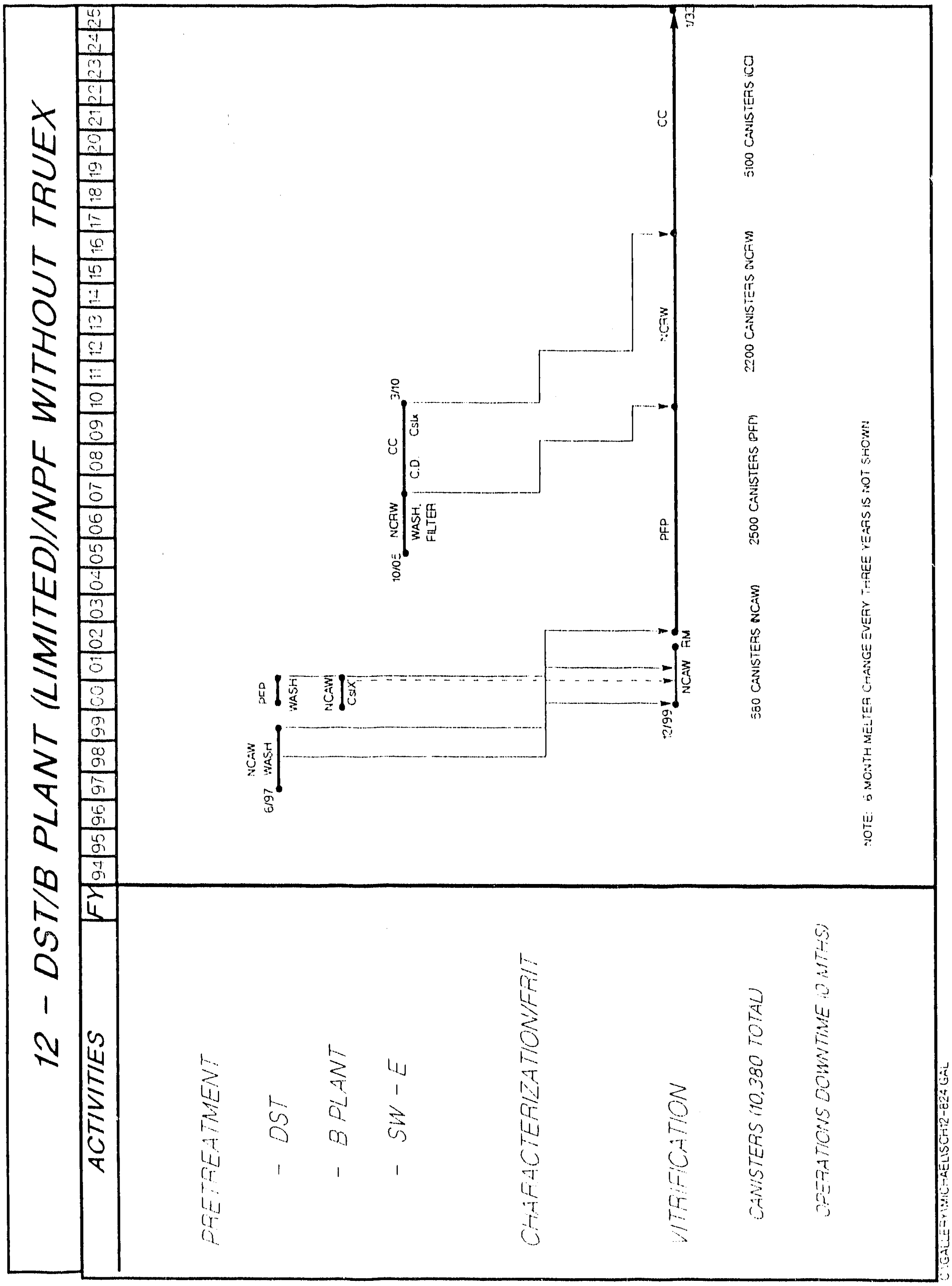


Figure 7-13. Operational Schedule for Double-Shell Tank/Hanford Waste Vitrification Plant (Limited)/New Pretreatment Facility with Transuranic Extraction (Alternative 13).

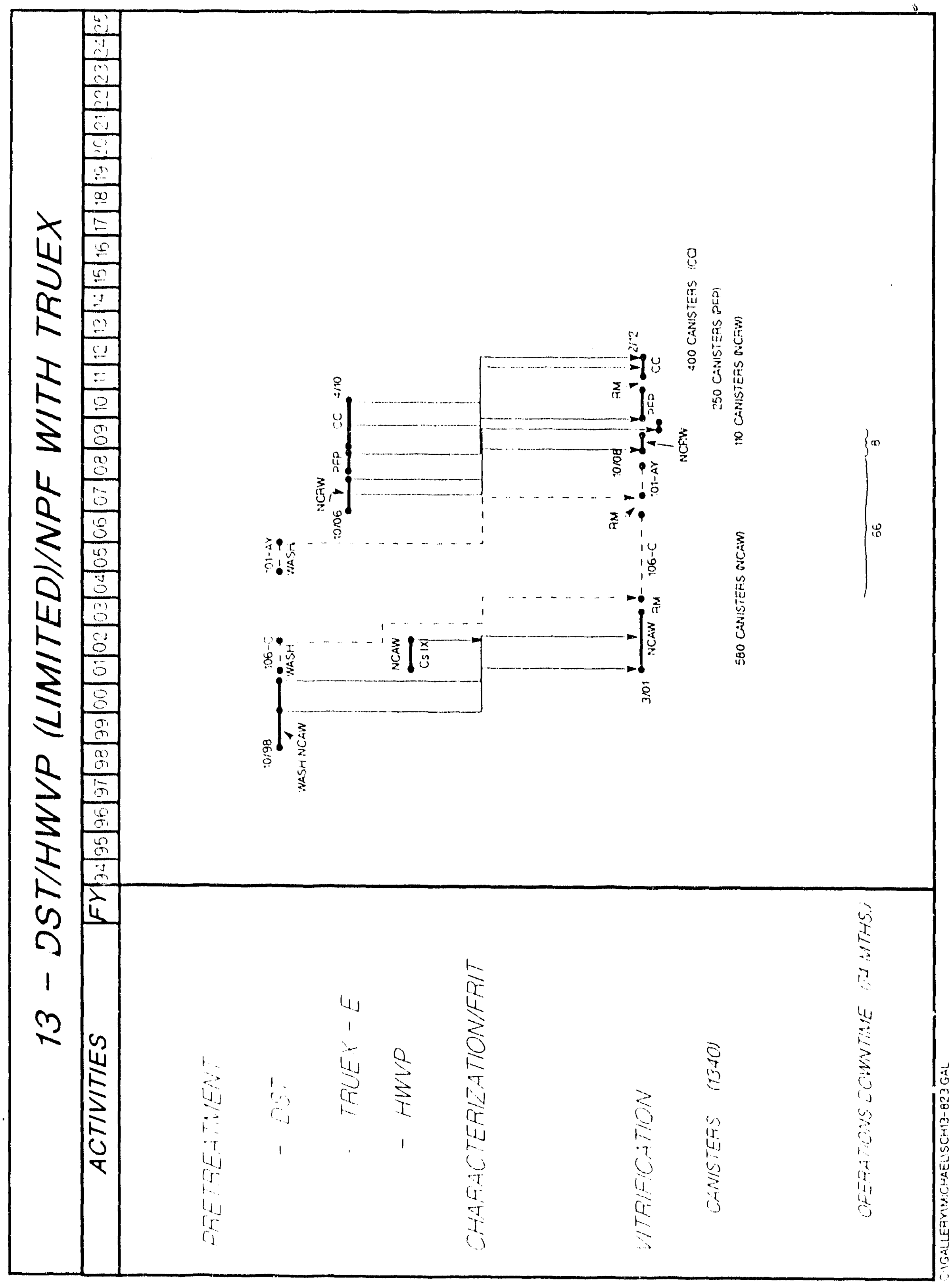


Figure 7-14. Operational Schedule for Double-Shell Tank/ Intermediate Processing/Hanford Waste Vitrification Plant (Limited)/New Pretreatment Facility with Transuranic Extraction (Alternative 14).

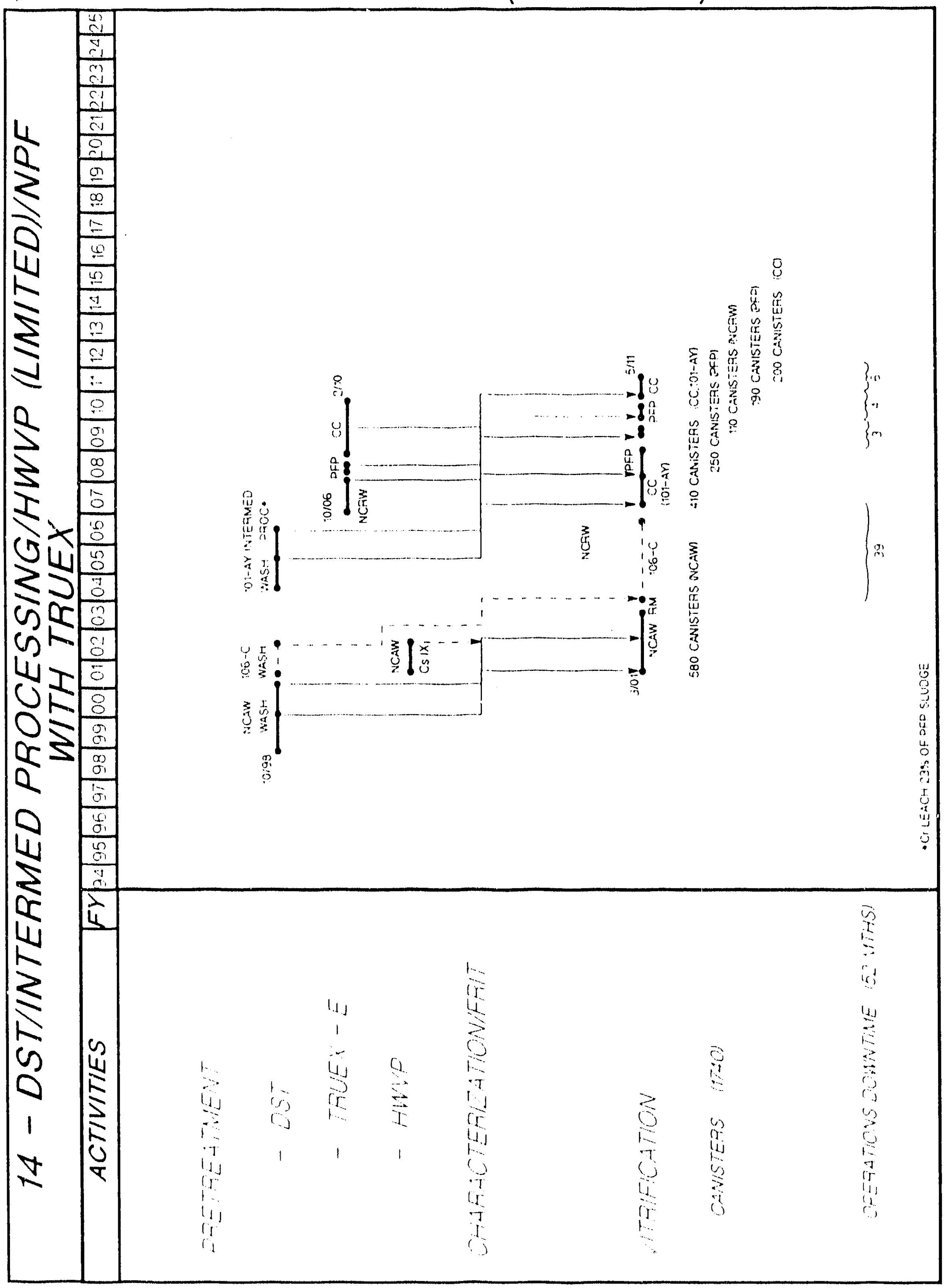


Figure 7-15. Operational Schedule for Double-Shell Tank/Hanford Waste Vitrification Plant/New Pretreatment Facility without Transuranic Extraction (Alternative 15).

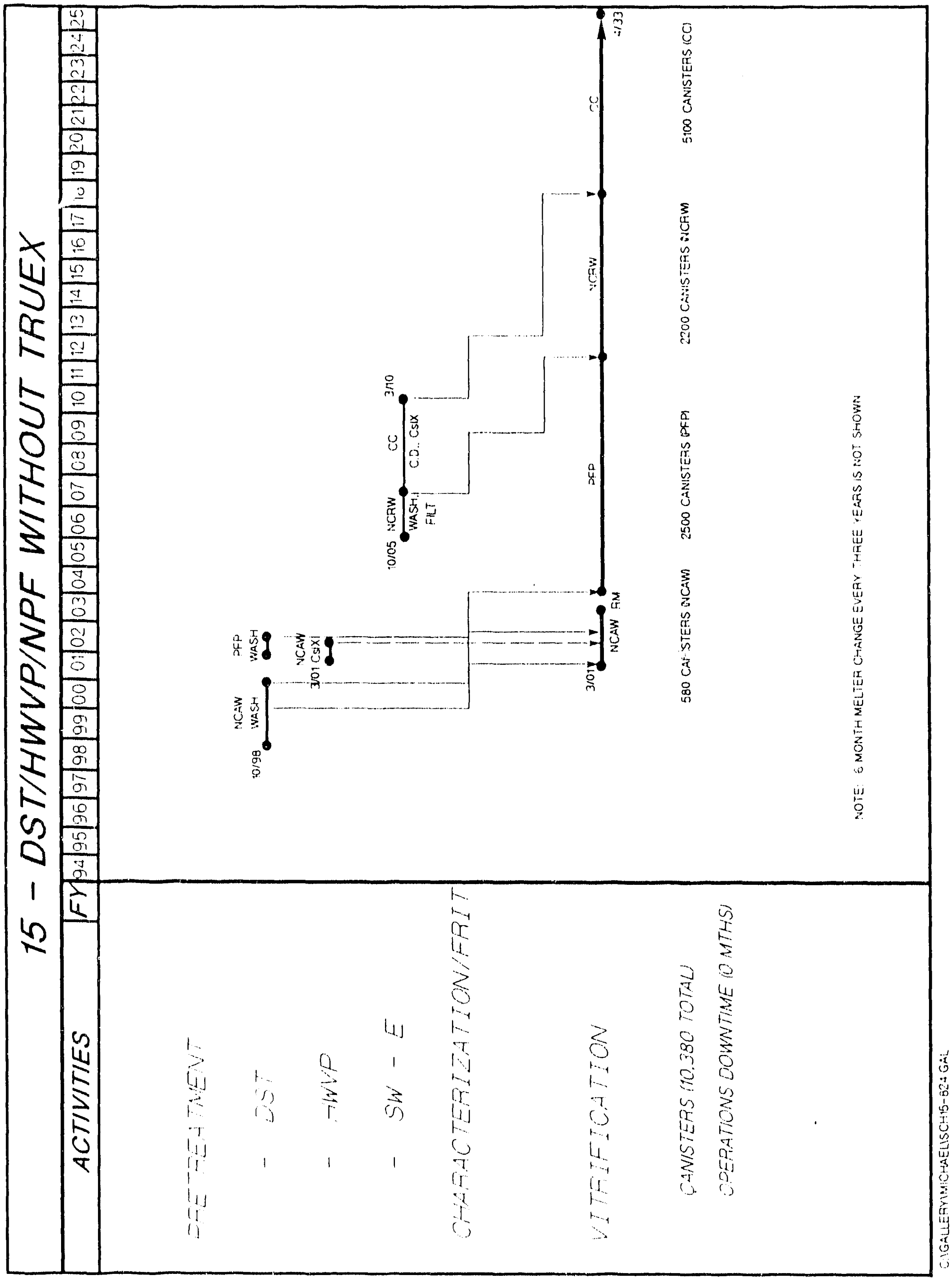
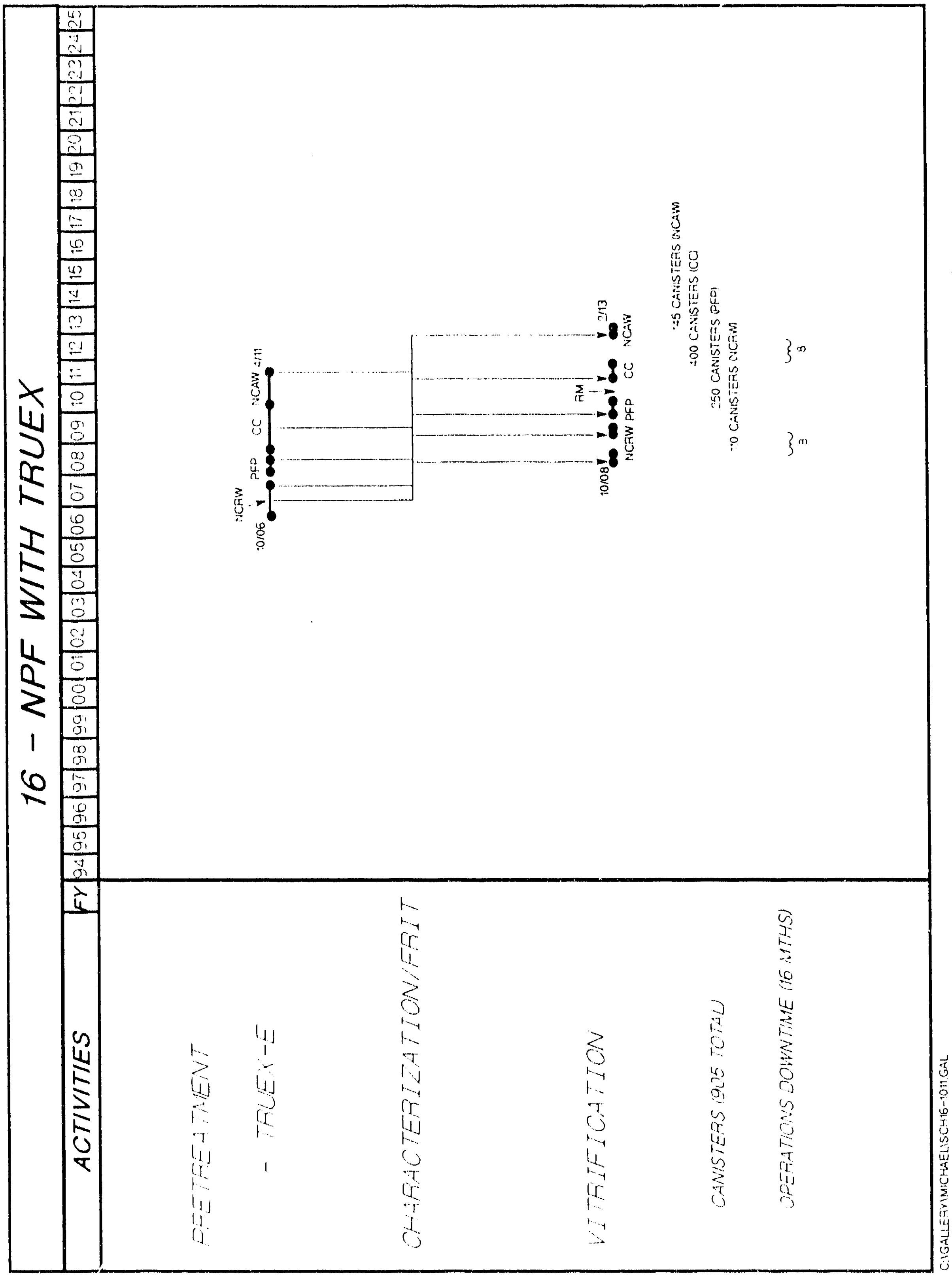


Figure 7-16. Operational Schedule for New Pretreatment Facility with Transuranic Extraction (Alternative 16).



7.3.1 Schedule

The assumptions used in development of the operational schedules and performance of the alternatives with respect to achieving *Hanford Federal Facility Agreement and Consent Order* (Tri-Party Agreement) (Ecology et al. 1990) milestones and completion of the vitrification mission are discussed in the following paragraphs.

7.3.1.1 Schedule Assumptions. General and specific schedule assumptions including those for technology, retrieval, pretreatment facility, characterization, and vitrification are discussed below.

Applied Engineering and Technology Assumptions

- A TRUEX process pilot plant and bench-scale melter for waste form qualification testing are installed in B Plant and/or WESF for all of the alternatives.

- For TRUEX process pretreatment alternatives, pilot-plant results are available in January 1998 to initiate design for a fiscal year (FY) 1998 line item in existing facility alternatives, or for design of a FY 1997 line item in NPF alternatives.

Retrieval Assumptions

- The neutralized current acid waste (NCAW) retrieval system for tank 241-AZ-101 is available in June 1997 for in-tank washing operations.

- Other retrieval systems are available as required to support the facility and process alternatives.

Pretreatment Facility Assumptions

- The startup date for an NPF that uses the TRUEX process[1] for DST waste is estimated to be FY 2007. The startup date for a sludge washing NPF is FY 2006 (Section 6.5.2.7).

- Alternatives that include SST processing assume that a record of decision (ROD) on the supplemental environmental impact statement (SEIS) for SSTs will be complete in FY 2003. These alternatives also assume that the decision is made to retrieve and process the waste. An ROD recommending retrieval and pretreatment of SST wastes will require a TRUEX NPF to pretreat the SST waste (Boomer et al. 1991). If a TRUEX NPF was constructed for the DST mission, this same NPF would be used for the SST mission. However, if an existing facility or a sludge washing NPF was used for DST waste pretreatment, then the TRUEX NPF for SST waste also must be constructed. If the ROD is complete in 2003, the TRUEX NPF for SST waste would not be operational until FY 2013. For the basis of

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[1]For convenience, such a facility is referred to as a TRUEX NPF in further discussions.

this document, it was assumed that DST waste pretreatment will not be deferred for processing in a TRUEX NPF that will start up in 2013. The implications of an ROD being completed in 1996 are addressed in Section 7.3.1.2.

- With limited modifications, DSTs are assumed to be suitable for conducting in-tank washing for some intermediate pretreatment processes or, as an alternate, one of four planned new DSTs is available for this purpose.

- Facility pretreatment time cycles are derived from equipment sizing and flowsheet information described in Section 6.5.2.2.

- For alternatives that use existing facilities, a 6-month transition period between pretreatment of waste types has been assumed. New facility alternatives require a 3-month transition period. This transition period allows for conversion to the new waste type. Less time is assumed to be required for a new facility.

Characterization and Frit Procurement Assumptions

- For all of the alternatives, an 18-month period is required to allow characterization of pretreated wastes and procurement of glass frit.

Vitrification Assumptions

- Operational schedules (see Figures 7-1 through 7-16) were prepared to show the earliest HWVP start dates for each alternative, ignoring standby time at HWVP. Standby time is a consequence of lack of pretreated waste available for vitrification. Some schedules (e.g., Figure 7-4) show dashed lines where HWVP continuity gaps could be filled using alternate wastes, for example, SST 241-C-106.

- Total vitrification time cycles for each pretreated DST waste are based on canister estimates from Section 6.4.3.

- Vitrification rates are 290 canisters/yr for pretreated NCAW and 370 canisters/yr for other pretreated DST wastes.

- A 6-month outage has been allowed after every 3 yr of melter operation for replacement of the melter.

7.3.1.2 **Compliance with Tri-Party Agreement Milestones.** Two major Tri-Party Agreement (Ecology et al. 1990) milestones are associated with the tank waste disposal mission:

M-03-00 Initiate hot operations (vitrification) with pretreated NCAW, December 31, 1999

M-09-00 Complete closure of all 149 SSTs, June 2018.

7.3.1.2.1 **HWVP Start Date (M-03-00).** All of the alternatives except alternatives 1 (baseline), 10, and 13 through 16 meet the December 1999 milestone date for HWVP startup. All of the alternatives that meet the

December 1999 startup date (alternatives 2 through 9, 11, 12) provide washed NCAW as feed using in-tank DST washing. Mixer pumps are scheduled to be installed to retrieve the NCAW in tank 241-AZ-101 in FY 1996. Washing of the NCAW sludge would be performed in FY 1997 to provide adequate time for characterization and qualification of the pretreated waste before vitrification (see Figure 7-2).

Only alternatives with DST sludge washing in FY 1997 can provide feed to HWVP to support the M-03-00 milestone of December 1999. A changeover to in-tank sludge washing rather than using 244-AR Vault as the baseline NCAW washing approach is required to meet the milestone. The baseline (see Figure 7-1, alternative 1) will delay startup of vitrification by 3.5 yr, from December 1999 to March 2003, because of extensive requirements for upgrading the 244-AR Vault for sludge washing and settle-decant operations with NCAW.

Alternatives that use the HWVP for DST waste pretreatment (alternatives 10, 13, 14, and 15) will not support HWVP startup in December 1999 because of the required design changes that result from adding a pretreatment annex. Alternative 10, which treats DST waste in an HWVP annex using the sludge-washing approach, would delay HWVP startup 2 yr (see Figure 7-10). Alternatives 13, 14, and 15 use an NPF with an HWVP annex that performs only cesium ion exchange treatment of the NCAW supernatant. Again, because of the design change requirements to the HWVP for performing cesium ion exchange, an estimated 15-month delay in the start of vitrification results.

For alternative 16, vitrification does not begin until feed is pretreated in a TRUEX NPF. Vitrification startup is delayed approximately 9 yr because the TRUEX NPF does not start up until FY 2007.

7.3.1.2.2 Ability to Meet SST Closure Date (M-09-00). The Tri-Party Agreement milestone (Ecology et al. 1990) for SST closure is defined as closure of the tank farm site and ancillaries under the provisions of RCRA. The SST closure can be attained by (1) treatment and disposal of the wastes in place, or (2) retrieval of wastes from the tank and closure of empty tanks. The 2018 closure date does not require treatment of retrieved wastes by 2018. The Tri-Party Agreement schedule calls for a draft SEIS by June 2002 and ROD by 2003. If the ROD recommends in situ treatment and disposal, the 2018 closure date can be accomplished. If the ROD recommends retrieval and treatment of SST wastes, the earliest SST closure would be 2025 as shown in Table 7-10.

Acceleration of the SEIS ROD for SST waste has been proposed to meet the 2018 Tri-Party Agreement milestone date for closure of SSTs in the event that retrieval and treatment of SST waste is recommended. Using the schedule assumptions defined in Section 7.3.1.1, accelerating the SEIS to obtain an ROD in 1996 results in acceleration of the SST closure date to 2021. With the accelerated ROD, the TRUEX NPF is a FY 1997 line item and has a FY 2007 startup. The 2018 SST closure date can be met with a FY 2007 startup of a TRUEX NPF for all 16 alternatives by doing one of the following: (1) construction of approximately 40 additional DSTs to provide lag storage for retrieved SST wastes while the DST waste are processed in the NPF (schedule assumptions), or (2) by processing the SST waste first in the NPF followed by DST wastes. A significant assumption is that retrieval systems will be in place as scheduled.

7.3.1.3 HWVP Campaign Completion and Continuity. The completion date for DST and SST wastes vitrification in the HWVP as well as HWVP operations continuity are discussed in the following sections.

7.3.1.3.1 DST Mission Completion. Completion of the DST waste disposal mission is defined as completion of vitrification of pretreated DST waste. It is recognized that the canisters containing vitrified waste may be shipped to a geologic repository and the LLW fraction generated from pretreatment of DST wastes may be solidified after vitrification. However, the pretreated waste vitrification completion date represents achievement of a major goal in the DST waste disposal mission; solidification of the HLW and TRU waste fraction. Additionally, completion of DST waste vitrification represents the earliest date for initiating vitrification of pretreated SST wastes and influences closure of SSTs, a major Tri-Party Agreement milestone. Comparison of the DST mission completion dates for the facility and process alternatives measures performance toward achieving both DST and SST mission goals.

The dates for completion of DST waste vitrification for the 16 alternatives identified in Table 7-10 are summarized in Table 7-11 and discussed below.

Table 7-11. Double-Shell Tank Waste Vitrification Completion in the Hanford Waste Vitrification Plant.

Alternatives	Year complete	Percent of HWVP design life
TRUEX process	2010 to 2015	30
Intermediate sludge washing (NPF)	2016	45
Sludge washing	2032 to 2034	80

HWVP = Hanford Waste Vitrification Plant
NPF = New pretreatment facility
TRUEX = Transuranic extraction.

TRUEX Process Alternatives--All of the alternatives that use the TRUEX process (alternatives 1, 2, 4, 5, 7, 8, 11, 13, 14, 16) result in earlier DST mission completion dates than similar facility alternatives that use only sludge washing and intermediate processing. For the TRUEX process alternatives, completion of the DST mission occurs between FY 2010 and FY 2015, with PUREX Plant alternatives completing earliest, followed by alternatives that use an NPF alone or in combination with B Plant or an HWVP annex, and B Plant alternatives completing the latest (i.e., FY 2015). Vitrification of pretreated SST wastes can begin between FY 2010 to FY 2015. The differences in dates among facility alternatives that use the TRUEX process can be attributed to one of the following:

1. Equipment sizing restrictions in B Plant, which contribute to longer DST pretreatment process durations than in the PUREX Plant or in an NPF

2. Delay in pretreatment processing resulting from construction of an NPF or HWVP annex.

Intermediate Processing Alternatives--Intermediate processing in combination with sludge washing (alternative 7) shows a significant reduction in the number of canisters of vitrified waste produced compared to sludge washing alone. This alternative also completes the DST mission significantly earlier, approximately FY 2016. Approximately 4,080 canisters of vitrified waste are produced by conducting intermediate processing with selective DST wastes in conjunction with sludge washing of the remaining DST wastes.

Intermediate processing of selected wastes in conjunction with TRUEX processing of the remaining DST wastes (alternatives 5 and 14) complete the DST mission slightly earlier than alternatives that use only the TRUEX process because HWVP down time is reduced for these alternatives.

Sludge Washing Alternatives--Facility alternatives that use only sludge washing complete the DST mission between FYs 2032 to 2034. The sludge washing alternatives represent using approximately 80 percent (i.e., 32 yr) of the 40-yr design life of HWVP for vitrification of DST wastes. This is because of the large number (approximately 10,380) of canisters of vitrified waste produced.

7.3.1.3.2 SST Vitrification Completion. Relevant information concerning completion of SST waste vitrification in the HWVP is summarized in Table 7-12.

Table 7-12. Single-Shell Tank Waste Vitrification Completion in the Hanford Waste Vitrification Plant.

Double-shell tank alternative	SST ROD to retrieve (yr)	
	FY 2003	FY 1996
Transuranic extraction process	2049	2043
Intermediate processing	2049	2043
Sludge washing	2063 to 2065	2043

FY = Fiscal year
SST = Single-shell tank
ROD = Record of decision.

SEIS ROD Completed in 2003--The completion of SST vitrification in HWVP for this document assumes that pretreated SST wastes from a TRUEX NPF are vitrified in the HWVP after the DST wastes. The SST vitrification completion date is approximately 31 yr after the DST vitrification completion date due to the time required to vitrify 10,000 canisters of SST wastes.

An ROD completed in 2003 directing retrieval of SST wastes results in a 2013 startup of a TRUEX NPF and can provide pretreated HWVP feed in 2015. Optimization of NPF and HWVP processing schedules by treatment of remaining DST wastes in a TRUEX NPF can result in completion of SST vitrification in 2049.

SEIS ROD Completed in 1996--As discussed in Section 7.3.1.2.2, an SST retrieval ROD completed in 1996 could result in all DST alternatives using a TRUEX NPF with a FY 2007 start up. The SST vitrification completion date for all DST alternatives is estimated to be 2043.

7.3.1.3.3 HWVP Continuity of Operations. This attribute measured the continuity of HWVP operations for the DST mission. Operating down times are defined as those caused by lack of pretreated feed. Operating down times for the 16 alternatives are discussed in the following paragraph.

TRUEX Process Alternatives--If a TRUEX NPF is used to pretreat DST waste, significant down time will occur if the HWVP processes NCAW beginning in December 1999. For alternative 4 (see Figure 7-4), 7 yr of HWVP down time occurs because a TRUEX NPF does not begin pretreatment operations until FY 2007. However, after startup of a TRUEX NPF, pretreated feed to the HWVP is nearly continuous because the facility is sized to provide feed to support the 100 kg/h melter throughput. As addressed later in this document, strategies can be used that reduce HWVP down times for all cases that use the TRUEX process.

If HWVP operation is delayed until feed becomes available from a TRUEX NPF (see Figure 7-16, alternative 16) vitrification down time is minimal since the TRUEX NPF is sized to support the 100 kg/h melter. However, HWVP operations will not begin until FY 2009.

Significant down times occur for cases that implement the TRUEX process in the existing B Plant and PUREX facilities (see Figures 7-1, 7-2, and 7-8). The TRUEX process would not be implemented in either B Plant or PUREX Plant until FY 2004. If NCAW is vitrified during the period from December 1999 to December 2001, no pretreated feed becomes available again until nearly FY 2006. After the startup of B Plant, additional HWVP down time would occur because of equipment size restrictions that result in longer pretreatment process durations than for either the PUREX Plant or an NPF.

Intermediate Process Alternatives--The alternatives that combine intermediate processing with a TRUEX NPF result in less HWVP down time than for those cases that use the TRUEX process alone (e.g., compare Figure 7-4 with 7-5 and Figure 7-13 with 7-14). Thus, as described in Section 6.4.3, some processing of waste could be performed in a DST before startup of a TRUEX NPF. For example, PFP sludge could be leached to remove chromium and the washed sludge vitrified in the HWVP. Although down time in the HWVP would be reduced by intermediate processing of waste, additional canisters of glass, compared to pretreating PFP waste by the TRUEX process, likely would result.

Alternatives that combine intermediate processing with sludge washing result in more HWVP down time than for alternatives that use sludge washing alone (e.g., compare Figure 7-6 with 7-7). This increases down time by 39 months.

Sludge Washing Alternatives--As shown in Table 7-10, all of the alternatives that use sludge washing, that is no TRUEX process (3, 6, 9, 10, 12 and 15), provide continuous feed to HWVP and, thus, no HWVP down time (e.g., see Figure 7-3). The sludge washing alternatives result in approximately 10,380 canisters of glass from DST waste, and consequently a backlog of pretreated feed will generally be available for HWVP operation.

7.3.2 Cost

The assumptions used in estimating life-cycle cost and performance of the alternatives with respect to the cost-related attributes are discussed in the following paragraphs.

7.3.2.1 Cost Assumptions. Major assumptions and bases for estimating the operational and capital expenditures for the different alternatives are presented in Appendix F. Appendix F also provides detailed backup to the costs. More pertinent cost assumptions include the following.

Expense-funded costs are given in respective year dollars for FY 1991 and FY 1992, and in FY 1993 dollars thereafter. Capital costs are shown in FY 1991 dollars. Capital costs are shown in FY 1991 dollars for comparison of alternatives. Actual budgetary cost numbers will be different because of escalation and further refinement of cost estimates. Total program costs are used: costs for capital construction and/or upgrade of the facility; costs for waste treatment, vitrification, and grout operations; and costs for disposal in a geolgic repository. Costs judged to be minor are excluded from the analysis. Wherever applicable, existing construction project cost estimates are used; but for comparison purposes, these costs are de-escalated to FY 1991. Costs not related to the defense waste remediation mission are not shown (e.g., normal tank farm operations). Where portions of these costs were judged to be related to the disposal mission (e.g., waste retrieval operations and in-tank washing operations), only the additional costs over nonrelated costs are shown. Costs for closure of tanks are not included.

The cost assumptions for SST pretreatment used in this document are based on Boomer et al. (1991). The SST mission cost is assumed to be $26 to 31 billion (1991 capital and 1993 expense) for this document. The range of $26 to 31 billion is a function of the DST alternative as discussed in Section 7.3.2.3.1.

7.3.2.2 Life-Cycle Costs for DST Mission. Capital and expense costs for retrieval, treatment, vitrification, and disposal of DST wastes for the 16 facility and process alternatives are shown in Table 7-13. Total mission costs are also summarized in Table 7-13 and discussed below. Appendix F provides detailed backup data.

Table 7-13. Capital and Expense Costs for Double-Shell Tank Waste Disposal Alternatives.

Alternative	Description	Total cost[a] (billion dollars)		
		Capital	Expense	Total
1	244-AR Vault/B Plant with TRUEX	2.8	6.3	9.1
2	DST/B Plant with TRUEX	2.7	6.5	9.2
3	DST/B Plant without TRUEX	3.1	10.8	13.9
4	DST/NPF with TRUEX	4.3	7.8	12.1
5	DST/Intermediate processing/NPF with TRUEX	4.3	8.1	12.4
6	DST/NPF without TRUEX	4.4	12.1	16.5
7	DST/Intermediate processing/NPF without TRUEX	3.9	8.5	12.4
8	DST/PUREX Plant with TRUEX	2.8	8.0	10.8
9	DST/PUREX Plant without TRUEX	3.5	12.8	16.3
10	DST/HWVP without TRUEX	3.4	10.6	14.0
11	DST/B Plant (limited)/NPF with TRUEX	4.4	8.0	12.4
12	DST/B Plant (limited)/NPF without TRUEX	4.5	12.4	16.9
13	DST/HWVP (limited)/NPF with TRUEX	4.5	7.9	12.4
14	DST/Intermediate processing/HWVP (limited)/NPF with TRUEX	4.4	8.1	12.5
15	DST/HWVP (limited)/NPF without TRUEX	4.6	12.2	16.8
16	NPF with TRUEX	4.4	7.5	11.9

[a]Cost estimates are 1991 dollars for capital and 1993 dollars for expense-funded activites. These estimates are for comparison only and are not total estimated project or program costs at completion.

NOTE: Limited means limited pretreatment capabilities, which includes cesium ion exchange and sludge washing only.

DST = Double-shell tank
HWVP = Hanford Waste Vitrification Plant
NPF = New pretreatment facility
PUREX = Plutonium-Uranium Extraction
TRUEX = Transuranic extraction.

The DST mission costs for alternatives that use the TRUEX process are typically $2 to 6 billion less than alternatives that use all sludge washing, primarily because of increased costs associated with extended HWVP operations and canister disposal (Table 7-14). Costs for alternatives that use existing facilities are $2 to 3 billion less than for those using a TRUEX NPF. Capital costs for modifying existing facilities are significantly less than those constructing an NPF.

Table 7-14. Double-Shell Tank Mission Cost Summary (Capital 1991 dollars, Operating 1993 dollars).

Alternative	Total cost (billion dollars)	Canisters of glass
TRUEX process		
Existing facilities	9-10	1,340
NPF	12	1,340
Intermediate processing, NPF	12	4,080
Sludge washing		
Existing facilities	14	10,400
NPF	16	10,400

NPF = New pretreatment facility
TRUEX = Transuranic extraction.

Use of intermediate processing in combination with sludge washing (see Figure 7-7, alternative 7) could reduce the DST mission costs by approximately $4 billion compared to sludge washing alone (see Figure 7-6, alternative 6). The cost for alternative 7, which uses intermediate processing, is comparable to that for alternative 4, which uses only the TRUEX process. Alternative 7 uses chromium removal and waste blending. However, as noted in Section 6.4.3, intermediate processing technology is relatively undeveloped compared to the TRUEX process.

The cost for using intermediate processing in combination with a TRUEX NPF (alternatives 5 and 14) is slightly higher than for using the TRUEX process with no intermediate processing (alternatives 4 and 13). As noted in Section 7.3.1.3, intermediate processing for these alternatives improves HWVP feed continuity but at the expense of producing additional canisters of glass compared to the all TRUEX alternatives.

Table 7-15 compares the costs for the 16 alternatives with and without repository disposal. This comparison is made to assess the costs for treatment and long-term onsite storage in the event disposal in a geologic repository is indefinitely or permanently delayed. The costs without repository disposal include capital costs for storage modules but do not include expense costs for extended storage and monitoring.

Table 7-15. Total Costs for Double-Shell Tank Waste Disposal Alternatives With and Without Repository Disposal Costs.

Alternative	Description	Total cost[a] (billion dollars)	
		With disposal	Without disposal
1	244-AR Vault/B Plant with TRUEX	9.1	8.6
2	DST/B Plant with TRUEX	9.2	8.7
3	DST/B Plant without TRUEX	13.9	10.3
4	DST/NPF with TRUEX	12.1	11.7
5	DST/Intermediate processing/NPF with TRUEX	12.4	11.7
6	DST/NPF without TRUEX	16.5	12.9
7	DST/Intermediate processing/NPF without TRUEX	12.4	11.0
8	DST/PUREX Plant with TRUEX	10.8	10.3
9	DST/PUREX Plant without TRUEX	16.3	12.7
10	DST/HWVP without TRUEX	14.0	10.4
11	DST/B Plant (limited)/NPF with TRUEX	12.4	11.9
12	DST/B Plant (limited)/NPF without TRUEX	16.9	13.3
13	DST/HWVP (limited)/NPF with TRUEX	12.4	12.0
14	DST/Intermediate processing/HWVP (limited)/NPF with TRUEX	12.5	11.9
15	DST/HWVP (limited)/NPF without TRUEX	16.8	13.2
16	NPF with TRUEX	11.9	11.6

[a]Cost estimates are 1991 dollars for capital and 1993 dollars for expense-funded activites. These estimates are for comparison only and are not total estimated project or program costs at completion.

NOTE: Limited means limited pretreatment capabilities, which includes cesium ion exchange and sludge washing only.

DST = Double-shell tank
HWVP = Hanford Waste Vitrification Plant
NPF = New pretreatment facility
PUREX = Plutonium-Uranium Extraction
TRUEX = Transuranic extraction.

Most alternatives that use the TRUEX process are still less costly than the sludge-washing alternatives if repository costs (assumed to be $350,000 per canister) are excluded because HWVP operating costs are significantly lower for the TRUEX process alternatives. However, because the cost differential between TRUEX process and sludge-washing alternatives is much smaller, the costs for three sludge-washing alternatives (3, 7, and 10) are less than all but the three TRUEX process alternatives (1, 2, and 8) that use existing facilities. Alternative 10 (DST/HWVP without TRUEX) without repository disposal costs and with engineered storage of waste canisters is the lowest cost alternative that provides pretreatment in a new facility.

7.3.2.3 Life-Cycle Costs for DST and SST Missions. Life-cycle costs for the combined DST and SST missions are affected significantly by the level of integration that can be achieved. The extent to which these missions can be integrated will be primarily determined by the SST ROD (to treat in situ or retrieve and treat) and the date of the ROD. The bases and assumptions for SST pretreatment, integration of the DST and SST missions, and resulting life-cycle costs are discussed in the following sections.

7.3.2.3.1 SST Schedule and Cost Bases. The bases for SST pretreatment used in this document were derived from the SST systems engineering study (Boomer et al. 1991). The SST mission costs include closure of the emptied tanks according to RCRA provisions, replacement of tank farm evaporators, and decontamination and decommissioning for all new facilities. Sludge-washing alternatives for SST pretreatment cost from 40 to 42 billion in 1991 dollars. The TRUEX process alternatives for SST pretreatment cost from approximately 26 to 28 billion in 1991 dollars. The recommended pretreatment facility for SST pretreatment is a TRUEX NPF sized to process the wastes from 149 SSTs in 10 yr with a 60 percent total online efficiency. The SST mission cost is assumed to be $30 billion (1991 capital and 1993 expense) for this document.

SEIS and ROD Completed in 2003--The SST mission costs used for combined DST and SST missions in this document and Table 7-10 are a function of the DST facility and process alternative, while assuming a TRUEX NPF for pretreatment processing. The SST mission costs for the DST processes are summarized in Table 7-16 and discussed below.

The estimated $30 billion cost for the SST mission applies to either processing DST wastes in an existing facility or in a TRUEX NPF, which is required for the pretreatment of SST wastes.

If the DST mission constructs the TRUEX NPF, the incremental cost to the SST mission is approximately $26 billion. The total capital and expense costs for construction, staffing, training, startup, shutdown, and decontamination and decommissioning is approximately $4 billion for a TRUEX NPF. The SST mission costs of approximately $30 billion are reduced by the estimated $4 billion included in the DST mission costs to avoid double accounting.

If the DST mission uses sludge washing only, the SST incremental costs are $31 billion. The $1 billion cost increase over the estimated $30 billion SST mission costs is caused by the need to construct a second HWVP. Using only sludge washing to pretreat DST wastes results in [illegible],380 canisters of glass and uses 80 percent of the HWVP design life.

Table 7-16. Single-Shell Tank Mission Costs for Double-Shell Tank Processes (Capital 1991 dollars, Expense 1993 dollars).

DST process and facility	Incremental SST mission costs (billions dollars)
TRUEX process	
Existing facility	30
New pretreatment facility	26
Intermediate processing	30
Sludge washing	31

DST = Double-shell tank
SST = Single-shell tank
TRUEX = Transuranic extraction.

SEIS and ROD Completed in 1996--An 1996 ROD that recommends retrieval and pretreatment results in an integrated DST and SST program and costs identical to a DST alternative that uses a TRUEX NPF. All DST alternatives default to processing DST wastes in a TRUEX NPF constructed to process SST wastes with a FY 2007 startup. Use of a TRUEX NPF for pretreating DST wastes results in cost savings from:

- Not duplicating capital cost for facilities
- Not operating facilities in parallel
- Termination of DST sludge washing or intermediate processing plans in favor of the more cost-efficient (less canisters) TRUEX NPF processing.

7.3.2.3.2 Integration of DST and SST Missions. The ability to integrate the DST and SST missions will be determined by the SST ROD. The decision to treat in situ or retrieve, the date of the ROD, and resulting cost impacts for the scheduled 2003 ROD and accelerated 1996 ROD are discussed below.

SEIS and ROD Completed in 2003--If a 2003 SEIS and ROD recommend a 2013 startup of a TRUEX NPF and a non-TRUEX process was employed for DST wastes, some cost savings for the DST mission costs can be realized by:

- Deferring pretreatment of selected DST wastes to a TRUEX NPF
- Retrieving and TRUEX processing previously sludge washed or intermediate processed DST wastes.

These potential cost savings are optimal processing scenarios and are not addressed in this document.

SEIS and ROD Completed in 1996--Acceleration of the SEIS and the subsequent ROD for SSTs have been proposed to meet the 2018 Tri-Party Agreement milestone date for closure of SSTs if retrieval and treatment of all SST wastes is recommended. A SST ROD that is completed in 1996 is assumed to result in a FY 1997 line item and a FY 2007 startup. A TRUEX NPF is assumed to be recommended as a result of the estimated $10 billion SST mission savings when compared to the sludge washing only alternative. The net result of a SST ROD that is completed in 1996 recommending retrieval and pretreatment of SST wastes in a TRUEX NPF is the early availability of an NPF with the capacity to pretreat both DST and SST wastes.

Processing schedules for combined DST and SST wastes are provided in Figures 7-17 through 7-21 for alternatives 2, 4, 5, and 16. Alternative 2, which uses the TRUEX process in B Plant with a TRUEX NPF, is presented with two operating scenarios, 2A and 2B. Scenario 2A operates B Plant to the completion of DST processing; Scenario 2B transfers DST waste from B Plant to the NPF in FY 2007. The five schedules (Figures 7-17 through 7-21) define and bracket the range of combined DST and SST processing scenarios with a TRUEX NPF. As discussed in Section 7.3.1.2.2, the Tri-Party Agreement SST closure date of 2018 can be met by scheduling SST wastes before DST wastes.

7.3.2.3.3 DST Plus SST Life-Cycle Costs. The DST plus SST life-cycle costs for the 16 alternatives shown in Table 7-10 are summarized in Table 7-17 and discussed in the following text.

Table 7-17. Double-Shell Tank Plus Single-Shell Tank Life-Cycle Costs (2003 Single-Shell Tank Retrieval Record of Decision, Capital 1991 dollars, Expense 1993 dollars).

Double-shell tank alternative[a]	Total costs (billion dollars)
TRUEX	38-39
Intermediate processing, sludge washing NPF	43[b]
Sludge washing	45-48[b]

[a]Single-shell tank processing always uses TRUEX NPF.

[b]A single-shell tank record of decision in 1996 reduces total costs to $38 to 39 billion by processing double-shell tank wastes through TRUEX NPF.

NPF = New pretreatment facility

TRUEX = Transuranic extraction.

Figure 7-17. Operational Schedule for Double-Shell Tank and Single-Shell Tank/B Plant with Transuranic Extraction/TRUEX A Single-Shell Tank (Alternative 2A).

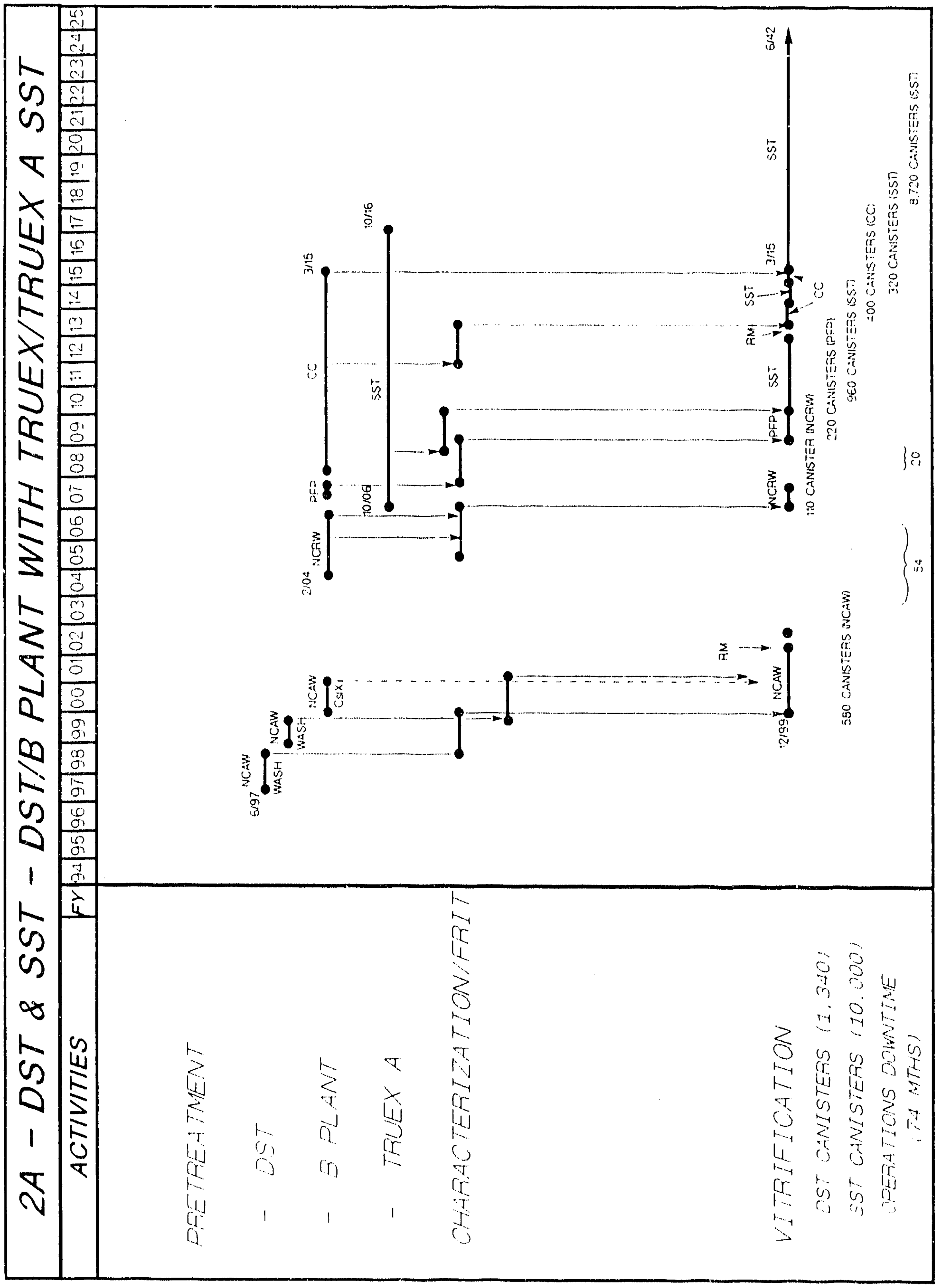


Figure 7-18. Operational Schedule for Double-Shell Tank and Single-Shell Tank/B Plant Neutralized Cladding Removal Waste with Transuranic Extraction/TRUEX A (Alternative 2B).

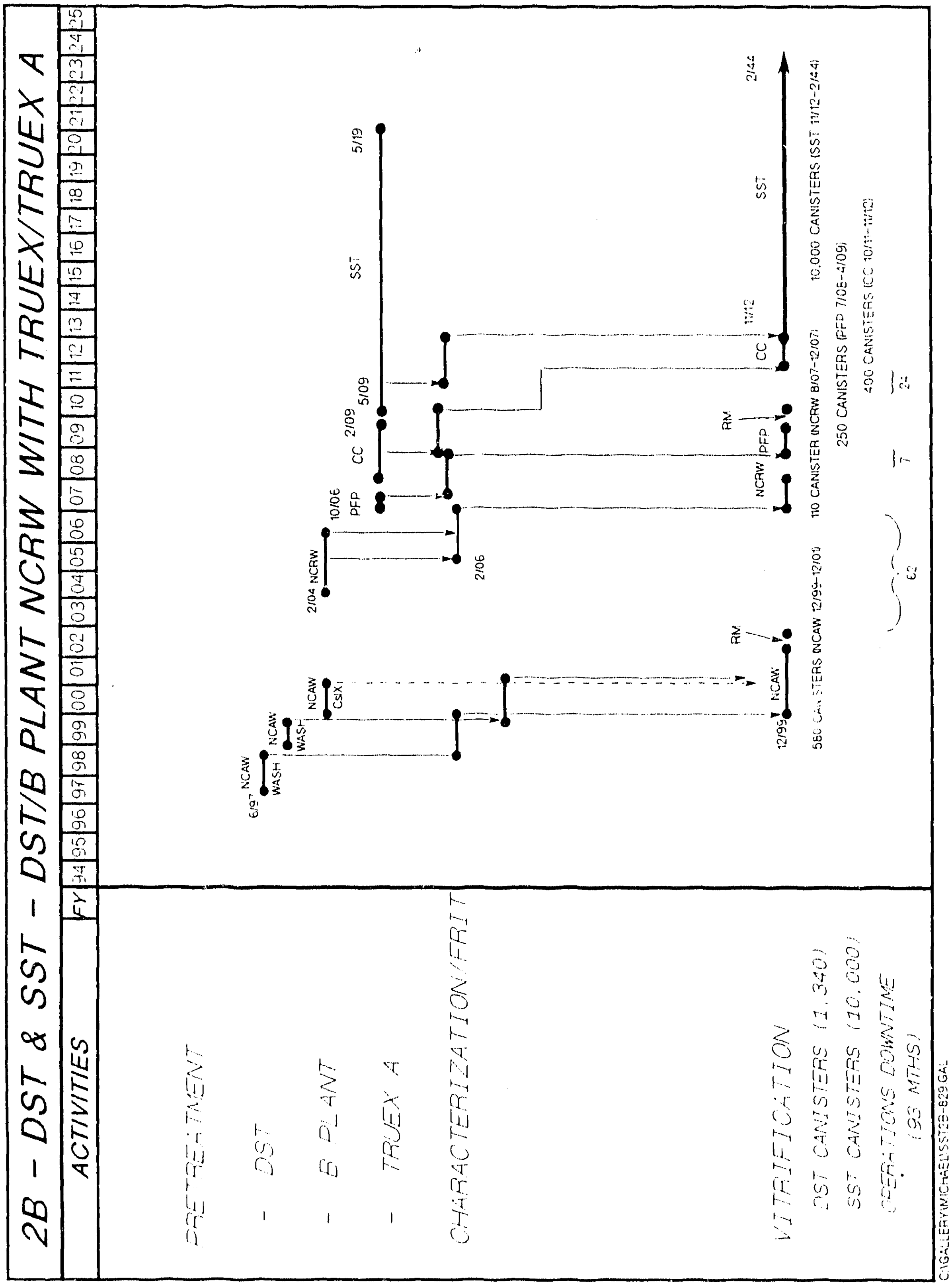


Figure 7-19. Operational Schedule for Double-Shell Tank and Single-Shell Tank/Double-Shell Tank/New Pretreatment Facility with TRUEX A (Alternative 4).

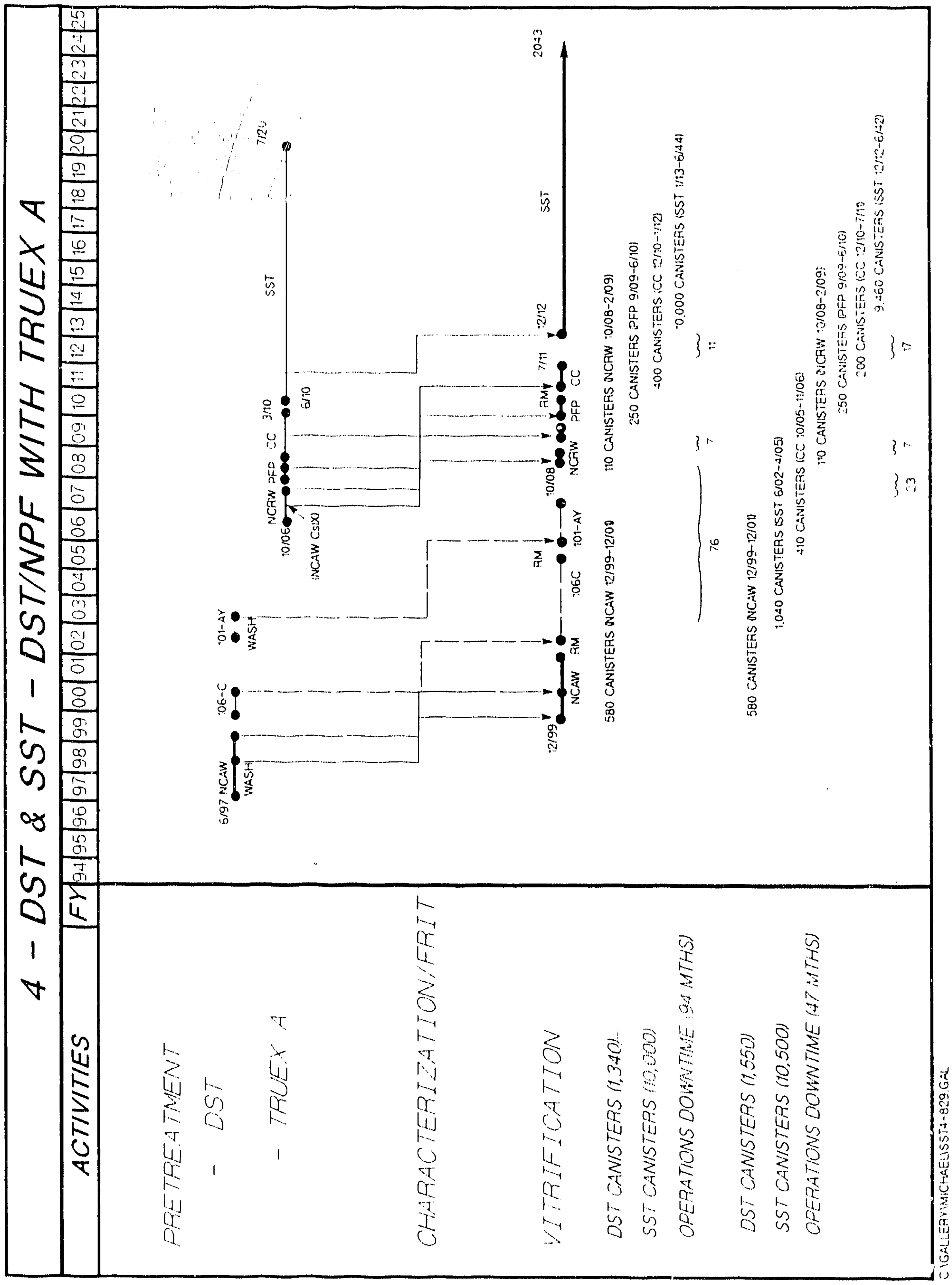


Figure 7-20. Operational Schedule for Double-Shell Tank and Single-Shell Tank/Double-Shell Tank/Intermediate Processing/New Pretreatment Facility TRUEX A (Alternative 5).

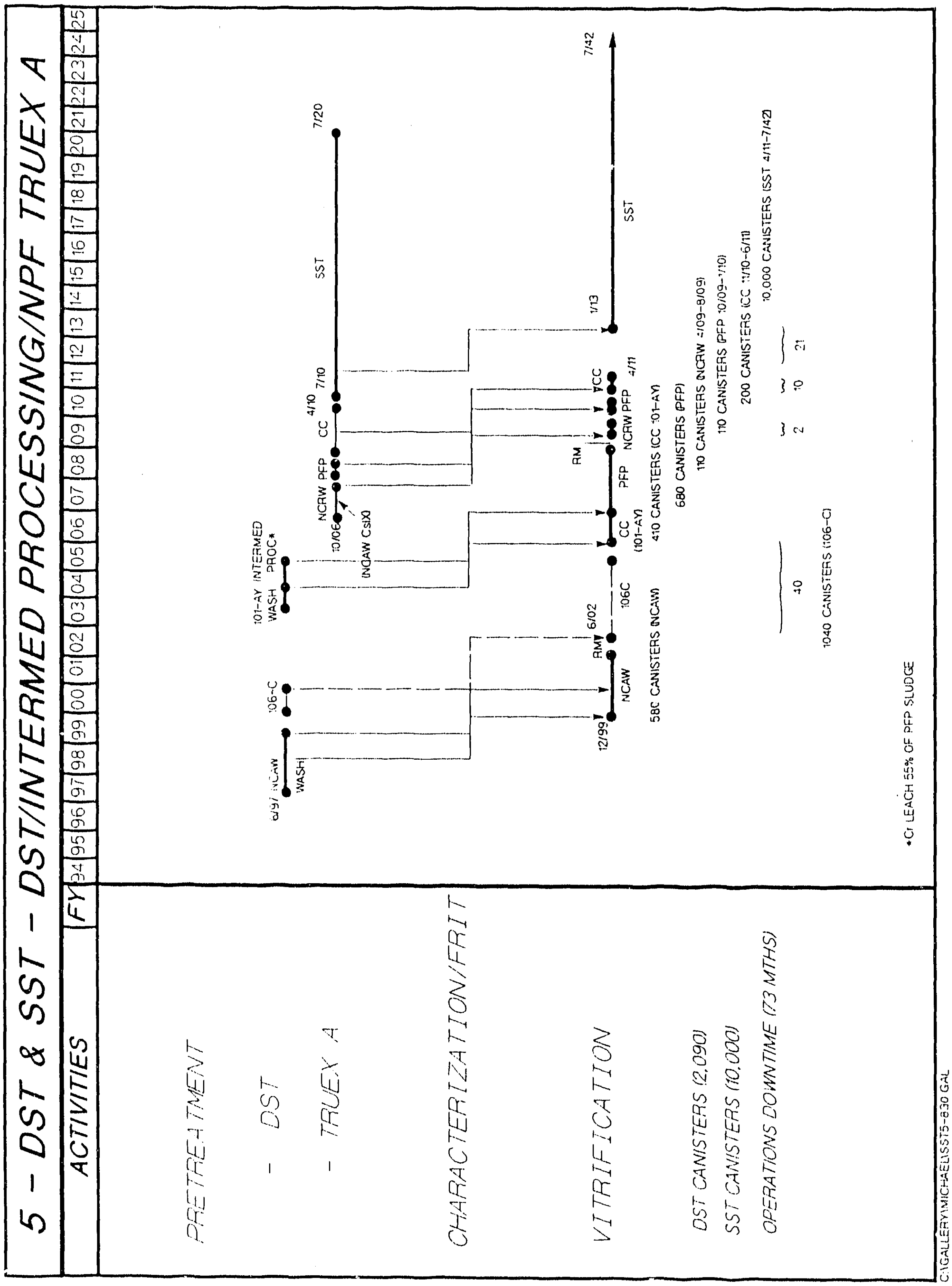
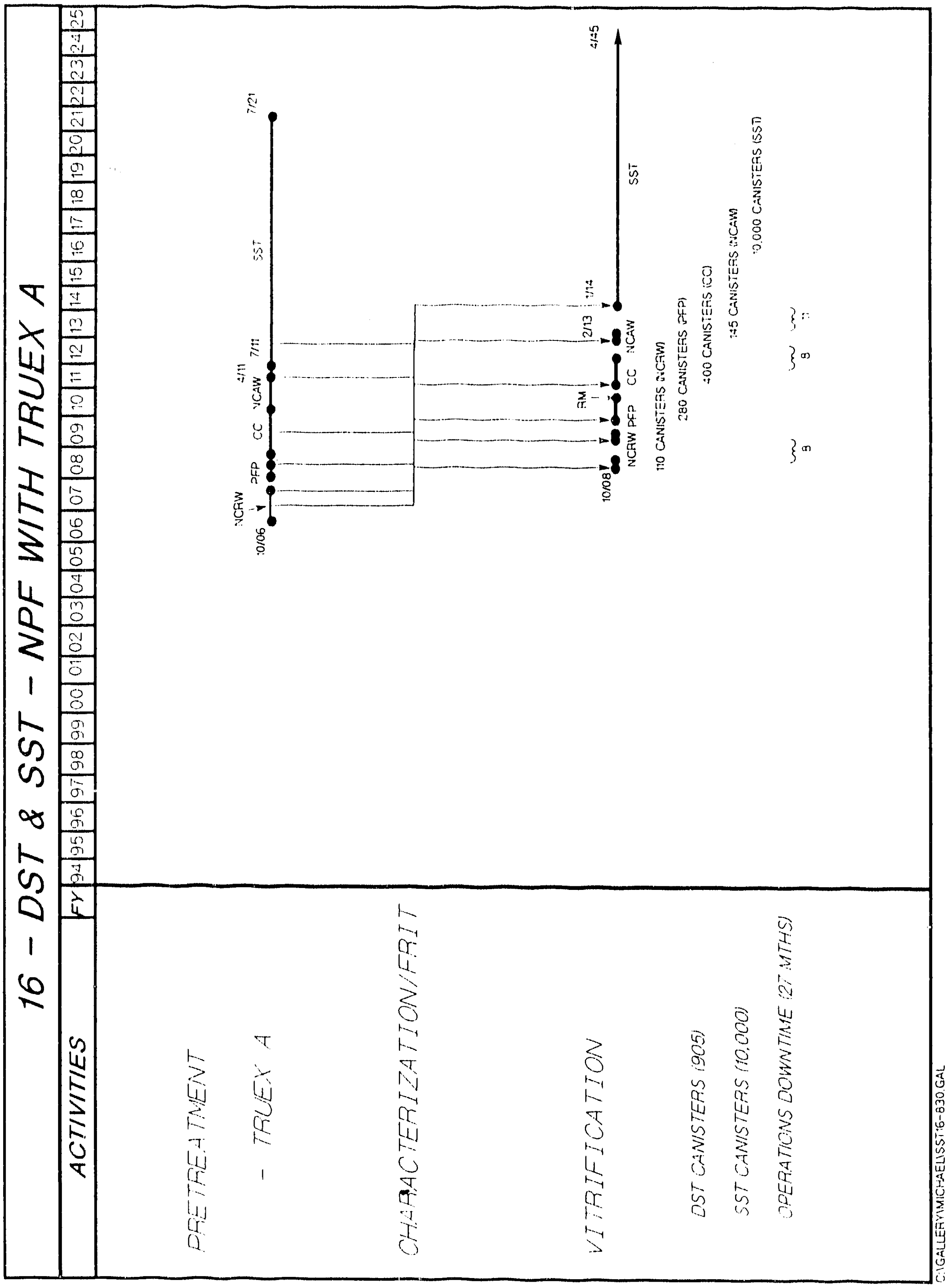


Figure 7-21. Operational Schedule for Double-Shell Tank and Single-Shell Tank/New Pretreatment Facility with TRUEX A (Alternative 16).



The DST plus SST life-cycle costs are for an SEIS ROD that is completed in 2003 that recommends SST retrieval. As discussed in Section 7.3.2.3.1, some cost savings can be attained by optimally processing DST wastes through a TRUEX NPF after the 2013 startup.

A SST SEIS and subsequent ROD completed in 1996, which recommend retrieval of SST wastes, result in processing both DST and SST wastes in a TRUEX NPF. This ROD results in all of the alternatives transformed to approximately $40 billion total DST plus SST mission cost with DST wastes processed in a TRUEX NPF. The costs for the combined DST and SST processing schedules in Figures 7-17 through 7-21 are shown in Table 7-18.

7.3.2.4 Peak Annual Cost.

Attribute Description--Peak annual cost for the 16 facility and process alternatives was a measure of the achievability of the alternative. An early concern was that concurrent construction of HWVP and an NPF would demand annual budgets exceeding reasonable limits for the Hanford Site.

Results--A summary of the results appears in Table 7-19. The alternatives that include an NPF show two peaks indicating that the HWVP and the NPF can be constructed one after the other without substantial penalty to other optimal attributes. No significant variance in peak annual cost appeared in this analysis.

Table 7-18. Double-Shell Tank Plus Single-Shell Tank Life-Cycle Costs (1996 Single-Shell Tank Retrieval Record of Decision), (Capital 1991 dollars, Expense 1993 dollars).

Alternative number	DST plus SST alternatives	Total cost (billion dollars)
2A	DST/B Plant/TRUEX NPF	38.8
2B	DST/B Plant/TRUEX NPF	39.1[a]
4A	DST/TRUEX NPF	38.3[a]
5A	DST/Intermediate processing/TRUEX NPF	38.6[a]
16A	TRUEX NPF	38.0[a]

[a]Operation of NPF for first year on SST then processing DST wastes results in HWVP down time reduction of 18 to 33 months and a cost reduction of $0.1 to 0.2 billion.
DST = Double-shell tank
NPF = New pretreatment facility
SST = Single-shell tank
TRUEX = Transuranic extraction.

Table 7-19. Peak Annual Cost (Millions).

Facility	Year	
	~1996	~2002
Existing facilities		
B Plant	560-600	-
PUREX Plant	670	-
New pretreatment		
NPF Sludge Wash	580-640	600
NPF TRUEX	570-650	710
NPF TRUEX (delayed) (case 16)	-	900 (FY 2004)
HWVP annex (case 10)	630	

FY = Fiscal year
HWVP = Hanford Waste Vitrification Plant
NPF = New pretreatment facility
PUREX = Plutonium-Uranium Extraction
TRUEX = Transuranic extraction.

7.3.2.5 Annual Percent Operating Funds Increase.

Attribute Description--This cost attribute was another measure of the achievability of the 16 facility and process alternatives. Operating or expense funds generally were applied to optimal or support activities and were a reasonable reflection of staffing. Large increases in operating fund requirements may indicate unreasonable or unachievable staff ramp-ups in any given year.

This measure was tempered by the fact that operating-funded projects are included in the program, and these projects do have significant operating fund increases as construction contracts or procurements occur.

Increases on the order of 20 percent to 40 percent are achievable if they are not sustained over extended periods of time. A more reasonable increase is in the 5 percent to 15 percent range, excluding inflation adjustments. High percent increases do not disqualify an alternative but indicate that further analysis of the operating increase elements is required.

Results--A summary of the annual percent operating funds increase is shown in Table 7-20. Of particular interest is that the maximum increase in all of the alternatives occurs between FY 1992 and FY 1993. This is a result of using data from the FY 1993-1997 Five-Year Plan Activity Data Sheets (DOE 1991). Because the president's budget provided a lower target than the FY 1992 required case, the percent increase between 1992 and 1993 is disproportionate for all the alternatives. This is known as the "bow wave" syndrome and is a regularly occurring phenomena for most programs that extend over long periods

Table 7-20. Annual Percent Operating Funds Increase.

Facility	Peak % Increase[a]
Existing facilities	
B Plant	60-70
PUREX Plant	30
New pretreatment facility	
NPF Sludge Wash	40
NPF TRUEX	40
HWVP annex	30

[a]Peak percent increase occurs between FY 1992 and FY 1993.
HWVP = Hanford Waste Vitrification Plant
NPF = New pretreatment facility
PUREX = Plutonium-Uranium Extraction
TRUEX = Transuranic extraction.

of time. The cost and schedule attribute summary in Table 7-10 indicates an average annual percent increase over a 5-yr period, to provide a less alarming view of the alternatives.

Main growth areas in the percent increase between 1992 and 1993 are the HWVP project, the Grout program, and pretreatment pilot plant projects. The HWVP project will start construction in the third quarter of 1992 and an operating increase tracks properly with the significant capital growth required by mobilization of construction forces. The Grout program will enter into new construction contracts in 1993. This program is funded entirely by operating dollars and that growth is expected and within the limits of achievability. The pilot-plant work in the pretreatment area is embarking into definitive design, which is a justifiable reason for growth.

Because all of the alternatives exhibit a similar increase in operating requirements, this measure becomes less of a discriminator between the alternatives but does indicate that an optimization effort between cost and schedule of the selected alternative must occur.

7.3.2.6 Community Economic Impact.

7.3.2.6.1 Description of Attribute. This attribute measured the impact of plant construction and operation on the local and regional economy. Positive benefits can result from increased revenues and employment for the region. Adverse impacts such as boom-bust cycles can result from large and sudden swings in employment levels. Large steady flows of business to the community would be the most beneficial. Uneven flows of economic activity adversely affect the community if the community must expand infrastructure (roads, schools, utilities, and housing stock) to meet a temporary burst of construction-related economic activity. This is particularly true if project construction is followed by a period in which the expanded infrastructure is chronically underused by a much smaller operating workforce.

There is no single best measure of the "unevenness" of economic activity. This is because the impact of a project on a community depends on the size of the project, the timing of the project in relation to other projects, and the overall absolute size and spare absorptive capacity of the community's infrastructure. Thus, depending on the timing, a large project can either help stabilize a depressed housing market and help use overbuilt utility and school systems, or it can exacerbate an already overcrowded housing stock and overtaxed utility and school system. However, the larger the absolute disparity between the level of employment during the construction period and the subsequent operating period, the more likely the adverse impacts on the demands for, and subsequent use of, community infrastructure. The absolute difference in employment during construction versus operation is used below to measure "unevenness" of economic activity.

7.3.2.6.2 Discussion of Results. The specific measure chosen for this attribute was the difference between the peak construction employment and the average employment during operations. The latter is measured by the average employment from 2005 to the completion of the DST pretreatment mission. To provide a consistent relative measure for all of the alternatives, employment levels were derived from the capital and expense cost estimates using the following assumptions.

- Fifty-five percent of the capital and 80 percent of expense costs were direct labor.
- Average labor rates from the B Plant budget were used in the following proportions (40 percent exempt at $116,000/yr, 16 percent nonexempt at $53,000/yr, and 43 percent bargaining unit at $90,000/yr) to derive an average labor rate of $95,000/year.

These rates were applied to the capital and expense estimates for all of the alternatives. The results are shown in Table 7-10.

The alternatives fell into several groups. Alternatives 6 and 12 show the smallest drop-off, about 2,100 workers. Alternatives 1, 2, 3, 7, 9, and 10 are slightly worse with a difference of between 2,400 and 2,800 workers. Alternatives 4, 5, 8, 11, 13, and 14 all have slightly higher employment drop-offs ranging from about 3,100 to 3,400 workers. Alternative 16 shows the largest drop-off in employment, 4,030 workers.

Recent employment fluctuations at the Hanford Site have shown comparable changes and in some cases greater changes. Scott et al. (1987) reports a decline of nearly 10,000 workers between 1981 and 1986 at the Washington Public Power Supply System reactor construction sites. Nearly half of this decline occurred from 1981 to 1983. Between 1987 and 1989, Hanford Site employment fell by 2,300 workers. To fully ssess the impact of these changes, one would ideally need to know the changes that are occurring in other sectors of the regional economy at the same time. If the drop-off in employment coincides with declines in other sectors, then the overall impact would be much more severe than if other sectors were growing at that time.

7.3.2.7 Maximum Annual Site Budget Increase. This attribute provided an alternative measure of the cost profile or slope of the program funding requirement. This attribute expressed the maximum annual funding increase for the program as a percentage of the total base budget for the Hanford Site. For purposes of comparison, the base budget for the Site is assumed to be $1.5 billion and remains fixed over the life of the program. While the total Site budget is expected to increase in constant dollar terms, this increase would not affect the estimated results because the maximum annual increase occurs within the next 5 yr for all of the alternatives. Thus, future increases in the Site budget would only lower the percentage increases in later years and would have minimal impact in the early years.

Table 7-10 illustrates the results for this attribute, maximum annual Site budget increase. The alternatives range from a low of about 8.5 percent to a high of almost 13 percent. The general belief among the stakeholders was that an increase of over 10 percent is extremely difficult to obtain. The more typical increases were in the 5 percent range. This document probably understated the true impact on the Site budget growth because other programs were not represented. Nevertheless, this attribute did show the relative impact of the 16 alternatives.

7.4 MULTIATTRIBUTE UTILITY ANALYSIS RESULTS

This section combines the attribute scores with the stakeholder weights to yield a composite measure of the relative utility, or value, of each alternative. To derive the overall scores for the alternatives, the attribute scores were renormalized to correspond with the units and scales used to derive attribute weights. The MAU analysis results provided a measure of the relative value of the alternatives and also indicated what attributes were most critical to the results.

7.4.1 Normalization of Scores

The attribute scores reported in the previous sections were measured in the units that were most natural to use. For most attributes, however, these units were not appropriate to link with the attribute weights without first normalizing the attribute scores using a common scale. The weight elicitation process provided the mechanism for confirming and normalizing the attribute scores.

Table 7-21 summarized the raw scores (using their natural units) for those attributes included in the MAU analysis. These scores corresponded to the values described in the previous sections.

Not all of the attributes described in the previous sections were included in the MAU analysis. In some cases, several attributes were developed even though the attributes measured the same concept, e.g., three different measures of the cost profile were calculated. Because there were different ways of measuring the same concept, a choice was made concerning which attribute to use in the model. Similar attributes were not used in the model at the same time to avoid double-counting an effect that would be captured by each attribute.

Table 7-21. Raw Scores for Multiattribute Utility Analysis Attributes.

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Attribute Description	Facility Options 1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
Stored Irradiated Fuel	100	100	100	100	100	100	100	0	0	100	100	100	100	100	100	100
Contribution to SST Mission	50	50	0	100	100	0	0	50	0	0	100	0	100	100	0	100
Cs & Sr Capsules	100	100	100	50	50	50	50	50	50	50	100	100	50	50	50	50
TECHNOLOGY ASSURANCE																
Maturity	63	61	59	64	61	59	51	61	59	59	64	59	64	61	59	64
Adaptability	67	67	75	98	94	94	86	80	81	94	94	89	98	94	94	96
Reliability	56	56	57	81	78	79	75	61	64	79	75	71	81	78	79	80
HWVP Downtime (months)	82	122	0	84	46	0	39	70	0	0	84	0	74	53	0	16
PUBLIC HEALTH AND SAFETY																
Rad Accident-Public	5.0E-05	5.0E-05	3.4E-05	4.0E-05	3.8E-05	4.0E-05	4.0E-05	3.7E-05	3.8E-05	4.1E-05	4.0E-05	4.0E-05	4.0E-05	3.8E-05	4.0E-05	4.3E-05
Nonrad Accident-Public	6.7E-03	6.7E-03	1.4E-05	5.9E-03	4.9E-03	3.8E-05	3.8E-05	6.5E-03	4.0E-05	4.2E-05	5.9E-03	3.8E-05	5.9E-03	4.9E-03	3.8E-05	7.4E-03
Transport Rad Routine-Public	3.9E-04	3.9E-04	3.0E-03	3.9E-04	6.0E-04	3.0E-03	1.2E-03	3.9E-04	3.0E-03	3.0E-03	3.9E-04	3.0E-03	3.9E-04	5.1E-04	3.0E-03	2.6E-04
Transport Rad Accident-Public	7.5E-05	7.5E-05	5.8E-04	7.5E-05	1.2E-04	5.8E-04	2.3E-04	7.5E-05	5.8E-04	5.8E-04	7.5E-05	5.8E-04	7.5E-05	9.9E-05	5.8E-04	5.1E-05
Transport Nonrad Accident-Public	1.9E-03	1.9E-03	1.4E-02	1.8E-03	2.8E-03	1.4E-02	5.5E-03	1.8E-03	1.4E-02	1.4E-02	1.8E-03	1.4E-02	1.8E-03	2.4E-03	1.4E-02	1.2E-03
WORKER HEALTH AND SAFETY																
Rad Routine-Worker	1.3	1.3	1.8	1.2	1.2	1.8	1.3	1.4	2	1.6	1.3	1.9	1.2	1.2	1.8	1.1
Nonrad Chem Accident-Worker	1.7E-01	1.7E-01	6.1E-04	1.5E-01	1.2E-01	1.7E-03	1.7E-03	1.6E-01	1.8E-03	1.9E-03	1.5E-01	1.7E-03	1.5E-01	1.2E-01	1.7E-03	1.9E-01
Rad Accident-Worker (Rem)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Nonrad Ind Accident-Worker	6.7	6.5	8.4	10	10.1	11.3	9.5	7.1	9	8.8	10.1	11.5	10.4	10.4	11.7	10.4
ENVIRONMENT																
Routine & Nonroutine Effluents	0	40	20	80	80	60	60	40	20	60	60	40	80	80	60	100
Solid Waste	155	135	180	24	27	89	39	103	173	88	32	104	21	26	94	21
Number of Grout Vaults	50	50	41	38	38	38	38	50	41	38	38	38	38	38	38	38
Number of Glass Canisters	1340	1340	10380	1340	2090	10380	4080	1340	10380	10380	1340	10380	1340	1770	10380	905
Land Use	90	90	72	78	80	78	80	90	72	68	78	78	78	90	78	78
SCHEDULE AND COMPLIANCE																
Compliance	0	25	25	75	75	75	75	25	25	75	50	50	75	75	75	100
HWVP Start Date	Mar-2003	Dec-99	Dec-99	Dec-99	Dec-99	Dec-99	Dec-99	Dec-99	Dec-99	Dec-2001	Dec-99	Dec-99	Mar-2001	Mar-2001	Mar-2001	Oct-2008
SST Closure Date	2025	2025	2025	2025	2025	2025	2025	2025	2025	2025	2025	2025	2025	2025	2025	2025
DST Completion Date	2015	2015	2032	2012	2011	2032	2016	2010	2032	2034	2012	2032	2012	2011	2033	2013
SST Completion Date	2046	2046	2063	2043	2042	2063	2049	2041	2063	2065	2043	2063	2043	2042	2064	2049
COST																
DST $93 (billions)	9.1	9.2	13.9	12.1	12.4	16.5	12.4	10.8	16.3	14	12.4	16.9	12.4	12.5	16.8	11.9
COST PROFILE																
Average Annual % Increase	34.00%	37.00%	36.00%	37.00%	37.00%	37.00%	37.00%	31.00%	29.00%	29.00%	26.00%	42.00%	33.00%	33.00%	32.00%	28.00%
Max. Ann. Site Budget Increase	8.67%	10.80%	11.20%	9.80%	9.80%	9.80%	9.80%	9.73%	9.80%	6.93%	10.80%	10.80%	11.53%	11.53%	12.40%	12.93%
COMMUNITY AND ECONOMY																
Community Economic Impact	2640	2570	2420	3130	3070	2170	2550	3420	2830	2710	3130	2080	3300	3120	2430	4030

Among the ES&H attributes, two attributes were excluded from the MAU analysis, worker radiological risk from accidents and the potential incremental leakage from SSTs. The first attribute was not used because it was measured in rem rather than fatalities and applies only to the maximally exposed individual. No justifiable basis was found for converting this measurement to total expected fatalities for the whole workforce. The impact of including a rough estimate of fatalities is examined later using a sensitivity analysis. The second attribute, potential incremental leakage from SSTs, was measured by the time delay before beginning retrieval or treatment of SSTs. It was believed that the direct schedule attributes (e.g., DST completion date) captured this effect. Thus, the reason for completing the DST mission was to make room for the SST wastes. Therefore, this attribute was not included as a separate input to the model.

Among the technical integration attributes, the contribution to the cesium and strontium mission and the contribution to the tank safety mission were not included in the analysis. The latter was not included because the alternatives showed no differentiation on this attribute. The contribution to the cesium and strontium mission was not included because a separate weight was not elicited from the stakeholder groups. The potential impact of including this factor can still be evaluated through sensitivity analysis.

Among the cost and schedule attributes, peak annual cost was not used. It was believed that a more appropriate measure of the cost profile, or "fundability," was provided by the maximum annual increase in the Site's budget. Also, among these attributes, the combined DST and SST mission cost was used as an alternative measure of total cost in place of the DST mission cost only. Both measures were not used at the same time. Finally, the HWVP down time attribute was used but is reported in this section along with the technical integration attributes. The down time was believed to be a measure of the operating efficiency of the system and, therefore, was appropriate to carry along with the other technical integration attributes, such as maturity, adaptability, and reliability.

Table 7-22 summarizes the normalized scores. High values indicate better relative performance than low values. All scores were renormalized to a 0-to-100 point scale where the endpoints of the scale were defined by the endpoints used in the weight elicitation process (see Section 5.5 and Table 5-1). Because the weight elicitation process and the attribute scoring were conducted in parallel, some of the actual attribute scores fall outside of the endpoints used in weighting. This caused some scores to fall outside of the 0-to-100 point range. For example, the range for the community and economic impact attribute (measured by the dropoff in employment from the construction peak to operations phase) was assumed to be between 4,000 (worst) and 0 (best). If an alternative had scored 4,000, its normalized score would have been 0. Similarly, if an alternative had scored 0 (i.e., perfectly stable employment), its normalized score would have been 100. The actual range for

Table 7-22. Normalized Scores for Multiattribute Utility Analysis Attributes.

DWR Strategy Redefinition

Normalized Scores

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Facility Options

Attribute Description	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
CONTRIBUTION TO MISSIONS																
Stored Irradiated Fuel	100.00	100.00	100.00	100.00	100.00	100.00	100.00	0.00	0.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00
Contribution to SST Mission	50.00	50.00	0.00	100.00	100.00	0.00	0.00	50.00	0.00	0.00	100.00	0.00	100.00	100.00	0.00	100.00
Cs & Sr Capsules	100.00	100.00	100.00	50.00	50.00	50.00	50.00	50.00	50.00	50.00	100.00	100.00	50.00	50.00	50.00	50.00
TECHNOLOGY ASSURANCE																
Maturity	92.31	76.92	61.54	100.00	76.92	61.54	0.00	76.92	61.54	61.54	100.00	61.54	100.00	76.92	61.54	100.00
Adaptability	0.00	0.00	25.81	100.00	87.10	87.10	61.29	41.94	45.16	87.10	87.10	70.97	100.00	87.10	87.10	93.55
Reliability	0.00	0.00	4.00	100.00	88.00	92.00	76.00	20.00	32.00	92.00	76.00	60.00	100.00	88.00	92.00	96.00
HWVP Downtime (months)	43.06	15.28	100.00	41.67	68.06	100.00	72.92	51.39	100.00	100.00	41.67	100.00	48.61	63.19	100.00	88.89
PUBLIC HEALTH AND SAFETY																
Rad Accident-Public	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00
Nonrad Accident-Public	99.33	99.33	100.00	99.41	99.51	100.00	100.00	99.35	100.00	100.00	99.41	100.00	99.41	99.51	100.00	99.27
Transport Rad Routine-Public	99.96	99.96	99.70	99.96	99.94	99.70	99.88	99.96	99.70	99.70	99.96	99.70	99.96	99.95	99.70	99.97
Transport Rad Accident-Public	100.00	100.00	99.98	100.00	100.00	99.98	99.99	100.00	99.98	99.98	100.00	99.98	100.00	100.00	99.98	100.00
Transport Nonrad Accident-Public	99.81	99.81	98.60	99.82	99.72	98.60	99.45	99.82	98.60	98.60	99.82	98.60	99.82	99.76	98.60	99.88
WORKER HEALTH AND SAFETY																
Rad Routine-Worker	-30.00	-30.00	-80.00	-20.00	-20.00	-80.00	-30.00	-40.00	-100.00	-60.00	-30.00	-90.00	-20.00	-20.00	-80.00	-10.00
Nonrad Chem Accident-Worker	83.10	83.10	99.94	85.20	87.70	99.83	99.83	83.80	99.82	99.81	85.20	99.83	85.20	87.70	99.83	81.50
Rad Accident-Worker (Rem)	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00
Nonrad Ind Accident-Worker	44.17	45.83	30.00	16.67	15.83	5.83	20.83	40.83	25.00	26.67	15.83	4.17	13.33	13.33	2.50	13.33
ENVIRONMENT																
Routine & Nonroutine Effluents	0.00	40.00	20.00	80.00	80.00	60.00	60.00	40.00	20.00	60.00	60.00	40.00	80.00	80.00	60.00	100.00
Solid Waste	25.00	36.11	11.11	97.78	96.11	61.67	89.44	53.89	15.00	62.22	93.33	53.33	99.44	96.67	58.89	99.44
Number of Grout Vaults	0.00	0.00	60.00	80.00	80.00	80.00	80.00	0.00	60.00	80.00	80.00	80.00	80.00	80.00	80.00	80.00
Number of Glass Canisters	92.00	92.00	5.90	92.00	84.86	5.90	65.90	92.00	5.90	5.90	92.00	5.90	92.00	87.90	5.90	96.14
Land Use	-157.14	-157.14	-105.71	-122.86	-128.57	-122.86	-128.57	-157.14	-105.71	-94.29	-122.86	-122.86	-122.86	-128.57	-122.86	-122.86
SCHEDULE AND COMPLIANCE																
Compliance	0.00	25.00	25.00	75.00	75.00	75.00	75.00	25.00	25.00	75.00	50.00	50.00	75.00	75.00	75.00	100.00
HWVP Start Date	63.25	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	77.35	100.00	100.00	85.87	85.87	85.87	0.00
SST Closure Date	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
DST Completion Date	79.17	79.17	8.33	91.67	95.83	8.33	75.00	100.00	8.33	0.00	91.67	8.33	91.67	95.83	4.17	87.50
SST Completion Date	79.17	79.17	8.33	91.67	95.83	8.33	66.67	100.00	8.33	0.00	91.67	8.33	91.67	95.83	4.17	66.67
COST																
DST $93 (billions)	109.00	108.00	61.00	79.00	76.00	35.00	76.00	92.00	37.00	60.00	76.00	31.00	76.00	75.00	32.00	81.00
COST PROFILE																
Average Annual % Increase	55.00	40.00	45.00	40.00	40.00	40.00	40.00	70.00	80.00	80.00	95.00	15.00	60.00	60.00	65.00	85.00
Max. Ann. Site Budget Increase	63.30	42.00	38.00	52.00	52.00	52.00	52.00	52.70	52.00	60.70	42.00	42.00	34.70	34.70	26.00	20.70
COMMUNITY AND ECONOMY																
Community Economic Impact	34.00	35.75	39.50	21.75	23.25	45.75	36.25	14.50	29.25	32.25	21.75	48.00	17.50	22.00	39.25	-0.75

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the raw scores varied from 4,030 (worst) to 2,080 (best). Therefore, the normalized scores ranged from -0.75 (worst) to 48.0 (best). The following calculations illustrate the procedure for normalizing values:

$$\textit{Normalized value } (4030) = 100* \left(\frac{4000-4030}{4000}\right) = -0.75$$

$$\textit{Normalized value } (2080) = 100* \left(\frac{4000-2080}{4000}\right) = 48.0$$

The technology assurance attributes (maturity, adaptability, and reliability) were scored using a 0-to-100 point scale. During the weight elicitation process, the endpoints of each scale were defined by the best and worst alternatives rather than an abstract description of an alternative that would score 100 points or 0 points. Consequently, these scores were normalized to a new 0-to-100 point scale with the highest-scoring alternative rated at 100 points and the lowest-scoring alternative rated at 0 points. For example, on maturity the original scores ranged from 51 points to 64 points. After normalization, the alternatives scoring 64 points were given a rating of 100.

For all of the attributes, an assumption of linearity was made. This means a change of $1 billion has the same utility whether the change is from $10 billion to $11 billion of from $15 billion to $16 billion. The impact of nonlinear utility was examined relative to HWVP startup date through a sensitivity analysis.

The "best" and "worst" scores used in the normalization process are shown in the last two columns of Table 5-1. These values are applied using the calculation described previously.

7.4.2 Composite Results

Table 7-23 shows the weighted scores for the alternatives using the weights derived from the Hanford Site contractors (Westinghouse Hanford and Pacific Northwest Laboratory management staff). The "total score" for each alternative shows its relative value and provides a measure of the strength of preference that the stakeholder group might have toward the alternative.

These results are shown graphically in Figure 7-22. Alternatives 4, 5, 11, 13, and 14 are grouped closely together at the top. The MAU analysis results show very little differentiation among these alternatives. They seem to show a clearly preferred set of alternatives, at least for the weights that were applied. All of these alternatives used an NPF with the TRUEX process to accomplish the bulk of the DST waste processing and to provide the capability to process retrieved SST waste. In addition, these alternatives used in-tank sludge washing to get early feed to HWVP before the NPF comes online. Alternatives 5 and 14 are variations on alternatives 4 and 13, respectively,

Table 7-23. Weighted Scores for Each Alternative Using Hanford Site Contractor Weights.

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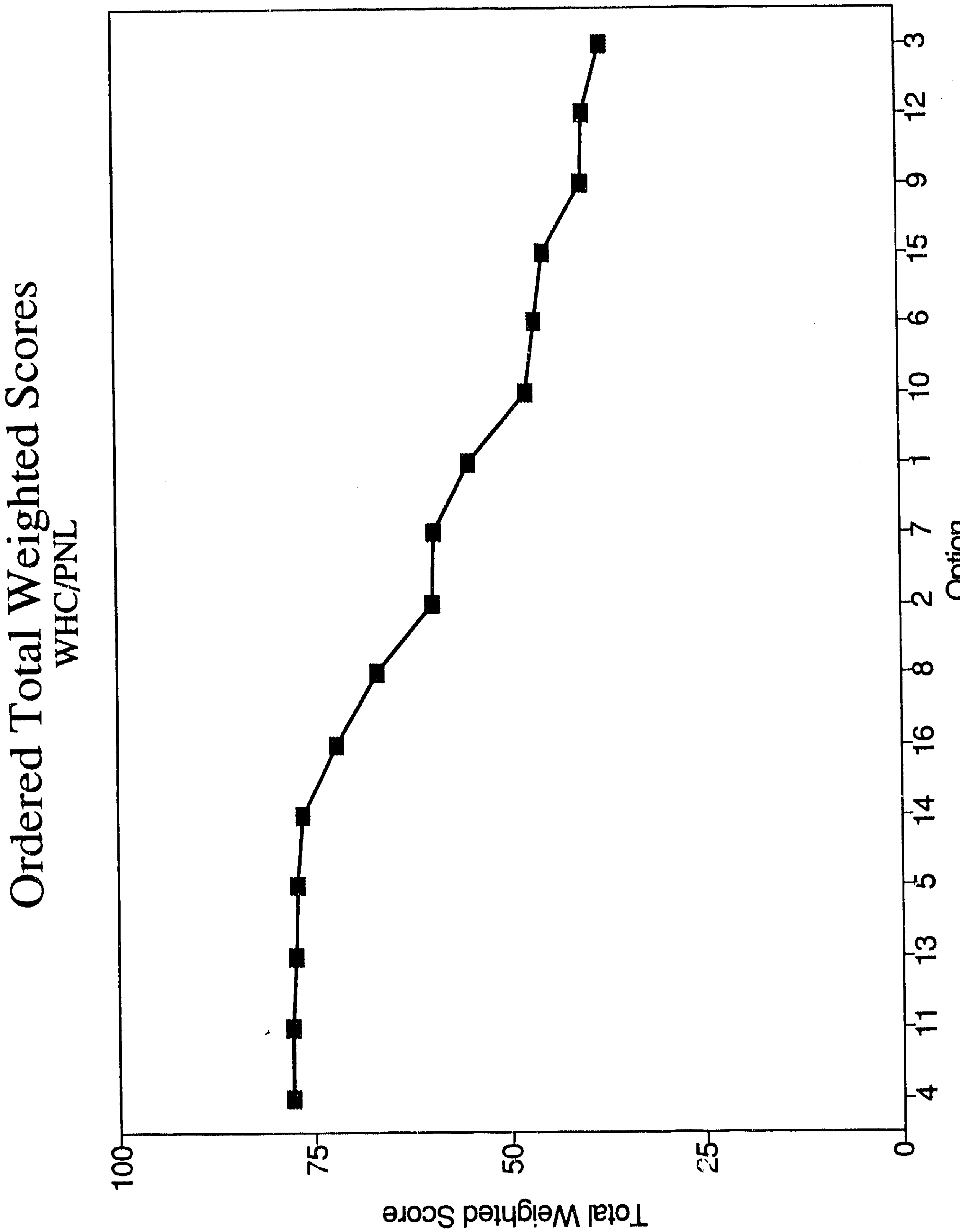
Facility Options
WEIGHTED SCORES

Attribute Description	Weights	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	Delta
CONTRIBUTION TO MISSIONS	WHC/PNL																	
Stored Irradiated Fuel	0.09%	0.09	0.09	0.09	0.09	0.09	0.09	0.09	0.00	0.00	0.09	0.09	0.09	0.09	0.09	0.09	0.09	0.09
Contribution to SST Mission	8.61%	4.31	4.31	0.00	8.61	8.61	0.00	0.00	4.31	0.00	0.00	8.61	0.00	8.61	8.61	0.00	8.61	8.61
Cs & Sr Capsules	0.00%	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
TECHNOLOGY ASSURANCE																		
Maturity	2.87%	2.65	2.21	1.77	2.87	2.21	1.77	0.00	2.21	1.77	1.77	2.87	1.77	2.87	2.21	1.77	2.87	2.87
Adaptability	2.87%	0.00	0.00	0.74	2.87	2.50	2.50	1.76	1.20	1.30	2.50	2.50	2.04	2.87	2.50	2.50	2.68	2.87
Reliability	2.87%	0.00	0.00	0.11	2.87	2.53	2.64	2.18	0.57	0.92	2.64	2.18	1.72	2.87	2.53	2.64	2.76	2.87
HWVP Downtime (months)	4.10%	1.77	0.63	4.10	1.71	2.79	4.10	2.99	2.11	4.10	4.10	1.71	4.10	1.99	2.59	4.10	3.64	3.47
PUBLIC HEALTH AND SAFETY																		
Rad Accident-Public	1.15%	1.15	1.15	1.15	1.15	1.15	1.15	1.15	1.15	1.15	1.15	1.15	1.15	1.15	1.15	1.15	1.15	0.00
Nonrad Accident-Public	0.23%	0.23	0.23	0.23	0.23	0.23	0.23	0.23	0.23	0.23	0.23	0.23	0.23	0.23	0.23	0.23	0.23	0.00
Transport Rad Routine-Public	1.15%	1.15	1.15	1.15	1.15	1.15	1.15	1.15	1.15	1.15	1.15	1.15	1.15	1.15	1.15	1.15	1.15	0.00
Transport Rad Accident-Public	3.44%	3.44	3.44	3.44	3.44	3.44	3.44	3.44	3.44	3.44	3.44	3.44	3.44	3.44	3.44	3.44	3.44	0.00
Transport Nonrad Accident-Public	0.23%	0.23	0.23	0.23	0.23	0.23	0.23	0.23	0.23	0.23	0.23	0.23	0.23	0.23	0.23	0.23	0.23	0.00
WORKER HEALTH AND SAFETY																		
Rad Routine-Worker	0.57%	-0.17	-0.17	-0.46	-0.11	-0.11	-0.46	-0.17	-0.23	-0.57	-0.34	-0.17	-0.51	-0.11	-0.11	-0.46	-0.06	0.51
Nonrad Chem Accident-Worker	0.06%	0.05	0.05	0.06	0.05	0.05	0.06	0.06	0.05	0.06	0.06	0.05	0.06	0.05	0.05	0.06	0.05	0.01
Rad Accident-Worker (Rem)	0.29%	0.29	0.29	0.29	0.29	0.29	0.29	0.29	0.29	0.29	0.29	0.29	0.29	0.29	0.29	0.29	0.29	0.00
Nonrad Ind Accident-Worker	0.69%	0.30	0.32	0.21	0.12	0.11	0.04	0.14	0.28	0.17	0.18	0.11	0.03	0.09	0.09	0.02	0.03	0.30
ENVIRONMENT																		
Routine & Nonroutine Effluents	5.74%	0.00	2.30	1.15	4.59	4.59	3.44	3.44	2.30	1.15	3.44	3.44	2.30	4.59	4.59	3.44	5.74	5.74
Solid Waste	1.15%	0.29	0.42	0.13	1.12	1.11	0.71	1.03	0.82	0.17	0.72	1.07	0.61	1.14	1.11	0.68	1.14	1.02
Number of Grout Vaults	1.15%	0.00	0.00	0.69	0.92	0.92	0.92	0.92	0.00	0.69	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92
Number of Glass Canisters	11.48%	10.56	10.56	0.68	10.56	9.74	0.68	7.57	10.56	0.68	0.68	10.56	0.88	10.56	10.09	0.68	11.04	10.36
Land Use	0.11%	-0.17	-0.17	-0.12	-0.14	-0.14	-0.14	-0.14	-0.17	-0.12	-0.10	-0.14	-0.14	-0.14	-0.14	-0.14	-0.14	0.07
SCHEDULE AND COMPLIANCE																		
Compliance	5.74%	0.00	1.44	1.44	4.31	4.31	4.31	4.31	1.44	1.44	4.31	2.87	2.87	4.31	4.31	4.31	5.74	5.74
HWVP Start Date	11.48%	7.26	11.48	11.48	11.48	11.48	11.48	11.48	11.48	11.48	8.88	11.48	11.48	9.86	9.86	9.86	0.00	11.48
SST Closure Date	5.74%	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
DST Completion Date	5.74%	4.54	4.54	0.48	5.26	5.50	0.48	4.31	5.74	0.48	0.00	5.26	0.48	5.26	5.50	0.24	5.02	5.74
SST Completion Date	5.74%	4.54	4.54	0.48	5.26	5.50	0.48	3.83	5.74	0.48	0.00	5.26	0.48	5.26	5.50	0.24	3.83	5.74
COST																		
DST $93 (billions)	5.74%	6.26	6.20	3.50	4.53	4.36	2.01	4.36	5.28	2.12	3.44	4.36	1.78	4.36	4.31	1.84	4.65	4.48
COST PROFILE																		
Average Annual % Increase	7.18%	3.95	2.87	3.23	2.87	2.87	2.87	2.87	5.03	5.74	5.74	6.82	1.08	4.31	4.31	4.67	6.18	5.74
Max. Ann. Site Budget Increase	2.87%	1.82	1.21	1.09	1.49	1.49	1.49	1.49	1.51	1.49	1.74	1.21	1.21	1.00	1.00	0.75	0.59	1.22
COMMUNITY AND ECONOMY																		
Community Economic Impact	0.92%	0.31	0.33	0.36	0.20	0.21	0.42	0.33	0.13	0.27	0.30	0.20	0.44	0.16	0.20	0.36	-0.01	0.45
TOTAL SCORE	100.00%	54.84	59.62	37.69	78.03	77.20	46.37	59.33	66.64	40.30	47.55	77.76	39.96	77.42	76.59	45.04	71.86	
HEALTH AND SAFETY	7.81%	6.67	6.66	6.29	6.54	6.54	6.13	6.52	6.59	6.15	6.38	6.48	6.06	6.52	6.52	6.10	6.57	0.62
ENVIRONMENT	19.63%	10.68	13.10	2.53	17.06	16.22	5.62	12.82	13.30	2.57	5.65	15.86	4.37	17.08	16.57	5.58	18.71	16.18
COMMUNITY AND ECONOMY	0.92%	0.31	0.33	0.36	0.20	0.21	0.42	0.33	0.13	0.27	0.30	0.20	0.44	0.16	0.20	0.36	-0.01	0.45
SCHEDULE & COMPLIANCE	34.44%	16.35	22.00	13.87	26.31	26.79	16.74	23.92	24.40	13.87	13.18	24.87	15.31	24.89	25.16	14.64	14.59	13.60
CONTRIBUTION TO MISSIONS	8.70%	4.40	4.40	0.09	8.70	8.70	0.09	0.09	4.31	0.00	0.09	8.70	0.09	8.70	8.70	0.09	8.70	8.70
TECHNOLOGY ASSURANCE	12.71%	4.41	2.83	6.72	10.32	10.02	11.01	6.93	6.09	8.08	11.01	9.26	9.62	10.60	9.82	11.01	11.95	9.12
COST	5.74%	6.26	6.20	3.50	4.53	4.36	2.01	4.36	5.28	2.12	3.44	4.36	1.78	4.36	4.31	1.84	4.65	4.48
COST PROFILE	10.05%	5.77	4.08	4.32	4.36	4.36	4.36	4.36	6.54	7.24	7.49	8.03	2.28	5.30	5.30	5.41	6.70	6.97

Figure 7-22. Ordered Total Weighted Scores from Westinghouse Hanford Company and Pacific Northwest Laboratory.



and include intermediate processing to enhance the processing capability before NPF startup. Alternatives 11, 13, and 14 include additional capability for cesium ion exchange before NPF startup. Alternative 11 houses this capability in B Plant, and alternatives 13 and 14 house this capability in HWVP.

The next highest ranked alternative is 16, which is identical to alternative 4 without in-tank sludge washing. Thus, HWVP start is delayed until after the NPF comes online and produces sufficient feed. All alternatives that use an NPF without TRUEX (alternatives 3, 6, 7, 9, 10, 12, and 15) scored low. These alternatives produced many more canisters of vitrified waste and would not be capable of processing SST waste. The remaining alternatives with TRUEX capability (alternatives 1, 2, and 8) also scored lower than the top set of alternatives. Each of these uses the TRUEX process in an existing facility, either PUREX Plant or B Plant.

One benefit of MAU analysis is its ability to easily examine the effects of variations in attribute weights and scores. The following sections summarize the sensitivity analyses that have been performed with the MAU model. These analyses help clarify the true differences between the alternatives and show how alternative stakeholder values can change the relative performance of the alternatives.

7.5 SENSITIVITY ANALYSIS

This section illustrates the results from a series of sensitivity analyses using the MAU model. These analyses examined how the relative merits of, and preferences for, the alternatives changed as either the attribute weights or attribute scores were changed. These results indicated the stability of the final results and their sensitivity to variations in stakeholder values or uncertain performance measures.

7.5.1 Sensitivity to Variation in Stakeholder's Weights

Separate sets of weights were derived from the four stakeholder groups. The variation in weights across these groups provided a set of sensitivity results. Table 7-24 shows the range of weights that were obtained from stakeholders for each of the major categories of attributes.

The ranges of weights in this table provided an indication of the attributes for which sensitivity analyses should be obtained.

The first set of sensitivity cases was generated by four sets of stakeholder weights. Figure 7-23 shows the final weighted score obtained for each alternative using each of the stakeholders' weights. The ordering of the alternatives along the x-axis was based on the average of the total scores for the four stakeholder groups. This average was computed to simplify the display of the data and was not intended to represent a "preferred" ranking of alternatives.

Table 7-24. Stakeholder Attribute Weights.

Attribute category	Highest weight (%)	Lowest weight (%)
Health and safety	24	0
Environment	68	12
Community and economic impact	2	0
Schedule and compliance	34	9
Contribution to other missions	12	5
Technology assurance	16	11
Cost and cost profile	41	1

Figure 7-23 shows that all four stakeholder groups ranked the same alternatives in the top six. While the order of preference for these six alternatives differed with each stakeholder group, the preferred set included alternatives 4, 5, 11, 13, 14, and 16. As shown by the flat slope of the solid line in Figure 7-23, the average total score for those six alternatives were fairly close. Again, all of these alternatives used an NPF and the TRUEX process and all, except alternative 16, used early in-tank washing in DSTs to provide early feed to HWVP. Alternatives 7, 8 and 10 showed slightly lower preferences on average. These data also showed the degree of spread or variation in preferences across stakeholder groups. There was fairly good agreement on the top alternatives, but a wide range of disagreement on the lower-ranked alternatives.

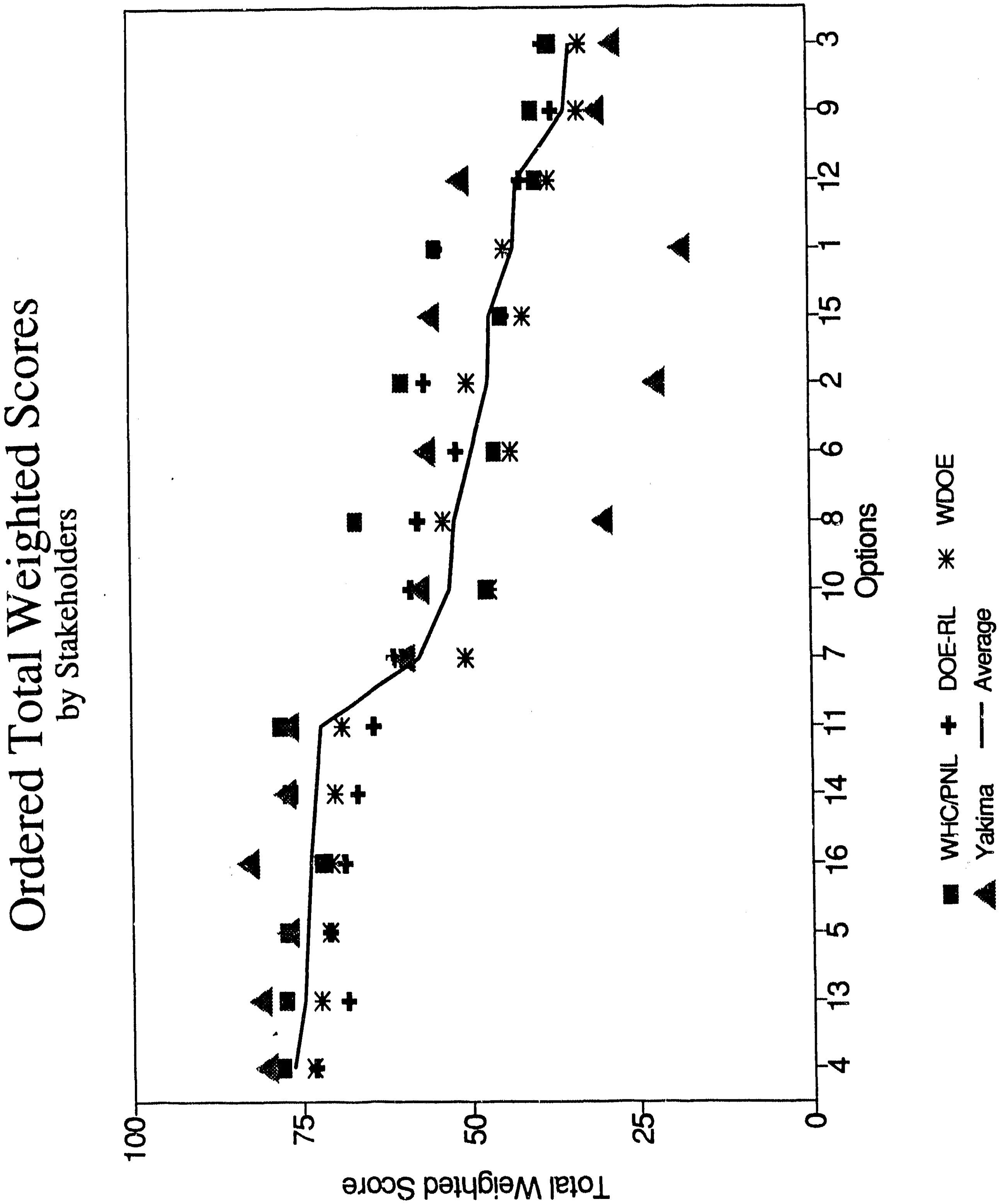
By incorporating these pretreatment processes into the program strategy, a consensus among stakeholders may be achieved. This would support the conclusions of the MAU analysis presented in Section 7.4.2, which indicated a stakeholder's preference for alternatives 4, 5, 11, 13, and 14.

All of the alternatives showed high cost growth. The impact of HWVP construction and initial operation alone causes high growth in the annual program budget and places a strain on the annual budget process. Cost profile, or funding viability, will be an issue with all of the alternatives and mitigating strategies will need to be developed.

7.5.2 Impact of Weight on Grout Vaults and Solid Waste

The difference in stakeholders' values on the impact of the weight of grout vaults and solid waste reflects the concern of the Yakima Indian Nation over the residual inventory of contaminants left on the Hanford Site. This does not appear to lead to a different set of preferred alternatives (see Figure 7-23). This insensitivity is because the alternatives that produce the fewest grout vaults are those that do most of the processing in new facilities, and thus allow optimization of process flowsheets. These are the same alternatives that are ranked highest by the other stakeholder groups. In deriving the weight for these attributes, it was determined that the real

Figure 7-23. Sensitivity Analysis--Variation in Stakeholder Weights.



concern was not the number of grout vaults or the amount of solid waste but the inventory of mobile constituents that would be disposed of onsite. If this inventory was reduced, the weight applied to the number of grout vaults would be substantially less. Therefore, the impact of the high weight placed on the number of grout vaults and solid waste generation was examined through sensitivity analysis.

Figure 7-24 shows the result of the sensitivity analysis on the weight placed on the number of grout vaults. The initial weight was approximately 30 percent for the Yakima Indian Nation. As the weight is lowered toward zero (which would correspond to some action taken to remove mobile constituents from grout), the preferred set of alternatives remains the same (i.e., alternatives 4, 5, 14, 16, etc.). Alternatives 7 and 11 become somewhat less preferred. This analysis shows that the preferred set of alternatives is quite insensitive to the weight placed on grout vaults (this is because these alternatives minimize the number of grout vaults through the use of an NPF). Nevertheless, there is a strong incentive to take additional steps to reduce the inventory of mobile constituents in grout (e.g., through technetium removal or nitrate destruction).

Figure 7-25 shows a similar sensitivity analysis on the weight placed on solid waste generation (assuming onsite disposal of the waste). Again, the initial weight from the Yakima Indian Nation was about 30 percent. As this weight was lowered toward zero (which would correspond to actions taken to minimize waste generation, improve onsite disposal, treat waste before disposal, or offsite disposal), the preferred set of alternatives did not change substantially.

7.5.3 Impact of Weight on Cost Profile

The next sensitivity analysis showed the impact of variations in the weight assigned to cost profile. The reference point for this analysis was the set of attribute weights provided by the U.S. Department of Energy Field Office, Richland, because this stakeholder group placed the highest value on cost profile, approximately 20 percent. The rationale for examining variations in this weight was the fact that the funding profile for all of the alternatives was quite steep. It was also difficult at this stage of the program redefinition to accurately predict the annual funding requirements. As the program and final strategy become better defined, steps will be taken to improve the "fundability" of the strategy. Also, this sensitivity analysis allowed us to examine the preferences independent of judgments about annual funding constraints. Figure 7-26 shows the total value for the top six alternatives as the weight on cost profile varies from its initial value, about 20 percent. As the weight was reduced to zero, alternative 16 showed the most noticeable relative change. This effect was caused by its relatively steeper funding profile--it has HWVP and an NPF built at approximately the same time. Thus, reducing the weight on this attribute tended to improve the relative ranking of this alternative. For the most part, the relative order of the top six alternatives stayed unchanged.

Figure 7-24. Number of Grout Vaults Attribute Sensitivity Analysis--
Yakima Indian Nation Preferences.

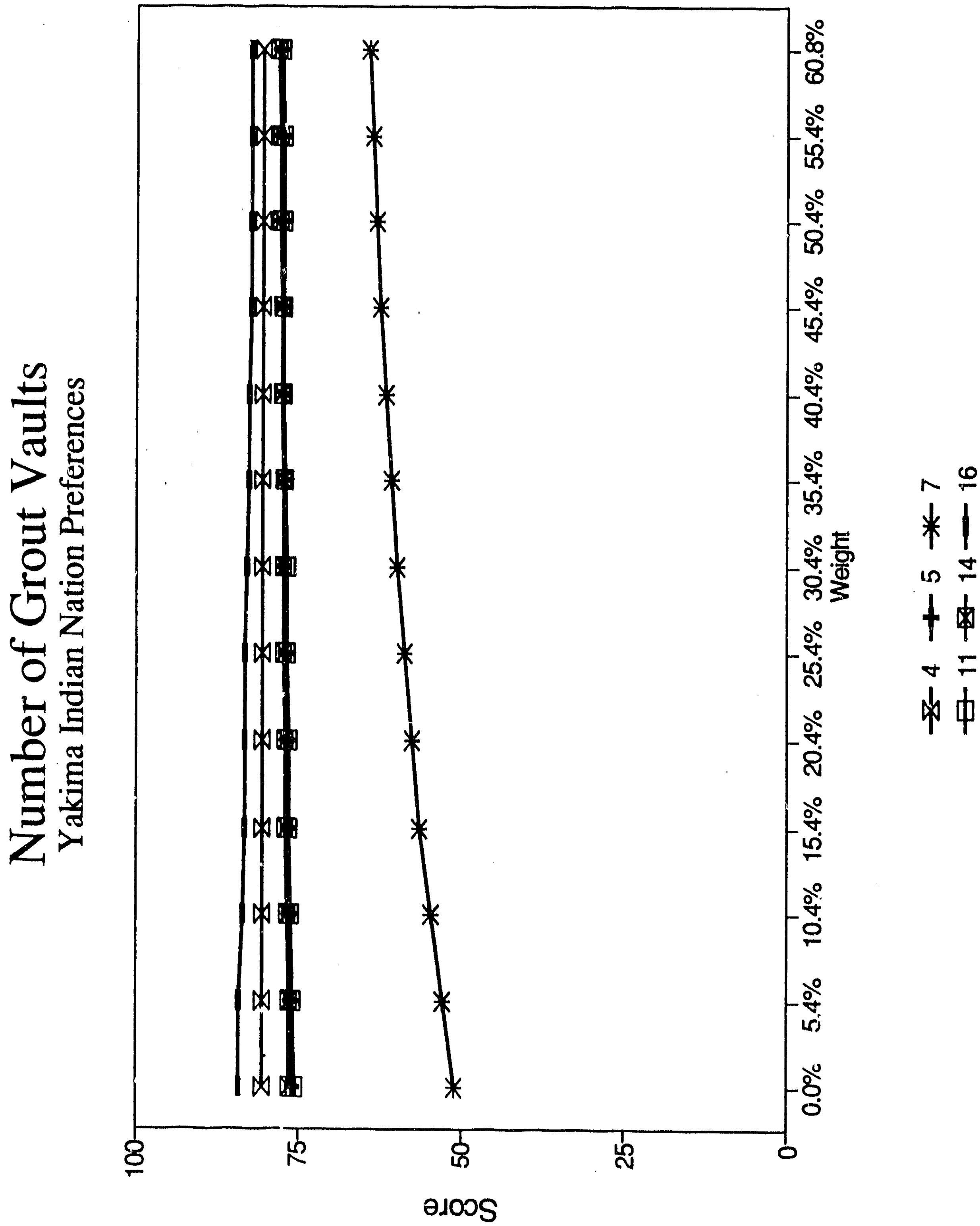


Figure 7-25. Solid Waste Generation Attribute Sensitivity Analysis--
Yakima Indian Nation Preferences.

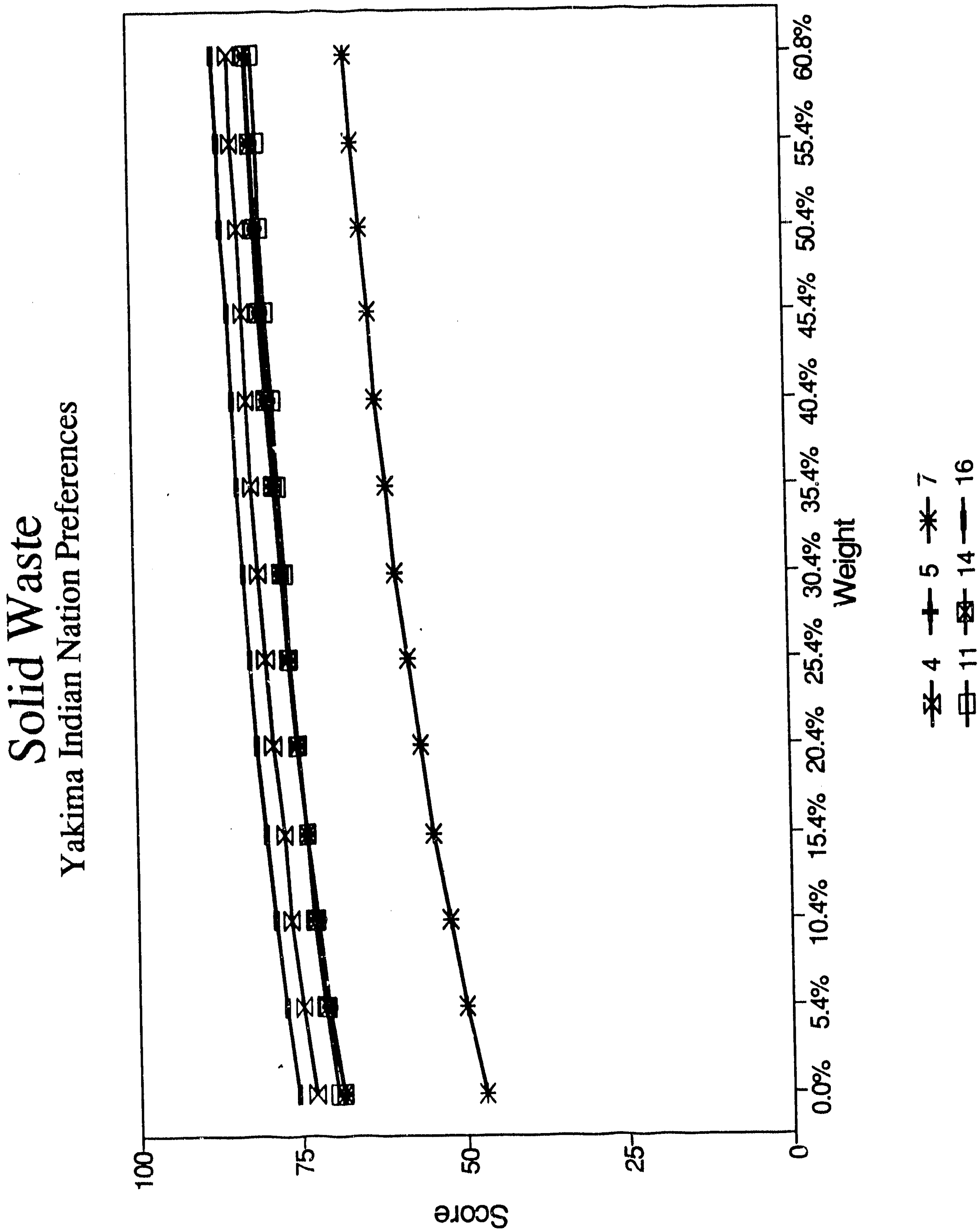
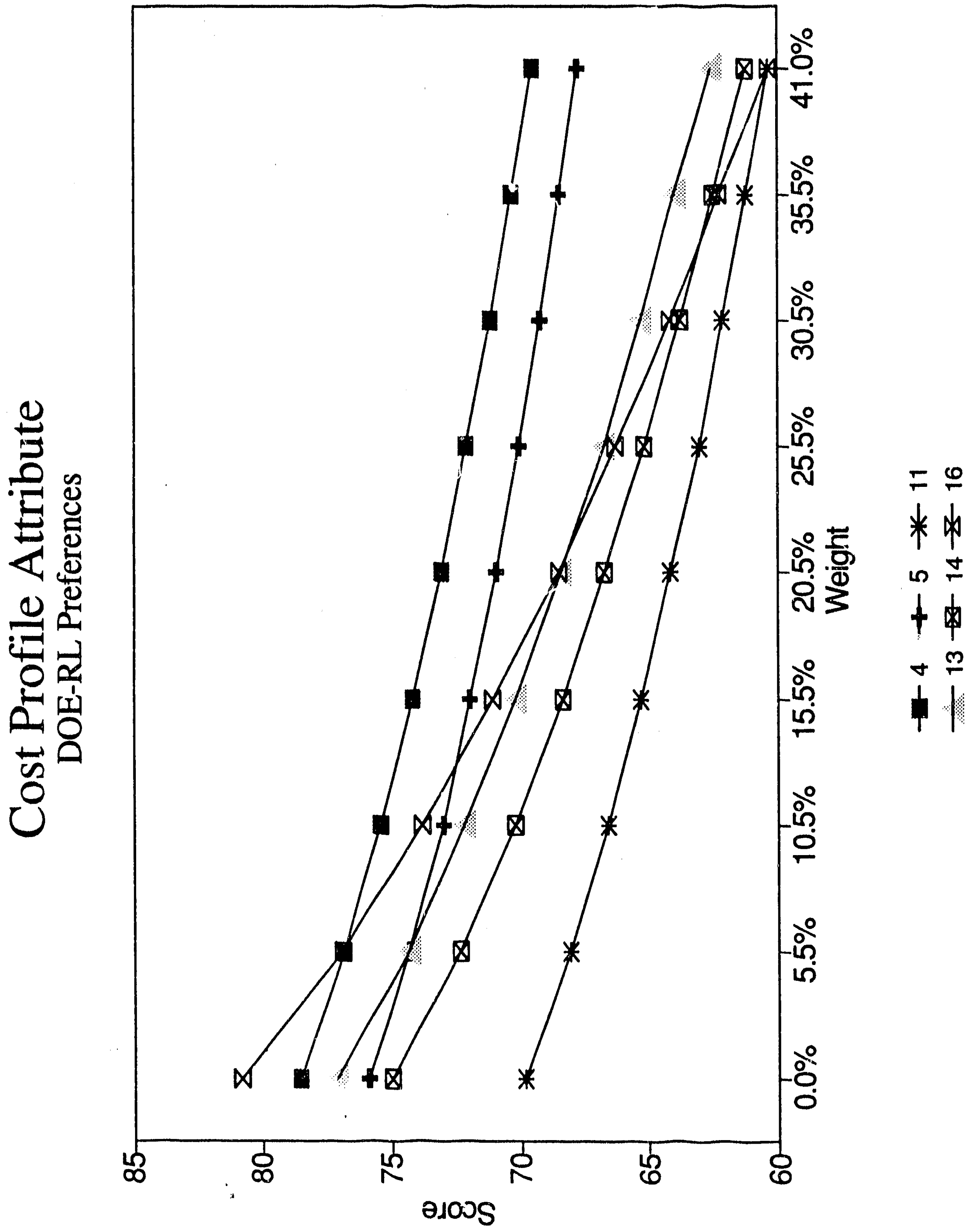


Figure 7-26. Cost Profile Attributes Sensitivity Analysis--
U.S. Department of Energy Field Office,
Richland, Preferences.



7.5.4 Impact of Combined Double-Shell Tank and Single-Shell Tank Mission Costs

The cost attribute included in the initial model covered only the cost for the DST mission. It did not include the cost for the SST mission. If the combined program costs were included, would the preference for the alternatives change?

Figure 7-27 shows the impact of including the cost for the combined DST and SST mission, where the SST mission is assumed to retrieve and treat waste in all 149 tanks. The cost impact that resulted was also discussed in Section 7.3.2.3.3. To compute the effect of broadening the cost basis of the alternatives on the overall preferences or ranking of alternatives, the DST cost attribute was replaced with the combined DST and SST cost and the same set of weights were applied.

As shown in Figure 7-27, the relative ranking of the top six alternatives does not change when compared to the ranking with DST costs alone (compare to Figure 7-23). This result is expected because cost was generally not the most highly weighted attribute, and all the top-ranked alternatives used an NPF with the TRUEX process. Those same alternatives tended to have the lowest total cost for the combined DST and SST waste disposal mission.

7.5.5 Impact of High-Level Waste Canister Cost Assumptions

The disposal cost for HLW canisters was assumed to be $350,000 per canister. This cost was assumed to be constant and independent of the number of canisters produced. It can be argued that scenarios that produce greater numbers of canisters would amortize the cost of the repository over a greater number of canisters and would thereby result in lower per canister disposal cost. Strong arguments can be made the other way as well. One way to test the importance of this assumption was to eliminate the canister disposal cost altogether. In addition, when the weight assigned to the number of HLW canisters that are made was allowed to drop to zero, in effect, no penalty was added for making more canisters. This was an extreme position but, as shown in Figure 7-28, only very small shifts occured in the preferences among the alternatives. Of the top alternatives, alternative 5 improved its relative performance if the canister costs and implications were ignored. Of the alternatives using the TRUEX process, alternative 5 made relatively more canisters because of the use of intermediate processing.

Alternative 7, the highest ranked non-TRUEX alternative, increased relative to the other alternatives, but not sufficiently to be included in the top set of alternatives.

Figure 7-27. Ordered Total Weighted Scores--Double-Shell Tank and Single-Shell Tank Costs.

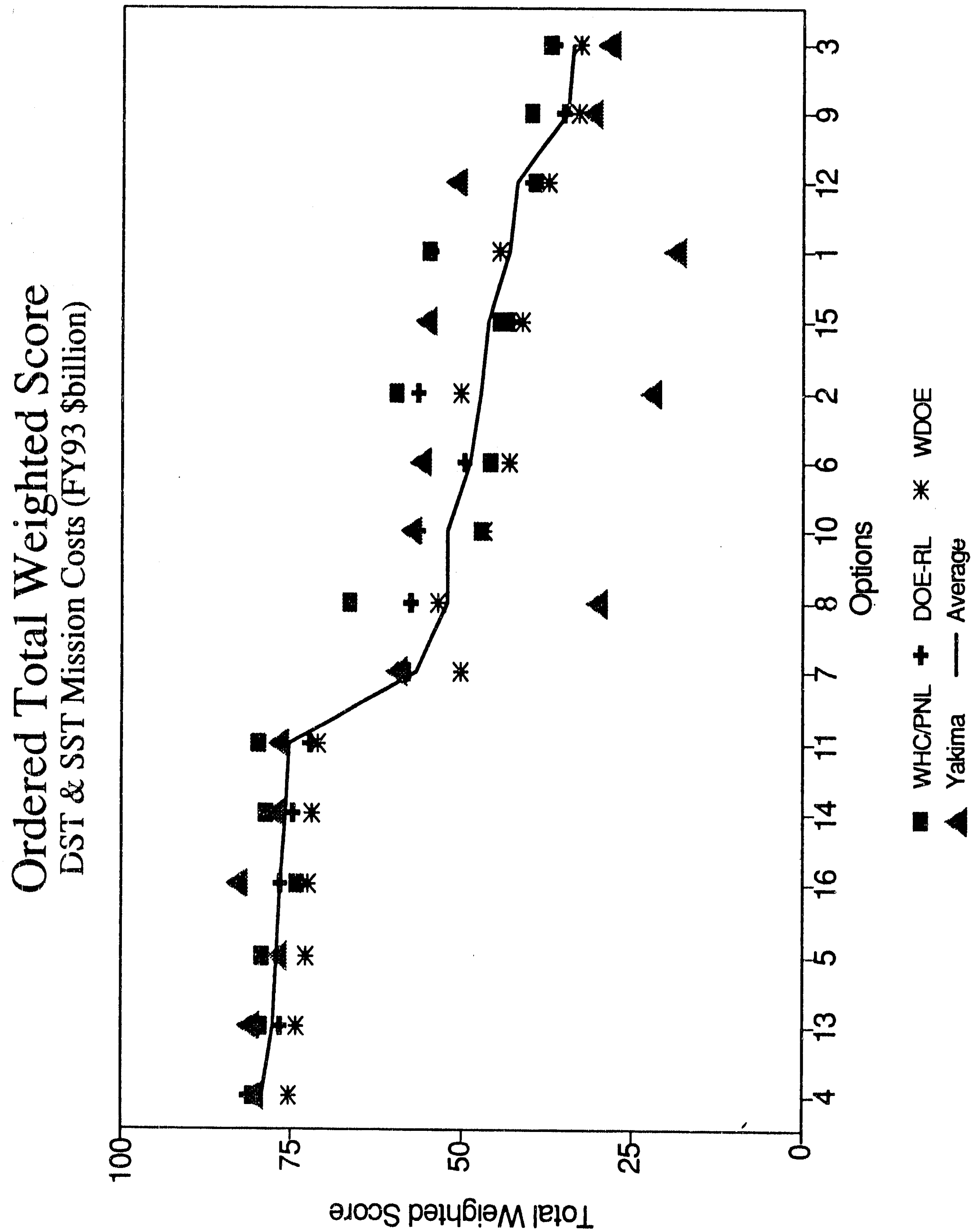
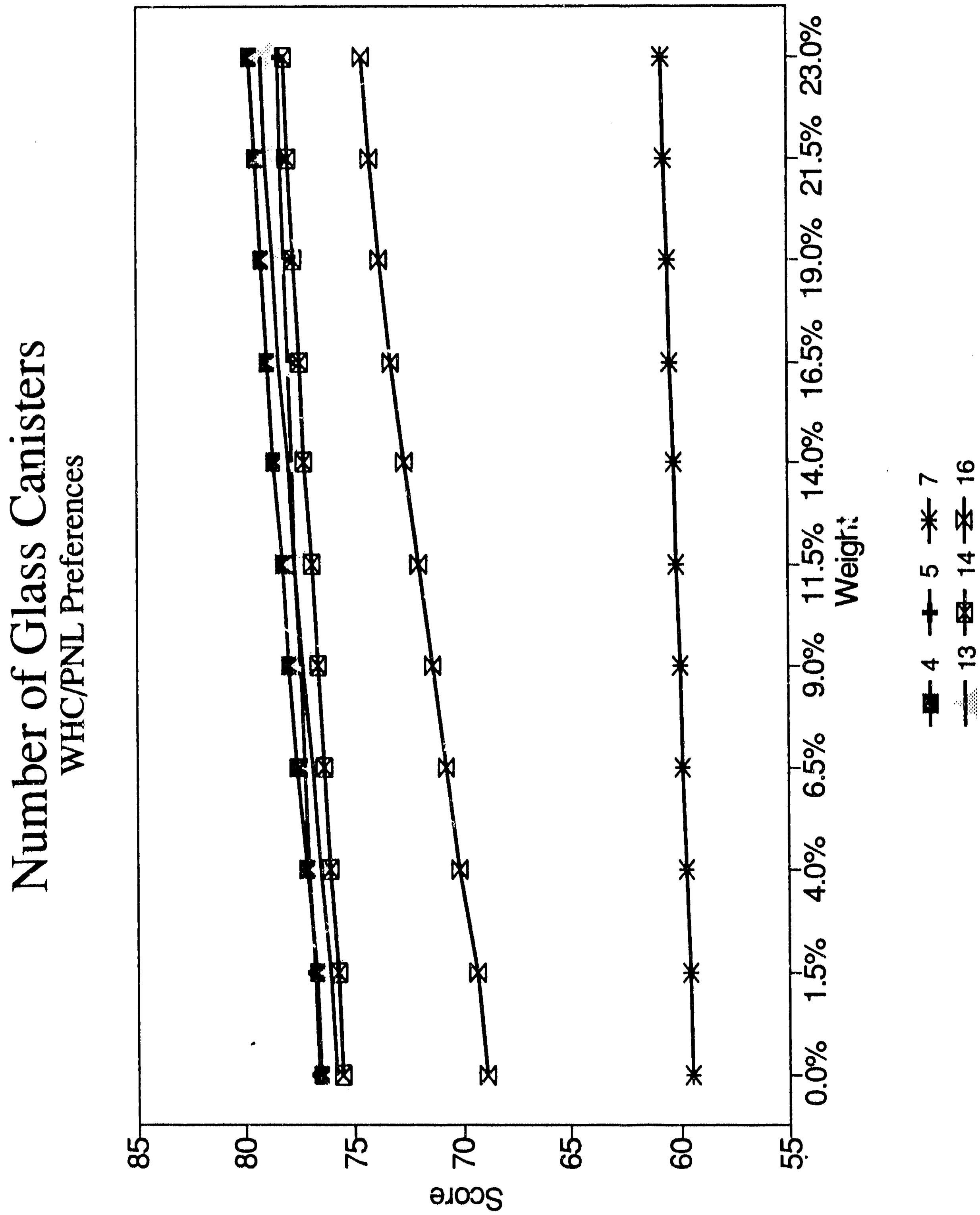


Figure 7-28. Number of Canisters of Vitrified Waste Attribute Sensitivity Analysis--Westinghouse Hanford Company and Pacific Northwest Laboratory Preferences.



7.5.6 Impact of Cesium and Strontium Capsule Mission

During the weight elicitation process, a separate weight was not obtained for the contribution to the cesium and strontium capsule mission. An attribute score, however, was obtained. Therefore, the impact of a range of potential weights placed on this attribute can be assessed. Figure 7-29 shows the impact of varying this weight from 0 percent to 5 percent (i.e., somewhat less than the weight for contribution to the SST mission). The Westinghouse Hanford and Pacific Northwest Laboratory weights for all other attributes were used as the point of comparison for this analysis. Alternatives that used B Plant scored higher on this attribute than alternatives that did not use B Plant (see Section 7.2.2). Therefore, of the top six alternatives, alternative 11 tended to rise relative to the other alternatives as the weight was increased on this attribute.

7.5.7 Impact of Estimates of Worker Radiological Accident Fatalities

Another attribute that was estimated but not used initially in the MAU analysis was the worker radiological risk from accidents. This attribute was measured in rem exposure to the maximally exposed individual. There was no easily justifiable basis for estimating the impact on the whole worker population. Very rough estimates, however, were postulated for worker fatalities. These estimates were three to four orders of magnitude less than the nonradiological accident risks to workers. Therefore, it was judged that a greatly improved estimate would still not have a discernable impact on the total score for these alternatives.

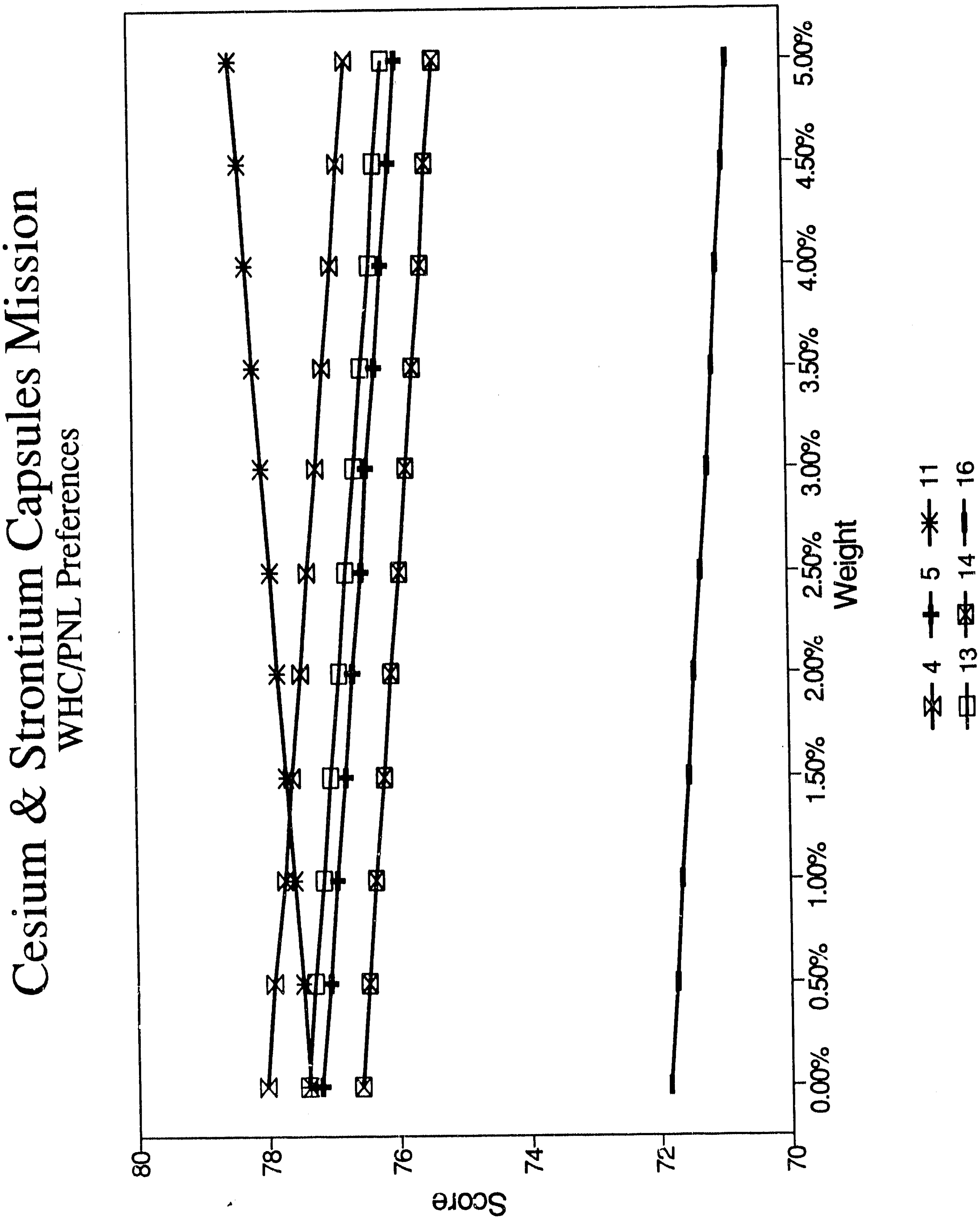
7.6 PROGRAMMATIC RISK ANALYSIS

Science Applications International Corporation was retained by Westinghouse Hanford to develop a systematic analysis of the technical, regulatory, and programmatic uncertainties associated with the characterization, retrieval, pretreatment, and vitrification of the various wastes stored at the Hanford Site (Bailey 1991). The risk analysis was performed on each of the 16 alternatives being considered in this document. The analysis was intended to be a preliminary phase in a multistep process that will produce a sophisticated risk analysis of the redefined tank waste disposal program in FY 1992.

In performing the preliminary phase of the risk analysis, Science Application International Corporation used the same basic approach and risk analysis modeling technique [venture evaluation review technique (VERT) software] originally used as part of the risk assessment (Miller et al. 1991). The quantified cost uncertainties, schedule uncertainties, and success likelihoods for each of the alternatives were aggregated into figures-of-merit, which were used to rank the alternatives.

The preliminary phase of the risk analysis process ranked TRUEX process alternatives above non-TRUEX process alternatives and favored alternatives that included fewer processing steps or involved fewer facilities.

Figure 7-29. Cesium and Strontium Capsule Mission Attribute Sensitivity--Westinghouse Hanford Company and Pacific Northwest Laboratory Preferences.



Comparing the MAU analysis and risk analysis results showed that four of the top five alternatives were the same. Thus, the risk was not explicitly included in the MAU attribute, but a viable set of proxy attributes existed. Comparing the figure of merit values within the risk analysis, three distinct groupings of alternatives appeared. The top four alternatives (4, 14, 5, and 13) formed the first group with the figure of merit values between 4.0 and 5.0. The fifth and sixth ranked alternatives (8 and 2) formed the second group with the figure of merit values between 2.0 and 3.0. The major reason for the lower figure of merit values for this second group was the lower probability of success for permitting the use of existing facilities, PUREX Plant and B Plant. The remaining 10 alternatives formed the third group with figure of merit values of 1.0 or less. The alternatives are ranked in descending order in Table 7-25.

Table 7-25. Risk Analysis Figure-of-Merit Ranking of Alternatives.

Alternative	Description
4	DST/NPF with TRUEX
14	DST/Intermediate processing/HWVP (limited)/NPF
5	DST/Intermediate processing/NPF with TRUEX
13	DST/HWVP (limited)/NPF with TRUEX
8	DST/PUREX Plant with TRUEX
2	DST/B Plant with TRUEX
11	DST/B Plant (limited)/NPF with TRUEX
1	244-AR Vault/B Plant with TRUEX
16	NPF with TRUEX
7	DST/Intermediate processing/NPF without TRUEX
10	DST/HWVP without TRUEX
6	DST/NPF without TRUEX
15	DST/HWVP (limited)/NPF without TRUEX
9	DST/PUREX Plant without TRUEX
3	DST/B Plant without TRUEX
12	DST/B Plant (limited)/NPF without TRUEX

NOTE: Limited means limited pretreatment capabilities, which includes cesium ion exchange and sludge washing only.

DST = Double-shell tank
HWVP = Hanford Waste Vitrification Plant
NPF = New pretreatment facility
PUREX = Plutonium-Uranium Extraction
TRUEX = Transuranic extraction.

Alternative 11, which was rated in the top five alternatives in the MAU analysis, was the top alternative in the third group. It was ranked lower by the risk analysis because it used an existing facility. It was ranked lower than the second group of alternatives because in addition to the existing facilities permitting risks, it included the risks associated with design, construction, and permitting of an NPF.

7.7 EXTERNAL PEER REVIEW

A peer review panel was formed to provide an independent overview of the process associated with the redefinition project. The panel consisted of representatives from the following organizations:

- Westinghouse Savannah River Company
- Westinghouse Idaho Nuclear Company
- Martin Marietta at Oak Ridge National Laboratory
- An independent consultant with experience from working with Oak Ridge National Laboratory
- British Nuclear Fuels, Limited
- Massachusetts Institute of Technology
- Westinghouse, West Valley Demonstration Project.

The group was chartered to review the decision process and results from both a national and international point of view. In addition, they were asked to comment on specific areas of concern to the project staff.

The peer review panel was in general agreement with the strategic course of action chosen by the project. There was strong support to begin the preparations for waste disposal including the start of HWVP construction.

Using in-tank sludge washing was also believed to be sound. The peer review panel also believed that better integrated planning was needed at all levels, but this should not prevent the start of near-term activities. While it was agreed that cesium ion exchange is necessary, the panel thought that more work was needed to support its incorporation in HWVP at the resultant cost and schedule impact.

Concern was expressed over the aggressive schedule duration and funding needs, the perception of a lack of institutional support from both DOE and Westinghouse Hanford, and the lack of analytical laboratory support available throughout the country.

The peer review panel reiterated their feeling that the problems could be overcome and that they did not justify a delay in starting planned activities for the near future. The results of the peer review are presented in Appendix E.

7.8 SELECTION OF A PREFERRED ALTERNATIVE

Several key conclusions were drawn from the comparative analysis of the decision attributes in Sections 7.1 through 7.5 for the 16 pretreatment alternatives. These conclusions are as follows.

- Remediation of tank wastes should proceed in a timely manner.
- Sludge washing in an existing or new DST is desirable to provide early feed for vitrification in the HWVP.
- An NPF is preferred to alleviate environmental compliance and safety issues involved with using existing facilities. Additionally, the design and construction of an NPF would support the processing of SST wastes, if the ROD determines this to be the selected disposal method for SST wastes.
- The remediation of SST 241-C-106 through waste retrieval and transfer resolves a priority tank safety issue and provides additional early feed for pretreatment to ensure continuity of HWVP operations.
- The TRUEX process alternatives result in fewer canisters of vitrified waste, reduced disposal mission costs, and will support completion of the tank waste disposal mission at an earlier date than achievable using sludge washing alone or sludge washing in combination with intermediate processing.
- The addition of intermediate processing provides flexibility to the tank waste disposal mission by accelerating the processing of some wastes before construction of an NPF and could potentially reduce the scope of process requirements for an NPF.

These conclusions, which are based on satisfaction of stakeholder's values, led to a preference for alternatives 4, 5, 11, 13, and 14. Differentiation and selection of a preferred alternative from among these five alternatives was accomplished by comparing the program redefinition objectives in Section 1.0.

Alternative 11 proposes limited use of B Plant to separate cesium from NCAW supernatant. The B Plant design is inherently difficult to qualify or modify to meet Washington State Department of Ecology secondary containment requirements for dangerous waste systems. Therefore, alternative 11 represents a significant risk to the tank waste disposal program and was eliminated from further consideration.

Alternatives 5 and 14 represent incorporation of the flexible strategy (i.e., intermediate processing) into the tank waste disposal program. Alternatives 4 and 13 are similar to alternatives 5 and 14, but do no include intermediate processing. Alternatives 5 and 14 provide additional flexibility to incorporate new technology and are preferred to alternatives 4 and 13.

The cesium ion exchange pretreatment process is included in the HWVP for alternative 14. Cesium ion exchange pretreatment capability is included in an

NPF for alternative 5. Including the cesium ion exchange process within the HWVP would allow for early disposal of NCAW supernatant as well as NCAW sludge. The NCAW supernatant represents approximately 40 percent of the total radioactivity present as HLW in DSTs. Remediation of NCAW supernatant along with the sludge would remove approximately 80 percent of the radioactivity from DSTs; this is a significant step toward disposal of all Hanford Site tank wastes. However, inclusion of the ion exchange process within the HWVP results in an estimated minimum 15-month delay to the initiation of hot (radioactive) startup of the facility. Because the primary objective of the tank waste disposal program is to remediate wastes in a timely manner using demonstrated technologies, incorporation of the cesium ion exchange process within the HWVP is preferred to delaying remediation of NCAW supernatant until an NPF is available.

Based on these considerations, alternative 14 was selected as the preferred alternative because it best supports the objectives of the Hanford Site tank waste disposal program when viewed in light of the stakeholder's values.

7.9 RESOLUTION OF MAJOR UNCERTAINTIES IDENTIFIED BY THE HANFORD WASTE VITRIFICATION SYSTEMS RISK ASSESSMENT-FINAL REPORT

The *Hanford Waste Vitrification Systems Risk Assessment-Final Report* (Miller et al. 1991) identified nine major uncertainties in the vitrification program. Each of these uncertainties was considered during the development of the recommended new program strategy. The *Hanford Waste Vitrification Systems Risk Assessment-Final Report* (Miller et al. 1991) uncertainties are paraphrased in the following text with a brief description of how each is addressed in the new program strategy.

1. **Acceptability of B Plant**--The acceptability of B Plant to unequivocally demonstrate compliance to modern regulatory requirements.

   This concern is addressed by replacing B Plant with an NPF. The new plan still uses B Plant and the WESF to support technology development activities, i.e., the TRUEX pilot plant. However, the technology development support requirements and facilities for the redefined program will be revised during FY 1992 to ensure an integrated, cost-effective technology development program is implemented.

2. **Waste composition variability**--The tank wastes have not been adequately characterized to bound potential impacts on waste retrieval and pretreatment processes.

   This uncertainty is mitigated in three ways. The first mitigating action is the integration of the tank waste characterization program to support the DST and SST remediation and tank waste safety programs (see Section 9.2). The second mitigating action is the prioritization of near-term characterization needs to support the highest priority data needs (see Section 9.2). The third mitigating action is the restructuring of the program to defer, by approximately 7 yr, the need for long-term (TRUEX and organic destruction) process development waste composition data. This change significantly reduces the program near-term characterization data that is needed.

3. **Waste retrieval**--There are concerns on the substantial variations in the physical properties of the various waste types, uncertain condition of the waste tanks, and the potential schedule impacts these may have on the design, development, and implementation of waste retrieval.

   This uncertainty is partially mitigated by the prioritization of characterization activities discussed previously and in Section 9.2. Additional mitigation results from the delay in startup of HWVP radioactive operations due to incorporation of cesium ion exchange pretreatment capabilities. The delay will greatly enhance the probability that the first retrieval waste type, NCAW from tank 241-AZ-101, will be available in time to support the hot startup of HWVP. The new schedule actually provides time for installation of the four pump retrieval system in tank 241-AZ-101, if the two pump system fail to achieve adequate solids recovery without impacting HWVP startup. The third retrieval uncertainty mitigating action is the restructuring of the program to retrieve and process similar waste types together. The wastes planned for retrieval after NCAW are tank 241-C-106 waste and then PFP waste. Both these waste types are anticipated to be similar to NCAW but may use different retrieval systems due to safety concerns for tank 241-C-106.

4. **Tank safety issues and tank farm upgrades**--Resolution of tank safety issues and completion of needed tank farm upgrades could potentially impact both the retrieval and treatment of tank wastes.

   This uncertainty is addressed by using the systems engineering approach that integrates DST, SST, and tank waste safety program activities. The tank waste safety program remains the top priority defense waste activity and, as such, the safety issues are being resolved on an expedited basis. Integration of tank safety issues into the characterization and retrieval portions of the tank waste disposal program are discussed in items 2 and 3, and in Section 9.2 in more detail. Completion of tank farm upgrades remains a program uncertainty that will have to be carefully managed particularly in light of the addition of in-tank sludge washing as an element of the new program. New DSTs are being considered for resolution of specific tank safety issues. The design of these new DSTs will accommodate both safety and disposal program functions.

5. **Pretreatment technology**--In the 1991 baseline program, relatively near-term implementation of complex, undeveloped pretreatment (TRUEX and organic destruction) processes was planned.

   This concern has been addressed by deferring the initial implementation of these processes by approximately 7 yr, thereby, extending the available process development time by this same duration. This change also reduces the peak annual outlay requirement for the program.

6. **Lack of integration of DST and SST waste programs**--The lack of integration of the DST and SST waste programs could adversely impact the cost and duration of the overall Hanford Site tank waste disposal program.

   This concern has been addressed through the use of a systems engineering approach that addresses the DST, SST, and tank waste safety program activities. In addition, Westinghouse Hanford has initiated a management realignment within the Defense Waste Remediation Division (the creation of the Waste Retrieval and Pretreatment organization responsible for integration of retrieval and pretreatment of both DST and SST wastes) to enhance communications and integration of the DST and SST programs.

7. **Closure of SSTs by 2018**--The current plan for preparation of an SEIS for SST wastes combined with the subsequent permitting process will not support the Tri-Party Agreement (Ecology et al. 1990) milestone for SST closure by 2018.

   This concern has been addressed by recommending that preparation of the SEIS for closure of SSTs be accelerated. If an expedited SEIS process achieves an ROD in 1996, SST closure can be completed by 2021. If, in addition to expediting the SEIS, SST wastes are pretreated before DST wastes, the 2018 closure date can be met (see Section 2.4.3). This milestone, however, remains a high risk area for completion.

8. **Availability of DST space**--The DST space availability is currently very limited, and additional DST storage space is needed by the mid- to late-1990's to store the segregated high- and low-level wastestreams generated by pretreatment operations. This space must be provided by disposal of the low-level double-shell slurry and double-shell slurry feed (DSSF) as grout. If further delays in the restart of grouting operations occur (beyond the recently negotiated 27-month slip in the Tri-Party Agreement milestone), delays in the tank waste disposal program may occur because of inadequate DST space.

9. **Availability of funding**--Completion of the tank waste disposal program will require the commitment of major financial resources. As planned in the FY 1991 baseline, the program showed major annual expenditure rate increases that may not be supportable given the competition for Federal funds.

   The funding availability concern has been addressed in the new program in two ways. First, the new program has been structured to be robust. If an element of the program fails, the program defaults to an alternative path for completion of the disposal mission. For example, if an NPF could not be funded in a timely manner, the pretreatment portion of the program could rely on just sludge washing and intermediate processes for a longer duration. The total program cost would, however, increase under this default scenario because of larger volumes of vitrified waste produced. The second mitigation of the funding concern is achieved by considering the annual expenditure growth rate factors (peak annual costs and annual percent cost increase) among the attributes used to rank the 16 alternatives considered in this document.

7.10 INCORPORATION OF NEW VITRIFICATION TECHNOLOGY AND DEFENSE WASTE PROCESSING FACILITY EXPERIENCE

Additional delays to the HWVP could potentially improve the ability to beneficially use experience gained by other vitrification projects and to use new technology with improved performance or lower cost. A review of this subject indicates that the recommended strategy will accommodate incorporation of the major lessons learned at other vitrification projects. The melter is the only area that has been identified where new technology is under development that could have a significant beneficial impact on HWVP. Successful development of advanced melters that include features to allow remote hot cell operation is expected to take many years. While some advanced features could provide benefits, these benefits are at present only theoretical (i.e., unproven). Additional delays to HWVP solely to allow incorporation of Defense Waste Processing Facility (DWPF) and West Valley Demonstration Project experience or to allow use of developing technology do not appear to be justified.

7.10.1 Vitrification Information Exchange

A fundamental strategy in developing the HWVP has been to use technology and lessons learned from the DWPF at the Savannah River Site to reduce costs and improve performance of the HWVP. Similarly, technology and lessons learned from the West Valley Demonstration Plant have been used but to a lesser extent. This strategy has been very successful. It has significantly reduced technology development costs and has resulted in a number of changes expected to reduce design, construction, and operating costs. This information is also expected to reduce startup time and cost. The basic HWVP facility and process concepts are similar to the DWPF. Detailed mechanical design of some specialized process equipment is identical. However, overall improvements to the design have been extensive and pervasive.

A close liaison is maintained between the HWVP and DWPF staff, with both formal technical exchanges and informal exchanges of experience and expertise. The HWVP resident manager at DWPF facilitates exchanges of information and lessons learned. This has greatly expedited information flow, so that emerging issues encountered during DWPF startup are immediately addressed in the ongoing design of HWVP. The 70 formal technical information exchanges conducted since 1984 (approximately every month since 1989) cover a broad range of topics. These are supplemented by frequent teleconferences and informal technical meetings. In addition, the DWPF design media and technical document transfer process provide complete access to the DWPF design and technical basis information. All DWPF design media are available to HWVP personnel.

While taking full advantage of the design development of the DWPF and incorporating the design features proven by extensive developmental testing, several factors mandate differences between the DWPF and HWVP. First, HWVP has been specifically designed to comply with all applicable U.S. Department of Energy orders, Federal regulations, and national codes and standards including State and Federal regulatory requirements. The DWPF has been retrofitted to many of these specific requirements. Second, the laboratory and pilot-plant testing, procurement, construction experience, and startup experience at the DWPF have shown the need to modify design features and startup plans. Third, differences are necessary because of the wastestreams to be vitrified and the pretreatment processes to be used on the streams.

Numerous HWVP design features have already been incorporated based on information gained from DWPF and West Valley Demonstration Project; however, several major issues and a number of minor issues are currently being worked. The recommended schedule will allow adequate time to resolve these issues and will allow incorporation of any needed changes into the HWVP design. There will likely be additional issues as the DWPF and West Valley Demonstration Project proceed through cold process tests and hot startup. However, these are expected to be relatively minor issues resulting in limited changes to design details and/or operating practices. Because of the extensive testing and experience base that currently exists, the probability of an issue that would result in major design changes is judged to be very low. With the recommended strategy, construction of the HWVP main process building will not be initiated until after the DWPF cold process tests are well under way, further reducing risk. A summary of the major DWPF-related issues currently being worked by HWVP follows.

- **Hydrogen Evolution During Feed Preparation**

  Issue: Recent testing by HWVP and DWPF personnel indicates higher than expected hydrogen generation during the formic acid reaction with the feed. Analyses indicate a design modification will be required to accommodate the increased generation rates.

  Status: A large amount of testing was performed in FY 1991 to better quantify expected hydrogen generation rates. Testing was also done to gain a better understanding of the chemistry and of the effect of variables on generation rates. Additional testing and analysis of the existing data are in progress. Finalization of a revised design basis and implementation of required changes into the HWVP design are expected in FY 1992.

- **Heating, Ventilation, and Air Conditioning System Control and Balancing**

  Issue: Serious air balancing and heating, ventilation, and air conditioning control problems have been encountered during startup testing at DWPF. Problems include ductwork leakage, improper sealing of electrical raceways, conduits, and embeds; air leakages across facility zone boundaries; complex startup logic; and complex safety interlocks. A fundamental balancing problem persists with the DWPF design because of the multiple supply systems with one exhaust.

Status: The HWVP heating, ventilation, and air conditioning design features that are different from DWPF include a simplified zone 1 supply system and simplified zone II and III heating, ventilation, and air conditioning systems. Supply, transfer, and exhaust fans have been balanced and the number of fans in series has been minimized. To minimize leakage, the facility design will include specific sealing details for electrical raceways, conduits, and jumper embeds. The vitrification building heating, ventilation, and air conditioning design is being further simplified as a result of the recent systems optimization, which provides for three independent zone II and III heating, ventilation, and air conditioning systems.

- **Distributed Control System Operability**

  Issue: The DWPF distributed control system data highway has experienced high error rates, noise, and heavy highway traffic that has resulted in control system failures. These include heating, ventilation, and air conditioning system upsets, and unacceptable system response times. This has been compounded by frequent hardware failures (boards, power supplies, modems).

  Status: The HWVP computer system design philosophy and architecture have evolved based on DWPF experience. The HWVP basic system architecture improves the distributed control system reliability while using it less for critical systems. The health protection computer system was specified as a separate computer system from the distributed control system; also, local control panels, rather than the distributed control system, are used for control of electrical generators, electrical distribution, steam generation, and plant air compressors. Fiber optic cable will be used for the distributed control system data highway for improved reliability. The grounding design for the computers and instrumentation will be optimized. Additional changes currently under evaluation for potential incorporation into HWVP include control of the heating, ventilation, and air conditioning systems using controllers that are not dependent on the distribution control system data highway.

- **Construction, Startup, and Turnover Logistics**

  Issue: The DWPF startup testing effort was not well defined until late in the project; thus, planning, staffing, and performance of testing has not met schedule expectations. The DWPF startup team entered the project at the startup test phase. This did not permit early planning and procedure development necessary for a smooth, logical flow of testing to support an orderly turnover to operations. The DWPF construction was over 95 percent complete before any preoperational test procedures were approved. Startup testing has revealed deficiencies that have required substantial efforts to correct. Preparation for the testing effort, conduct of individual tests, and resolution of problems encountered have all taken substantially longer than planned.

Status: The HWVP startup team was formed before the start of detailed design. This early involvement has allowed HWVP startup engineers to correct startup deficiencies identified by the DWPF. Early involvement and a phased, sequenced startup approach is planned for HWVP to allow for early turnover of construction packages, early performance of preoperational tests, and identification and correction of deficiencies. Early involvement will also allow time to develop level 1, 2, and 3 startup test schedules as well as startup plans and procedures.

- **Noble Metal Accumulation in the Melter**

  Issue: Buildup of noble metal sludges may reduce melter life. This is primarily an issue for the highest noble metal feed (first NCAW tank).

  Status: Testing is in progress at the Pacific Northwest Laboratory and the Savannah River Site to better quantify the effect of noble metals on melter life. If the results show substantial reduction in melter life may be expected, several corrective actions may be considered, including the following:

  - Modifications to the melter to increase capacity for accumulation of noble metal sludges
  - Blending of high noble metal feed with low noble metal feed
  - Toleration of shortened melter life for processing the limited quantities of high noble metal feed.

7.11 IMPACTS OF ADDITIONAL RADIONUCLIDE REMOVAL FROM LOW-LEVEL TANK WASTES

Washington and Oregon States have petitioned the U.S. Nuclear Regulatory Commission to amend regulations governing the treatment and disposal of LLWs in near-surface disposal sites. The petitioners have requested that LLWs be treated to remove all radionuclides to the extent technically feasible. If adopted, this petition could require pretreatment of existing and future LLWs before disposal in grout. The DST wastes that could require pretreatment for radionuclide removal include DSSF, double-shell slurry, dilute noncomplexed, and saltwell wastes from interim stabilization of SSTs. An estimated 75,700 m^3 (20 Mgal) of present and future DST wastes could be affected by this petition.

The recommended pretreatment facility and process strategy (alternative 14) can provide additional radionuclide removal from LLWs. The recommended strategy incorporates cesium ion exchange capabilities in the HWVP. This process could be used to remove ^{137}Cs from LLWs. However, the projected radioactive startup date for the modified HWVP is FY 2001.

Additionally, ^{99}Tc and ^{137}Cs treatment capabilities could be incorporated into an NPF. The estimated commencement of operations in an NPF is 2007.

Projections of waste volume in DSTs indicate the available storage capacity may be exceeded by 7,570 m^3 (2 Mgal) during 1998 and by 33,800 m^3 (9 Mgal) during 2001, if additional treatment of LLWs is required. Tank waste volume management alternatives to alleviate this concern before the availability of pretreatment capabilities include the following:

- Limit disposal of LLW to grout based on radionuclide content of waste
- Additional concentration of dilute noncomplexed wastes
- Construct additional DSTs beyond the four currently planned
- Defer saltwell pumping and the interim SST stabilization [see Tri-Party Agreement (Ecology et al. 1990) milestone M-05-09]
- Defer in-tank sludge washing of NCAW (see Tri-Party Agreement milestone M-03-00).

Additionally, in-tank processes (e.g., ion exchange) or activation of an existing processing facility could be used to treat LLWs. These alternatives will need to be further addressed if the U.S. Nuclear Regulatory Commission amends regulations for disposal of LLWs.

7.12 REFERENCES

Bailey, J. W., 1991, *Tank Waste Disposal Program Redefinition Option Risk Analysis*, WHC-MR-0297, Westinghouse Hanford Company, Richland, Washington.

Boomer, K. D., S. K. Baker, A. L. Boldt, M. D. Britton, L. E. Engelsman, J. D. Galbraith, J. S. Garfield, K. A. Giese, C. E. Golberg, B. A. Higley, K. J. Hull, L. J. Johnson, R. P. Knight, J. S. Layman, R. S. Marusich, R. J. Parazin, M. G. Piepho, E. J. Slaathaug, T. L. Waldo, and C. E. Worcester, 1991, *Systems Engineering Study for the Closure of Single-Shell Tanks*, WHC-EP-0405, Vol. 1 and 2, Westinghouse Hanford Company, Richland, Washington.

DOE, 1987, *Final Environmental Impact Statement, Disposal of Hanford Defense High-Level, Transuranic and Tank Wastes, Hanford Site, Richland, Washington*, DOE/EIS-0113, Vol. 1 through 5, U.S. Department of Energy, Washington, D.C.

Ecology, EPA, and DOE, 1990, *Hanford Federal Facility Agreement and Consent Order*, Vol. 1 and 2, Washington State Department of Ecology, U.S. Environmental Protection Agency, and U.S. Department of Energy, Olympia, Washington.

Lowe, S. S., 1991, *Preliminary Material Balance for Pretreatment of NCAW, NCRW, PFP, and CC Wastes*, WHC-SD-WM-TI-492, Rev. 0., Westinghouse Hanford Company, Richland, Washington.

Miller, W. C., D. W. Hamilton, L. K. Holton, and J. W. Bailey, 1991, *Hanford Waste Vitrification Systems Risk Assessment-Final Report*, WHC-EP-0421, Rev. 0, Westinghouse Hanford Company, Richland, Washington.

NSC, 1985, *Accident Facts*, National Safety Council, Chicago, Illinois.

O'Donnell, F. R., and H. C. Hoy, 1981, *Occupational Safety Data and Casualty Rates for the Uranium Fuel Cycle*, ORNL-5797, Oak Ridge National Laboratory, Oak Ridge, Tennessee.

Resource Conservation and Recovery Act of 1976, 42 USC 6901, et seq.

RL, 1991, *Environmental Restoration and Waste Management Five-Year Plan for FY 1993-1997*, DOE/RL-91-25, U.S. Department of Energy Field Office, Richland, Richland, Washington.

Scott, M. J., D. B. Belzer, R. J. Nesse, R. W. Schultz, P. A. Stokowski, and D. C. Clark, 1987, *The Economic and Community Impacts of Closing Hanford's N Reactor and Nuclear Materials Production Facilities*, PNL-6295, Pacific Northwest Laboratory, Richland, Washington.

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ACRONYMS

DST	double-shell tank
FY	fiscal year
HWVP	Hanford Waste Vitrification Plant
NCAW	neutralized current acid waste
PUREX	Plutonium-Uranium Extraction
ROD	record of decision
SEIS	supplemental environmental impact statement
SST	single-shell tank
TRUEX	transuranic extraction

8.0 RECOMMENDED BASELINE FOR SELECTED ALTERNATIVE

The selected alternative (14) (Section 7.8) includes sludge washing in double-shell tanks (DST), cesium ion exchange in an expanded Hanford Waste Vitrification Plant (HWVP), development and potential use of in-tank intermediate processing, and the construction of a new facility capable of pretreating both single-shell tank (SST) and the remaining DST wastes using the transuranic extraction (TRUEX) or an alternate actinide partitioning process. Alternative 14 embodies a technical baseline that obtains maximum benefit from mature processing technologies in the near term, with ample time allowed for minimizing the risk of successive development of more complex process technologies, such as the TRUEX process. The technical baseline promotes acceleration of the decision to leave or retrieve SST wastes.

The technical, cost, and schedule baselines for the selected alternative are to be developed, optimized, and validated during 1992. Figure 8-1 shows a preliminary schedule; the dates shown are preliminary estimates to be finalized during the baseline process. This activity is expected to take one calendar year from the date of a formal decision. Optimization of annual funding allocations and work elements will be necessary to bring funding requirements into an acceptable profile (Section 8.1.1). Significant features of the target schedule are (1) validating the project for a new pretreatment facility in the 1995 timeframe, (2) starting Title I design in 1997, and (3) commencing operations in 2007. HWVP radioactive operations will begin in 2001.

Assumptions and key program decisions as well as an implementation strategy for the baseline program are presented in the following sections.

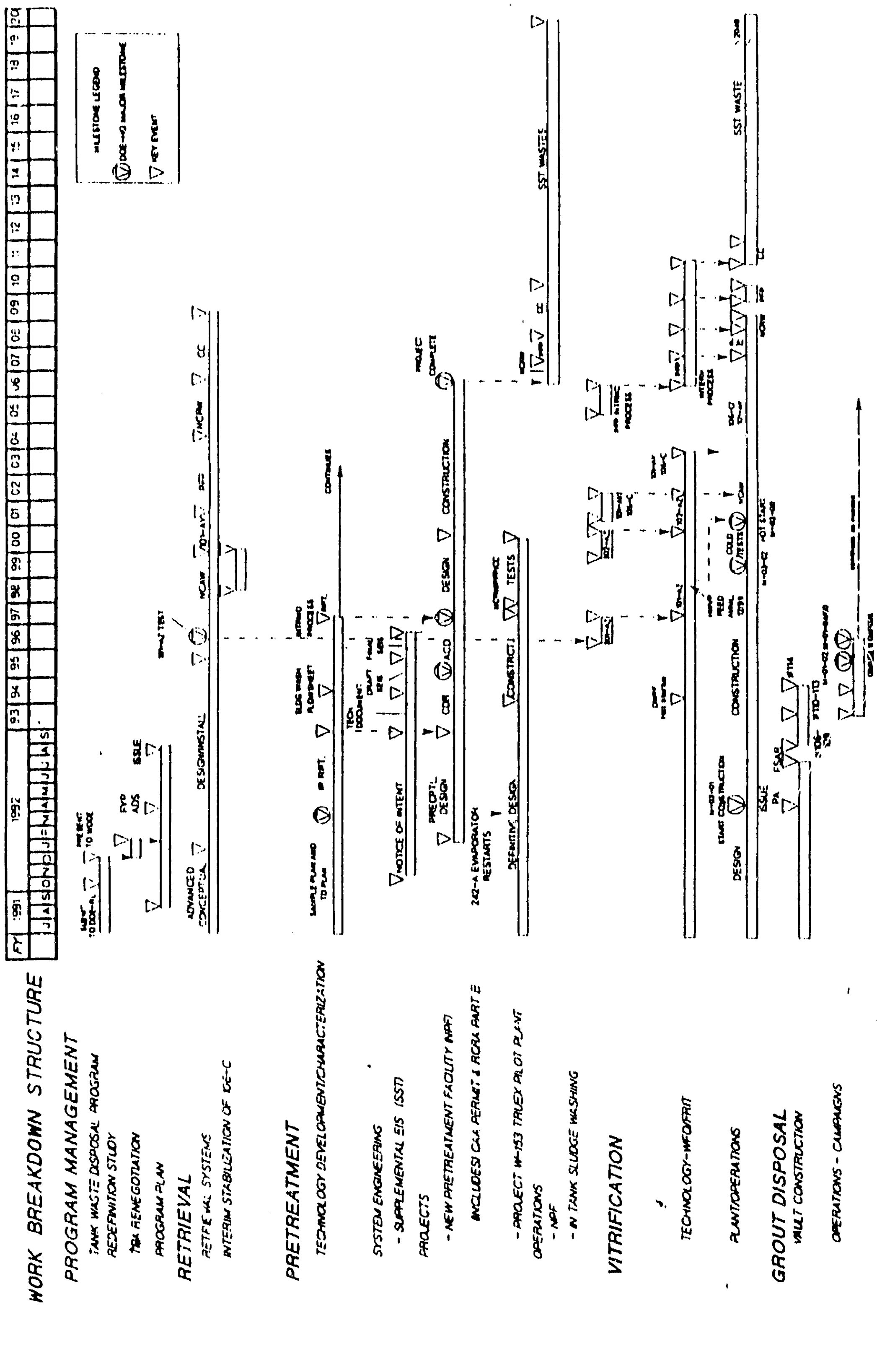
8.1 IMPLEMENTATION OF PROGRAM STRATEGY

Implementation of the selected program alternative (alternative 14) requires evaluation and development of pretreatment process methodologies, resolution of key program issues, and integration of these activities with waste tank safety remediation activities. Key program activities are performed early in the program, thus reducing program risk and providing a balanced, but aggressive, budget growth in fiscal year (FY) 1992 and FY 1993. These aspects of the program is discussed in Section 8.1.1. The overall program strategy for implementing the target schedule is discussed in Section 8.1.2.

8.1.1 Near-Term Program Activities

During FY 1992 and FY 1993, the Hanford Site tank waste disposal program will emphasize the preparation of planning documents to develop, optimize, and validate the selected alternative. Funds in addition to those presently approved in the FY 1992 president's budget (RL 1991) and validated for FY 1993

Figure 8-1. Program Schedule for the Selected Alternative



ACD = Advanced conceptual design
CAA = Clean Air Act of 1977
CDR = Conceptual design report
FSAR = Final safety analysis report
FYPADS = Five Year Plan Activity Data Sheet
PA = Preliminary assessment
TPA = Hanford Federal Facility Agreement and Consent Order (Tri-Party Agreement)
WDOE = Washington State Department of Ecology
WFQ = Waste form qualification

will be required. Optimization and validation of program activities and funding allocations for FYs 1994 through 1998 will be conducted as part of the preparation for the environmental restoration and waste management 5-yr plan, FYs 1994 through 1998 (to be developed).

A risk analysis of the selected alternative elements will be conducted to measure the confidence of achieving the major program elements, such as characterization, retrieval, pretreatment, and disposal technology development, facility construction, continuity of operations and economics. An assessment of *National Environmental Policy Act of 1969* (NEPA) requirements for the selected alternative will be conducted in FY 1992, with follow-on NEPA documentation environmental permitting activities incorporated into subsequent years.

A waste pretreatment technology development plan will be prepared and will form the foundation for a comprehensive demonstration of existing treatment concepts and development of intermediate and for actinide separation emerging technologies such as the TRUEX process or alternate treatment processes. Waste characterization needs for laboratory- and pilot-scale development and demonstration of waste pretreatment concepts will be defined. Similarly, a plan integrating development, fabrication, and installation of retrieval systems for DST and SST wastes will be prepared. The ongoing development of tank 241-AZ-101 prototypical retrieval system will be a cornerstone of the overall retrieval systems plan. These development plans will be key elements of the overall program plan for remediation of tank wastes and will be issued during 1992. In conjunction with pretreatment technology and retrieval systems development, minimizing the volume of glass resulting from vitrification of wastes will continue to be studied. These studies will focus on, but will not be limited to, advanced melter concepts and methods for optimizing glass composition.

As part of the strategy to apply proven technologies to treatment of wastes and to remediate wastes in a timely manner, the HWVP design will be modified to include an ion exchange process for separating cesium from alkaline Plutonium-Uranium Extraction (PUREX) Plant waste solutions [e.g., neutralized current acid waste (NCAW) and similar waste types]. Title I design will be initiated for inclusion of ion exchange pretreatment capability within the HWVP. The long-term strategy for treatment of tank wastes will incorporate new technologies as demonstrated from the comprehensive technology development program. To support the treatment and disposal of SST and DST wastes in the long term, design and location conceptual studies for a new pretreatment facility will be conducted during FY 1992 and FY 1993.

The existing low-level waste disposal system will be evaluated to optimize vault design and minimize construction costs. Concurrent with continued preparations for grout disposal of low-level tank wastes, alternate waste forms and treatment concepts will be evaluated to enhance long-term performance and reduce hazardous constituents.

8.1.2 Summary of Program

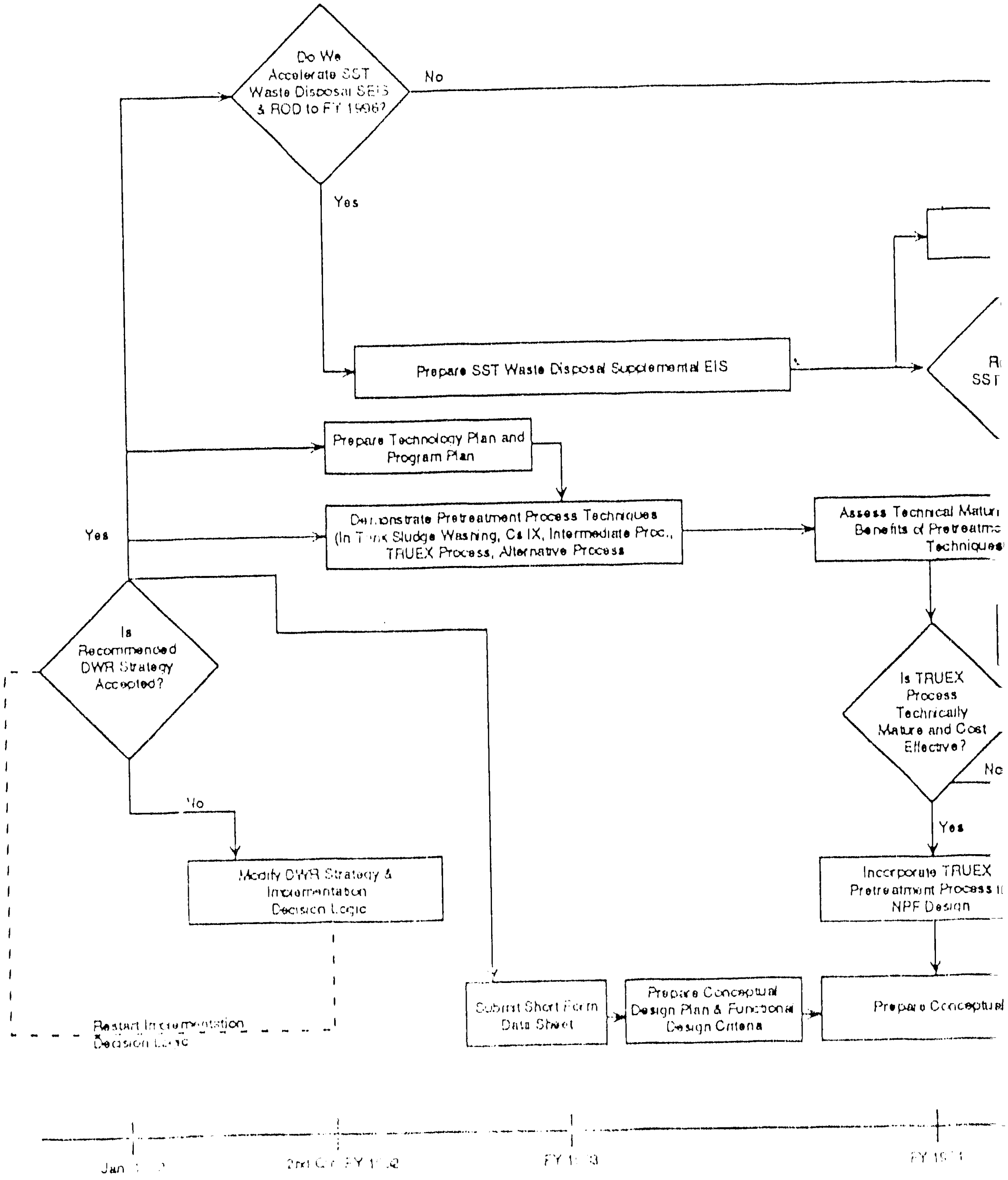
The major program elements are waste sampling and characterization, waste retrieval system development and demonstration, pretreatment technology evaluation and demonstration, vitrification technology development and waste form qualification, HWVP (including pretreatment modifications), new pretreatment facility construction, and grout disposal activities. These elements are embodied in Figure 8-1 and are discussed below. Major programmatic decisions and key activities are presented in Figure 8-2.

- Sampling and characterization of tank wastes is performed to provide information for resolving tank waste safety issues, developing retrieval systems, pretreatment concepts, verifying the vitrification system design, and formulating designs for low-level wastes. Five core samples from four DSTs are planned to be obtained during FY 1992. Characterization of these core samples will be conducted in FY 1992 and FY 1993. An integrated sampling plan will be prepared and issued by March 1992 *Hanford Federal Facility Agreement and Consent Order* (Tri-Party Agreement) milestone M-10-05 (Ecology et al. 1990). Additional core samples from DSTs and SSTs will be based upon waste tank safety and remediation priorities defined in this sample plan.

- Implementation of retrieval technology is initially focused upon NCAW waste. Development of retrieval technologies for other DST waste types will be conducted using simulants and information gained from demonstrating the NCAW retrieval system. Demonstration of the NCAW mixer pump retrieval system is planned for early FY 1996.

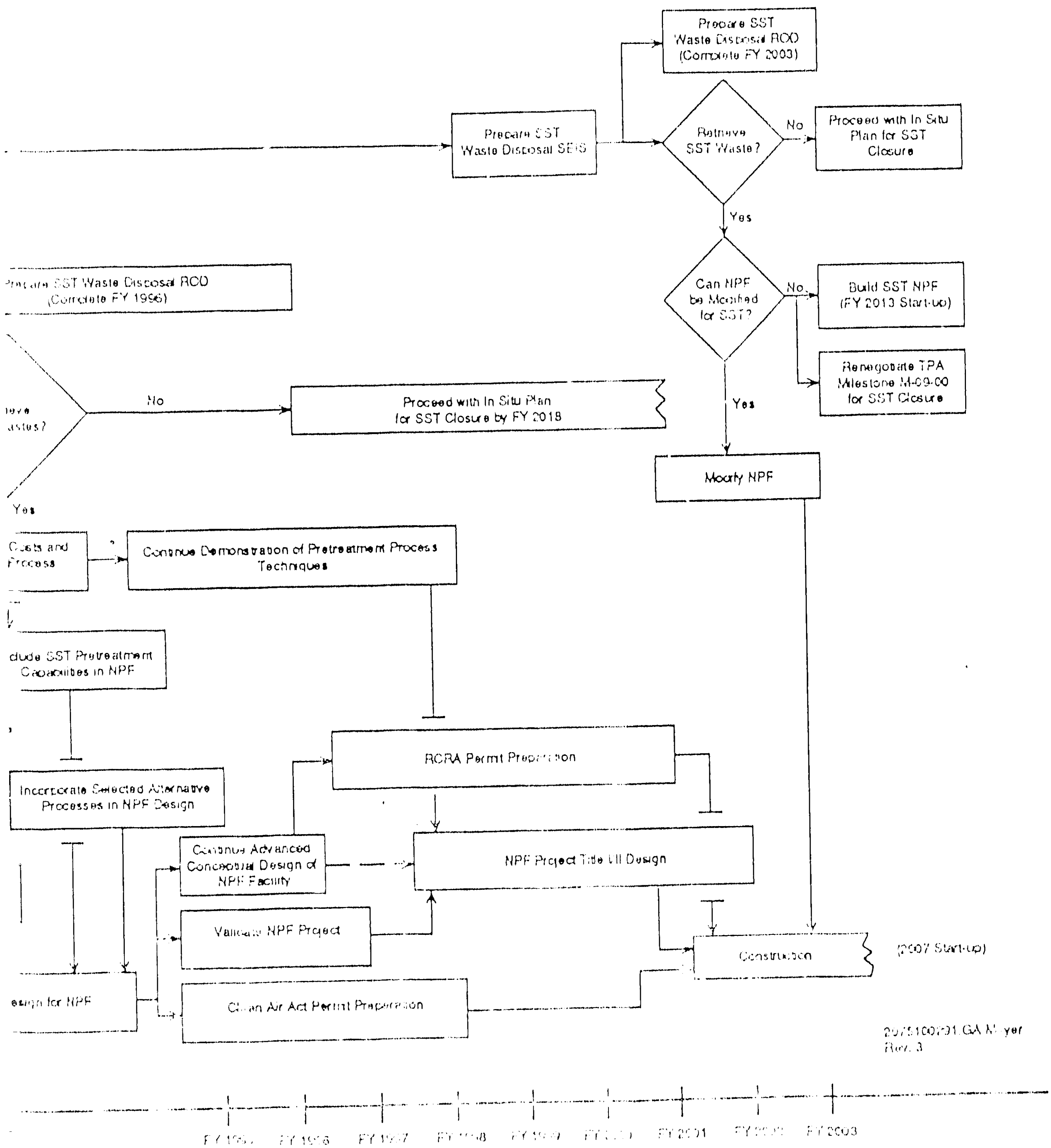
- A systems engineering evaluation of SST waste retrieval and treatment will be continued. A key program decision is necessary in FY 1992 on the timing of the supplemental environmental impact statement (SEIS) for the disposal of SST wastes (see Figure 8-2). Accelerating the preparation of this SEIS so that it is complete by FY 1994, with issuance of the record of decision (ROD) in FY 1996, will allow incorporation of the recommended alternative into the waste disposal program plan for a pretreatment facility. Proceeding with the preparation of the SEIS and ROD, as scheduled in the Tri-Party Agreement, for completion in FY 2003 (milestone M-09-00) can adversely impact the commitment for closure of SSTs by FY 2018. Refer to further discussion of this issue in Section 7.3.

- A technology plan will be prepared later in FY 1992 to define development requirements for in-tank sludge washing, intermediate process methods, and the TRUEX process or an alternate solvent extraction process. This technology plan will define an evaluation of the low-level waste disposal system to determine if waste pretreatment or enhancement of the waste form is warranted. Solids settling tests and thermal modeling of washing NCAW in-tank will be performed in FYs 1992 through 1994. Modifications to DSTs for conducting in-tank washing will be conducted in FYs 1994 through 1997. Intermediate processing will focus on the development of sludge washing and inert component dissolution, transuranic leaching, and blending of wastes. A pilot plant will be designed and constructed for development of the TRUEX process. An evaluation of the technical maturity, cost, and benefits of demonstrated technologies (TRUEX or alternate pretreatment processes) is planned



Do We Accelerate SST Waste Disposal SEIS & ROD to FY 1996?
No
Yes
Prepare SST Waste Disposal Supplemental EIS
Prepare Technology Plan and Program Plan
Demonstrate Pretreatment Process Techniques (In Tank Sludge Washing, Cs IX, Intermediate Proc., TRUEX Process, Alternative Process
Yes
Is Recommended DWR Strategy Accepted?
No
Modify DWR Strategy & Implementation Decision Logic
Restart Implementation Decision Logic
Submit Short Form Data Sheet
Prepare Conceptual Design Plan & Functional Design Criteria
Prepare Conceptual
Is TRUEX Process Technically Mature and Cost Effective?
No
Yes
Incorporate TRUEX Pretreatment Process NPF Design
SST

Figure 8-2. Programmatic Decision and Key Activities.



during FY 1994 for incorporating the recommended alternative into the waste disposal program plan for a pretreatment facility (see Figure 8-2).

- Preconceptual engineering as well as project planning for a new pretreatment facility will be initiated in FY 1992. The conceptual design (FY 1994) for the new pretreatment facility will incorporate processes based upon demonstrated technologies, with emphasis upon existing proven technologies. As technologies such as TRUEX or alternate treatment processes are developed, they will be evaluated for incorporation into the new pretreatment facility concept. Similarly, the results of the systems engineering evaluation of SST wastes will be incorporated into the design of the new pretreatment facility. The new pretreatment facility project is planned for validation in FY 1995 and for Title I design start in FY 1997. Operation of the new pretreatment facility is planned to begin during FY 2007.

- The extent and timing of SST waste retrieval will have a major effect on the facility and process design of both intermediate processing and the new pretreatment facility. An early SST ROD (i.e., by 1996) is necessary to achieve the 2018 milestone for SST closure. This accelerated ROD presents several challenges in the relative timing of design and environmental permitting activities associated with the new pretreatment facility. Resolution of these issues will require commitment and cooperation among regulatory groups (i.e., U.S. Department of Energy, Washington State Department of Ecology, and U.S. Environmental Protection Agency) and contractors (Westinghouse Hanford Company and Pacific Northwest Laboratory).

- Additional activities that will be conducted but are not yet scheduled include detailed planning for possible reintroduction of the encapsulated cesium and strontium into the vitrification wastestream and possible modification of the Waste Encapsulation and Storage Facility to remove its dependence on B Plant for some service and safety functions. There activities will be evaluated during FY 1992.

8.2 REFERENCES

Ecology, EPA, and DOE, 1990, *Hanford Federal Facility Agreement and Consent Order*, Vol. 1 and 2, Washington State Department of Ecology, U.S. Environmental Protection Agency, and U.S. Department of Energy, Olympia, Washington.

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

RL, 1991, *Environmental Restoration and Waste Management Site Specific Plan for the Richland Operations Office - Hanford Site Five Year Plan Fiscal Years 1993-1997*, DOE/RL-91-25, U.S. Deparment of Energy Field Office, Richland, Richland, Washington.

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ACRONYMS

CC	complexant concentrate
CEPOD	catalyzed electrochemical plutonium oxide dissolution
CMPO	octyl(phenyl)-N,N-diisobutylcarbamoylmethylphosphine oxide
CVS	composition variability study
DOE	U.S. Department of Energy
dppmO	bis(diphenylphosphino)methane dioxide
DST	double-shell tank
EDTA	ethylenediaminetetraacetic acid
HDW-EIS	*Final Environmental Impact Statement, Disposal of Hanford Defense High-Level, Transuranic and Tank Wastes, Hanford Site, Richland, Washington*
HEDTA	hydroxyethylenediaminetriacetic acid
HLW	high-level waste
HWVP	Hanford Waste Vitrification Plant
LLW	low-level waste
NCAW	neutralized current acid waste
NCRW	neutralized cladding removal waste
PFP	Plutonium Finishing Plant
PUREX	Plutonium-Uranium Extraction
RCRA	*Resource Conservation and Recovery Act of 1976*
REDOX	reduction-oxidation
risk assessment	*Hanford Waste Vitrification Systems Risk Assessment-Final Report*
SST	single-shell tank
Tri-Party Agreement	*Hanford Federal Facility Agreement and Consent Order*
TRU	transuranic
TRUEX	transuranic extraction
UV	ultraviolet
WFQ	waste form qualification

9.0 PROGRAM TECHNOLOGY APPROACH AND NEEDS

This chapter describes an approach for developing the technology needed for tank waste disposal. The described development efforts are general and will be defined in greater detail and implemented through technical task plans. The identified workscope will complement the existing technology development and demonstration activities currently proceeding for the major program functions:

- Characterization
- Retrieval
- Pretreatment
- Low-level waste (LLW) form operations
- High-level waste (HLW) vitrification operations.

9.1 TECHNOLOGY DEVELOPMENT APPROACH

Technology development is a major element of the tank waste disposal program. The tank waste program priorities are to first resolve tank safety issues and then complete remediation and disposal activities. To complete these tasks, technology must continue to be developed. The technology development approach relies on a detailed understanding of the physical, chemical, and process behavior of the various tank wastes. From this detailed knowledge, the technology for retrieving, pretreating, and immobilizing the waste is established.

9.2 WASTE CHARACTERIZATION

9.2.1 Waste Characterization Approach

Characterization provides the technical foundation for, and influences the specific approaches used in the major process functions (retrieval and pretreatment) and deployment functions (LLW and HLW forms) for the disposal of the double-shell tank (DST) wastes and eventually, the single-shell tank (SST) wastes. Characterization was identified in the *Hanford Waste Vitrification Systems Risk Assessment-Final Report* (risk assessment) (Miller et al. 1991) as a major factor contributing to the uncertainty in successfully completing the program. These uncertainties resulted from the lack of a comprehensive analytical database for all tank wastes and the potential impacts this had on follow-on processing activities.

Pending completion of the characterization capability enhancements discussed in the following text, the sampling and characterization program is being optimized to meet near-term data needs. The optimized fiscal year 1992 sampling plan is documented in the Baseline Integrated Core Sampling Schedule

(Hill et al. 1991). This plan prioritizes and schedules DST and SST core samples to meet the most pressing tank safety issues as well as DST disposal and SST characterization program data needs.

The core sampling and characterization needs of the tank waste disposal program exceed the capabilities of available sampling equipment, laboratories, and personnel resources. The actions that are underway to expand these characterization capabilities include the following:

- Procurement of an additional core sampling drilling rig (doubles the core sampling capacity and provides a hard waste sampling capability not currently available)
- Construction of a laboratory hot cell annex at Building 222-S (greatly expanding core sample processing capabilities).

The full integration of all the tank waste disposal program waste characterization needs will be accomplished by March 31, 1992. This is the due date for the new *Hanford Federal Facility Agreement and Consent Order*, (Tri-Party Agreement) (Ecology et al. 1990) interim milestone, M-10-05, "Integrated Plan for Sampling and Analysis of Hanford Site Wastes Greater Than 10 mR."

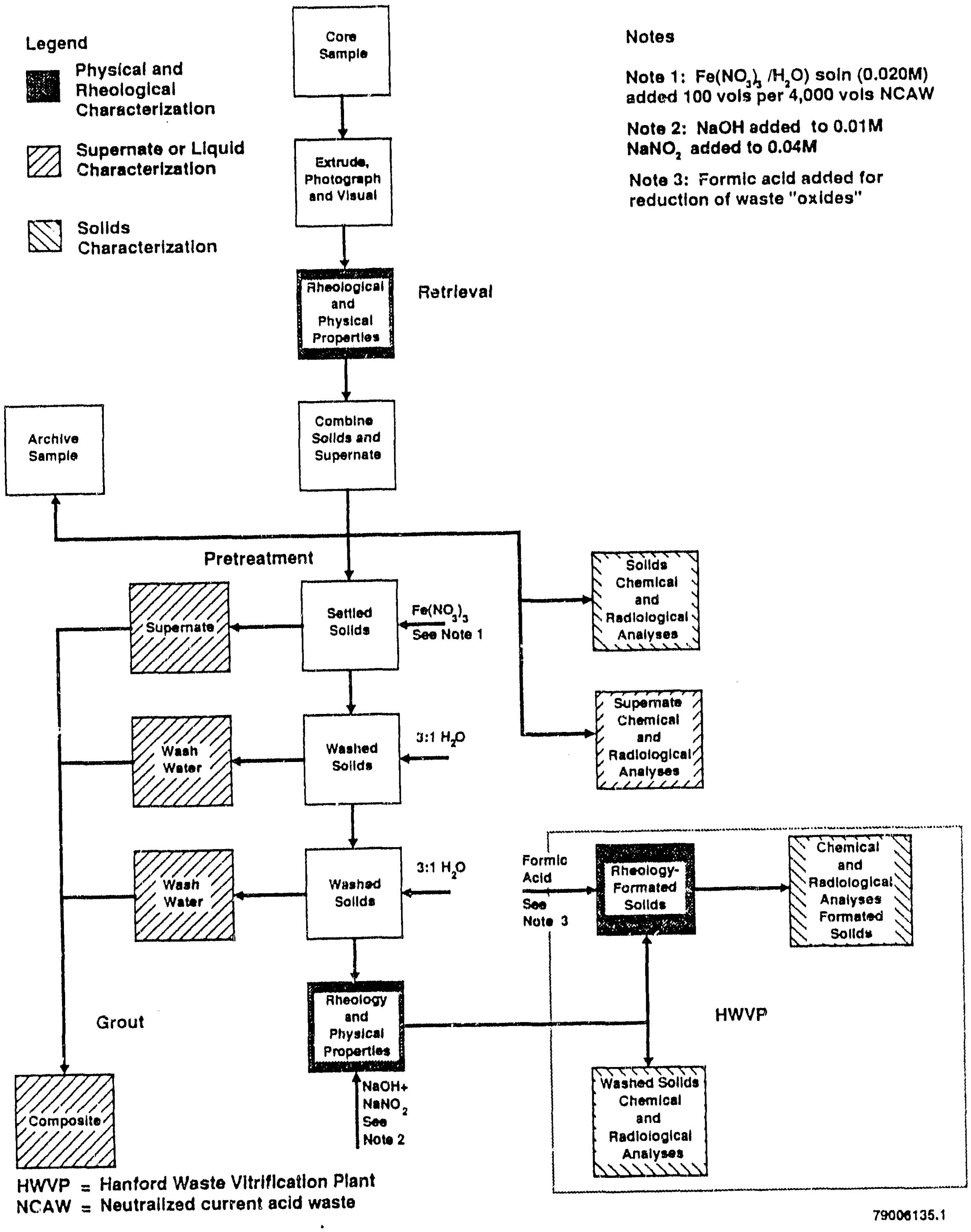
9.2.2 Waste Characterization Needs

The waste characterization program provides the technical basis for SST and DST disposal activities and resolution of tank safety issues. Each of these major activities needs extensive waste characterization data. The data will be used for technology development, design basis confirmation, supporting information for analysis in the supplemental environmental impact statement for SSTs, and other program needs.

The waste characterization program includes sampling and analysis of the supernatant, suspended solids, and settled solids. Characterization data for both untreated and pretreated wastes are needed. Pretreated waste data are preferred over untreated waste data for waste form technology development. Until data can be provided, estimates of feed properties are used as the basis for design, waste form qualification (WFQ), safety analyses, permitting, technology development, and operational planning. These estimates are obtained mainly by processing waste samples through laboratory-simulated processes.

Pretreatment process simulation is used for complete, integrated characterization of the DST core samples. Core samples must provide sufficient waste for laboratory analyses and laboratory-scale pretreatment development. This provides feed material for evaluation of retrieval technology, pretreatment, and Hanford Waste Vitrification Plant (HWVP) and grout technology development activities. Thus, waste characterization allows radioactive feed material and process laboratory characterization data to be obtained for all the major DST waste disposal program functions. A flow diagram of the neutralized current acid waste (NCAW) sample integrated waste characterization is shown in Figure 9-1.

Figure 9-1. Flowsheet, NCAW Core Sample Analysis.



A flow diagram of the complexant concentrate (CC) waste, Plutonium Finishing Plant (PFP) waste, and neutralized cladding removal waste (NCRW) integrated characterization is shown in Figure 9-2.

The HWVP and Grout Treatment Facility perform the final processing steps in waste disposal. Each previous handling and processing step can impact the feed composition. Therefore, DST samples and process flowsheet development, including retrieval, pretreatment, and waste transfer must be carefully coordinated with the HWVP and grout projects to provide meaningful data for final waste disposal.

The waste characterization needs are summarized as follows:

- Identify the nominal (mean) chemical and radiochemical composition, and the physical and rheological properties of each waste type
- Identify the range of compositions and properties for each waste type and the confidence level
- Develop sampling and analysis plans to support waste characterization
- Develop analytical methodologies and facilities to characterize the waste samples
- Develop basic data to characterize the entire disposal process including retrieval, pretreatment, and production of the HLW and LLW forms.

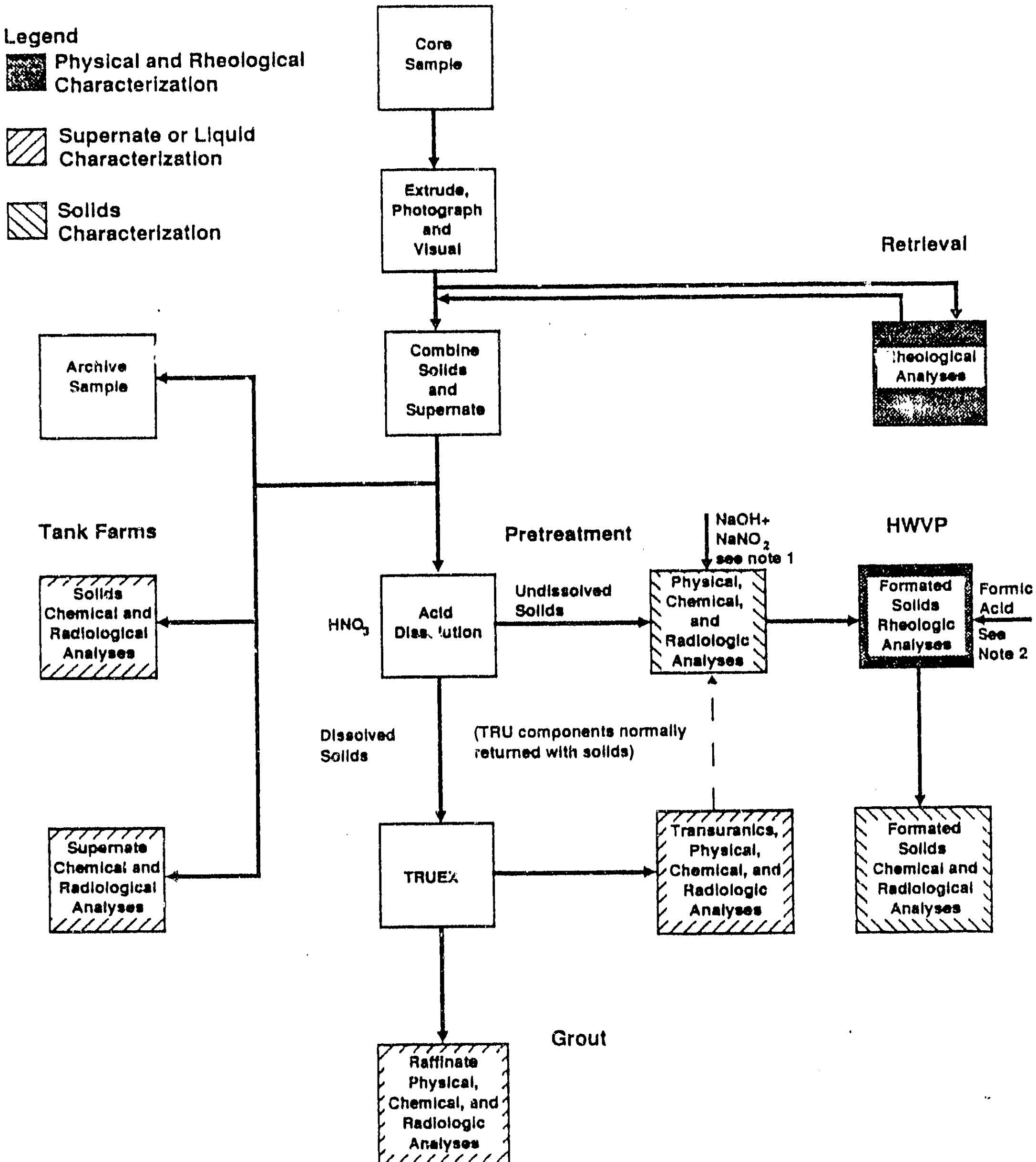
9.2.3 Characterization Technology Development

A revision of the tank sampling plan is needed to support tank farms operations, retrieval, pretreatment, grout, and vitrification because of tank safety impacts as well as disposal program and environmental documentation needs. A sample management plan is being prepared integrating these various needs and will be issued in March 1992 as part of Tri-Party Agreement milestone M-10-05.

Development of analytical methods for the following species is also needed and is nearing completion:

- Mercury
- ^{129}I
- Cyanide
- Noble metals (ruthenium, rhodium, palladium)
- Iron and chrome oxidation states
- Hydroxide (to improve quality assurance level)

Figure 9-2. Flowsheet, CC Waste, PFP Waste, and NCRW Cores Sample Analysis.



Notes

Note 1: NaOH added to 0.01M $NaNO_2$ added to 0.025M

Note 2: Formic acid added for reduction of waste "oxides"

HWVP = Hanford Waste Vitrification Plant
PNL = Pacific Northwest Laboratory
TRU = Transuranic
TRUEX = Transuranic extraction

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- ^{63}Ni, ^{93}Zr, and ^{59}Fe (LLW disposal impacts)
- Improved charge balances in analytical results
- Organic species [for *Resource Conservation and Recovery Act of 1976* (RCRA)]
- Mineral compositions of sludges to identify chemical treatment approaches.

9.3 WASTE RETRIEVAL

9.3.1 Waste Retrieval Approach

The technology needs for retrieving DST and SST wastes are quite different. The DSTs are assumed to be structurally sound, and a liquid mobilization technique such as the mixer pump system used at the Savannah River Site can be applied. Many of the SSTs that have been out of active service since 1980, at the latest, are known or suspected to have leaked, and the integrity of the other SSTs cannot be verified. For this reason, large volume liquid retrieval systems planned for DSTs are inappropriate for SSTs. The approaches planned for the DSTs and SSTs are discussed in the following sections.

9.3.1.1 DST Retrieval. Retrieval of tank wastes for pretreatment and final disposal was identified by the risk assessment (Miller et al. 1991) as a major source of program cost and schedule uncertainties because funding levels for retrieval development activities have not kept pace with other program elements. The projected failure of the retrieval activities to provide needed feeds produced significant schedule and cost uncertainties in the other program elements. The risk assessment (Miller et al. 1991) recommended that laboratory- and full-scale retrieval testing, which will overcome these uncertainties, be expedited.

The mixer pump retrieval system developed by the Savannah River Site is the baseline technique that is being adapted for NCAW retrieval. There is high confidence that this technology can be successfully adapted for retrieval of the NCAW. This confidence is based on current knowledge of NCAW characteristics (NCAW has been sampled and analyzed). The number of mixer pumps required and their arrangement in the tank to optimize solids mobilization will be resolved by the NCAW retrieval process test scheduled to be completed in 1996. The addition of flocculating agents to the tank as part of the sludge washing effort will impact retrieval operations. This impact will be assessed during the retrieval process test. If the two mixer pumps planned for the initial process test do not adequately mobilize solids, two additional mixer pumps will be installed.

Mixer pump technology from the Savannah River Site is the technical baseline for retrieval of NCAW and post-NCAW, such as NCRW, PFP, and CC waste types. Retrieval techniques may require other technologies such as sluicing separately or in combination with mixer pump technology. Therefore, as characterization information is developed for the other DST waste types, a systems engineering evaluation will be performed to choose appropriate technology for each waste type.

9.3.1.2 SST Retrieval. Currently 16 technical alternatives are being studied for possible retrieval of the SSTs. These 16 alternatives include a variety of mechanical retrieval, sluicing, limited sluicing, hydraulic retrieval, and pneumatic retrieval techniques. These alternatives are discussed in detail, and recommendations for continued development of the most promising alternatives are contained in *Systems Engineering Study for the Closure of Single-Shell Tanks* (Boomer et al. 1991).

9.3.2 Needed Retrieval Technology Development

Completion of NCAW retrieval process testing and engineering evaluations and development of alternative post-NCAW retrieval technologies are the main near-term retrieval technology needs.

The use of in-tank pretreatment processes, such as sludge washing and intermediate processes, will need to be evaluated in terms of their potential impact on the retrieval operation tank cleaning efficiency and waste transfer operations. The pretreated and washed wastes may have significantly different physical and rheological properties that would hinder the retrieval and waste transfer processes. Testing will need to be conducted on nonradioactive simulants to verify the integrated tank pretreatment, retrieval, and waste transfer process. Integral to these tests will be the evaluation of the corrosive potential of the solutions and an evaluation of construction materials.

The long-term retrieval technology needs are those supporting retrieval of SSTs. These include development of confined sluicing, pneumatic retrieval, and other techniques to allow selection of a series of preferred alternatives. Full-scale development of the preferred alternatives will follow.

9.4 WASTE PRETREATMENT

9.4.1 Waste Pretreatment Approach

The waste pretreatment objectives are to do the following:

- Provide continuous pretreated feed to the HWVP consistent with the need to resolve Hanford Site tank safety issues, minimize the volume of HLW being produced, minimize the quantity of radionuclides in grout, and apply available chemical and radiochemical partitioning technology

- Ensure that the HWVP can support the DST and SST disposal missions by developing a pretreatment approach that minimizes the number of canisters of glass produced

- Provide an approach to pretreat and prepare feed for the HWVP that reduces risks by ensuring the development of alternate technologies for completing the pretreatment function.

The pretreatment strategy has been selected to apply existing technology in the short term and maintain flexibility in facility and process alternatives for the long term to ensure effective and efficient disposal of tank wastes.

9.4.2 Near-Term Technology Alternatives

The near-term pretreatment approach for the DST wastes will employ sludge washing and cesium ion exchange technology to pretreat alkaline Plutonium-Uranium Extraction (PUREX) Plant wastes to provide early feeds to the HWVP. Sludge washing operations are planned to be conducted within the DSTs. Final filtration of supernatant and wash solutions and removal of cesium from these solutions using ion exchange technology will be conducted in an annex to the HWVP.

The objective of sludge washing is to remove greater than 95 percent of the soluble components, such as sodium, potassium, NO_2, NO_3, and SO_4, that limit the waste loading in glass and can result in a significant NO_x emissions from the HWVP, from the waste. The sludge washing operation will be conducted in existing and future DSTs. The sludge washing operation involves an initial separation of the sludge and supernatant, followed by washing the sludge with a series of two or more batch contacts using a solution of dilute $NaOH/NaNO_2$. It is envisioned that washing of NCAW will be done in the tanks in which the waste is stored. Later sludge washing operations will be done in yet-to-be-constructed tank farm facilities.

Supernatant recovered from separation of sludge and supernatant and the wash solutions will be transferred to a second DST for interim storage. The homogenized supernatant and wash solutions will be transferred to the HWVP for filtration and cesium removal by means of ion exchange. Duolite[1] CS-100 has been selected as the reference ion exchange resin. The initial ion exchange column configuration will use three ion exchange columns, two of which will be loaded while the third is being eluted and regenerated. This loading, elution, and regeneration sequence for the columns has been selected based upon the desire to effectively load the columns and provide a continuous feed to the ion exchange system.

The initial feeds to be considered for in-tank washing include the following:

- Neutralized current acid waste (tanks 241-AZ-101 and 241-AZ-102)
- Alkaline PUREX Plant waste heels (tank 241-AY-102)

[1]Trademark of Rohm and Hass, Inc.

- Dilute CC waste (tank 241-AY-101)
- Alkaline PUREX Plant and strontium waste (tank 241-C-106).

9.4.2.1 In-Tank Sludge Washing Technology Needs. In-tank washing for the removal of inert (nonradioactive) components from alkaline PUREX Plant wastes has been used previously at the Hanford Site. Sludge washing was used during waste management activities involving the recovery of ^{90}Sr and ^{137}Cs from SST sludge in the late 1960's and early 1970's. This in-tank sludge treatment approach has also been employed at the Savannah River Site and will be used at the West Valley Site in late 1991. Thus, a significant experience base is available to support this technical approach for pretreatment. However, because of the solid-liquid separations efficiency needed and the decay heat content of the initial wastes to be treated, a number of technical uncertainties must be resolved to assure a successful program. These include the following:

- Estimating the effect of thermal currents within the tank on settling rates
- Completing analysis to ensure that dynamic forces placed on the tank and tank components by the mixer pumps are acceptable
- Identifying appropriate flocculation agents and establishing the approach for flocculent addition
- Modeling tank heat transfer to establish temperature rise in the tank and tank vault during different tank operating modes
- Verifying that uncontrolled venting of steam or vapors (i.e., tank bump) cannot occur
- Determining the shear forces acting on agglomerated particles from the mixer pump operation and the impacts the shearing of particulate masses have on their settling rate
- Optimizing the washing efficiency for each waste type
- Verifying that the sludge washing and solution storage operations do not adversely impact chemical corrosion of the tank
- Establishing the impact and identifying mitigating actions to counteract the effect of CO_2 adsorption with subsequent hydroxide depletion in the washed sludge and wash solutions.

9.4.2.2 Cesium Ion Exchange Technology Needs. The use of Duolite CS-100 for the removal of cesium from alkaline supernatant has been studied extensively at the Hanford Site for use in the DST waste disposal mission. This exchanger was also studied for use at West Valley (Bray et al. 1984) and for use at the Savannah River Site. Because of the significant technology base associated with this resin, it was selected as the baseline ion exchange material. Like sludge washing, there is a significant technical foundation for the use of Duolite CS-100 in the early stages of the tank waste disposal program. There is, however, some remaining technical work to characterize the performance of the exchanger to establish optimum performance during operations. This work involves conducting continuous ion exchange loading tests to establish the separations' performance with the following process parameters varied:

- Sodium-to-cesium mole ratio
- Absolute feed concentration
- Temperature
- Solution pH
- Feed flowrate.

In addition, elution studies using both formic acid and HNO_3 need to be completed. Previous work at the Hanford Site has focused on the use of HNO_3 as the eluant while other researchers (Bray et al. 1984) have focused on the use of formic acid as the eluant. Alternative ion exchange medias (e.g., Savannah River Site resorcinal-formaldehyde resin) and process concepts (e.g., in-tank columns such as those used at the West Valley Site) also need to be elevated for potential application.

9.4.3 Intermediate-Term Pretreatment Approach

Intermediate pretreatment approaches such as enhanced sludge washing involving selective removal of components that limit waste glass loading and blending of wastes may be employed between the baseline processes of simple sludge washing (i.e., minimum treatment) and transuranic (TRU) partitioning (i.e., maximum treatment). These technologies are an improvement over sludge washing in that fewer canisters of glass will be produced. Many of the technologies have the potential to be implemented in-tank, although several are restricted to implementation in a new pretreatment facility. The benefits of intermediate processing in terms of reducing canister production requirements are summarized in Section 6.4.4.

9.4.3.1 Sludge Washing and Selective Dissolution. The sludge washing and selective dissolution approach involves sludge washing to remove soluble components and selective dissolution of components that limit the waste loading in glass. The initial wastes considered in this approach along with the chemical components that limit the waste loading in glass are as follows:

- PFP waste--chromium, phosphorous, sulfate, and aluminum compounds
- CC waste--chromium and aluminum compounds
- NCRW--zirconium.

Technology needs associated with the removal of selected components from the waste include the following:

Bench-scale laboratory work with actual wastes is required to demonstrate and confirm the feasibility of the selective dissolution processes. Several samples of each sludge type should be tested to gain confidence that the dissolution process will not be affected by variations in the waste properties. It is also necessary to try each waste type, as the waste may contain other compounds that will interfere with the dissolution process. This is quite possible in the CC waste sludge that may contain organics that will react with the oxidant added to solubilize chromium. It is also important to identify the types of compounds present in the wastes because this may allow the design of better dissolving solutions.

The method of mixing and suspending the solids in the dissolution solutions needs to be defined and tested. It is important that most of the solids be contacted with the solutions and that stagnant zones be eliminated. The effect of particle shear (resulting from mixer pump operation) on the settling rate and solid-liquid separation efficiency needs to be determined. Testing in the pilot-scale tanks being constructed for the DST retrieval program may be necessary.

The method of solid-liquid separation needs to be defined and tested in pilot-scale equipment. The addition of flocculents should be evaluated. These tests will probably have to be done using synthetic waste, although the possibility of an engineering-scale test in an existing (i.e., plant) tank should be considered. Confirmation of results from work with synthetic waste may be possible with a small batch of actual radioactive waste.

The compatibility of the dissolution solutions with grout disposal requirements needs to be assessed although most of these solutions appear to be acceptable for disposal in grout. The exception may be oxalic acid, which may need to be destroyed or recovered for recycle.

The dissolution solutions also need to be compatible with the DSTs construction material. Testing of the waste and resultant dissolver solutions will be required to verify tank materials compatibility.

9.4.3.2 Sludge Washing and TRU Dissolution. The sludge washing and TRU leaching approach involves sludge washing to remove soluble components and leaching of the TRU components from the bulk of the solids. Once the TRU components are solubilized, it should be possible to recover the TRU components by a number of different methods as indicated in the section on acid dissolution and TRU recovery (Section 9.4.3.3). Alternately, the TRU-bearing solution can be concentrated for direct feed to HWVP. The most promising candidate for this process is the NCRW sludge. Alternatives for leaching solutions include dilute HNO_3/HF, dilute HNO_3/silver persulfate, catalyzed electrochemical plutonium oxide dissolution (CEPOD), and Na_2CO_3/$NaHCO_3$ with or without an oxidant such as potassium ferrate.

Most of the technology needed for this alternative is similar to the sludge washing and selective dissolution alternative (Section 9.4.3.1). The technology requirements include the need for additional laboratory work to demonstrate the processes with actual wastes, characterization of minerals in the waste, mixing and solids suspension, solid-liquid separation, materials compatibility, grout disposal of residual solids, TRU recovery from the dissolution solutions, and criticality concerns. The latter concern may preclude TRU recovery in a DST.

9.4.3.3 Acid Dissolution and TRU Recovery. The acid dissolution and TRU recovery approach involves dissolving as much of the TRU-bearing solids as possible followed by a TRU recovery process. Possible TRU recovery processes include precipitation (e.g., with oxalate, lanthanum fluoride, titinate), ion exchange, or a batch extraction process.

The technology requirements associated with this approach include additional laboratory work to demonstrate the candidate processes with actual wastes, characterization of minerals in the waste, solid-liquid separation (assuming incomplete dissolution), materials compatibility, grout disposal of residual solids, and evaluation of potential criticality concern. The corrosive nature of the proposed dissolution solutions will preclude large-scale dissolution in a DST and the criticality concern (i.e., precipitation of kilogram quantities of plutonium) would almost certainly preclude TRU recovery in a DST.

9.4.3.4 Sludge Washing and Blending. The HWVP feeds that are limited in waste loading by one or more components will be considered for blending to average the limiting component in the glass manufacturing process. In this approach, a feed that is limited in one component will be mixed with a different feed that has a low quantity of the limiting component This, in effect, dilutes the limiting component and allows a higher waste loading in the glass to be obtained and will result in an overall reduction in the number of canisters. In theory, the blending strategy can be applied to any of the feeds to the HWVP including those that may result from the intermediate processing approaches. A high temperature melter may expand waste loading and further complement blending approaches by allowing the incorporation of higher waste loading in the glass.

While a blending strategy is conceptually simple, there are some practical difficulties that need to be addressed. These include a detailed evaluation of the various blending strategies, tank farm logistics, suspension, transfer and measurement of the appropriate quantities of each type of solid, mixing, and solid-liquid separation.

9.4.4 Long-Term Pretreatment Approach

The long-term pretreatment approach is dictated by the need to efficiently dissolve and partition the radioactive materials from the dissolved sludges to accomplish the highest level of tradionuclide removal technically and economically practical. The transuranic extraction (TRUEX) process has been selected as the reference method for extraction of actinides from the dissolved tank sludges. Other solvent extraction technologies and solid sorbents to partition the actinides and fission products from the waste will also be evaluated. A significant effort will need to be directed at dissolution and clarification of the sludges as preparation for subsequent partitioning of radioactive materials.

9.4.4.1 Dissolution of Sludges. The critical step in preparing retrieved waste for further treatment is dissolution of the sludge to solubilize TRU waste elements and other radionuclides, principally ^{90}Sr, in an acid media.

Economically, the ideal sludge dissolution procedure would solubilize sufficient TRU and ^{90}Sr values, and to the extent necessary, leave certain nonhazardous inert chemicals.

The Hanford Site DST and SST wastes were generated during nuclear materials production operations over 35 yr ago using processes that resulted in several types and amounts of water-insoluble sludges. The operations that produced sludges include the following:

- Neutralization of high-level nuclear fuel reprocessing wastes from the reduction-oxidation (REDOX), PUREX Plant, and bismuth phosphate ($BiPO_4$) processes
- Dissolution of aluminum-silicon bonded aluminum cladding in NaOH-$NaNO_3$ solutions in which the aluminum-silicon material remained largely undissolved
- Precipitation of $Ni_2Fe(CN)_6$ in certain SSTs
- Precipitation of aluminosilicates, carbonates, and other inorganic compounds from alkaline waste solutions
- Neutralization of acidic wastes produced in PFP and T Plant operations
- Neutralization of zirflex process decladding solution
- Fission product separation operations resulting in CC waste
- Addition of miscellaneous solids (e.g., diatomaceous earth, cement) to some tanks.

Table 9-1 lists some components expected to be present in the SSTs and selected DSTs. This data is based upon historic process flowsheets and known inorganic chemistry (Schulz and Kupfer 1991). The sludge types found in Table 9-1 will contain varying amounts of sodium compounds even after extensive water washing. Some of these sodium compounds, such as $Na_2U_2O_7$ and sodium aluminosilicates, are only slightly soluble in water, while others are soluble sodium salts incorporated in insoluble metal precipitates.

Based upon historical records, $BiPO_4$ process wastes were stored in SSTs, mainly in the 241-B Tank Farm; REDOX wastes were stored in the 241-SX, 241-S, and 241-U Tank Farms; pre-1972 PUREX process wastes were stored in the 241-A, 241-AX, 241-AY, and 241-AZ Tank Farms; while $Ni_2Fe(CN)_6$ and $Sr_3(PO_4)_2$ precipitates were stored in the 241-BY and 241-C Tank Farms. Many of the SSTs contain a mixture of process sludges as a result of multiple waste transfers in and out over 35 yr of operations. Various waste management processes contributed to mixing of sludges in many SSTs. The waste management processes included retrieval, acid dissolution and tributyl phosphate extraction of uranium from the $BiPO_4$ process wastes in the 1960's, and retrieval and acid dissolution of some early PUREX process sludges in the 1960's and 1970's. In addition, large amounts of siliceous materials have been deliberately added to certain SSTs including diatomaceous earth, portland cement, ion exchange resin, bottles, and solid wastes.

Table 9-1. Components Present in Single-Shell Tanks and Selected Double-Shell Tanks.

Type	Typical components[a,b]	
PUREX process	$Fe_2O_3.H_2O$ $Al_2O_3.H_2O$ MnO_2 $SiO_2.H_2O$	$Cr_2O_3.H_2O$ NiO Zr metal fines
REDOX process[c]	$Al_2O_3.H_2O$ $Fe_2O_3.H_2O$ Al-Si[d]	$Cr_2O_3.H_2O$ MnO_2 NiO
$BiPO_4$ process[c]	$BiPO_4$ $Fe_2O_3.H_2O$ Al-Si	LaF_3 $Cr_2O_3.H_2O$ MnO_2
Nickel ferrocyanide[c]	$Ni_2Fe(CN)_6$ $Sr_3(PO_4)_2$	$Fe_2O_3.H_2O$ $Na_2U_2O_7$
Zircaloy cladding waste[e]	$ZrO_2.H_2O$ Metal Fluorides	$Fe_2O_3.H_2O$ $Cr_2O_3.H_2O$ NiO
PFP--T Plant[e,f]	$Fe_2O_3.H_2O$ $Cr_2O_3.H_2O$ $Ca(OH)_2$ $Mg(OH)_2$	NiO CaF_2 $Al_2O_3.H_2O$

[a]Data from Kupfer (1981).
[b]Actual tank species may be different from that listed.
[c]In single-shell tanks.
[d]Intermetallic compound used as bonding material in aluminum-jacketed, uranium metal slugs.
[e]In double-shell tanks.
[f]Mixed waste from Plutonium Finishing Plant and T Plant in tank 241-SY-102.
PFP = Plutonium Finishing Plant
PUREX = Plutonium-Uranium Extraction
REDOX = Reduction-oxidation.

Schulz and Kupfer (1991) identify two different approaches that can be taken to solubilize actinide elements and other important radionuclides in Hanford Site sludges: aqueous leaching and dissolution, and fusion.

Aqueous leaching involves contact of moist water-washed sludge with a series of aqueous reagents to adequately solubilize actinides and fission products without necessarily dissolving all solid materials. Leaching operations would likely be performed at or near boiling temperatures. The desired goal is to dissolve all, or nearly all, the sludge and obtain leached residues that can either be disposed of as LLW or economically vitrified.

A sequential leaching and dissolution process may not be required for some waste types because a single dissolution step will increase waste treatment process rates. The processing approach chosen, sequential leaching or single reagent, will be based on weighing the economic advantages of minimizing the mass of waste feed to glass versus the disadvantages of a lengthened time cycle for sludge dissolution.

Schulz and Kupfer (1991) state that there are several candidate leaching reagents that can be applied to the different waste sludges. The reagents are as follows.

- **NaOH**--In certain instances, exposure of water-washed sludges to hot NaOH solutions may be beneficial. Hot NaOH will solubilize the aluminum component of process sludges provided that mineralization has not occurred. Similarly, $Ni_2Fe(CN)_6$ sludge may be converted to $Fe(OH)_3$, $Ni(OH)_2$, and NaCN when exposed to hot NaOH solutions.

  Also, initial conditioning treatment of all types of sludges with hot NaOH makes them more amenable to subsequent acidic leaching.

- **HNO_3**--HNO_3 solutions are expected to have limited usefulness in dissolving either SST or DST sludges. This expectation follows from the well-known chemistry of silicates and transition metal oxides that are present in many of the sludges.

- **HNO_3/Oxalic Acid**--Oxalate ion is known to form relatively strong complexes with iron (III) in acidic solutions. The HNO_3/oxalate solutions have been extensively considered for removal of residual sludges that are expected to remain after sluicing Savannah River tanks (Hill 1977).

- **HNO_3/F**--When dissolving sludges in Hanford Site wastes, HNO_3 solutions containing fluoride ion may be used as an (1) initial primary dissolvent or (2) a final dissolvent after previous treatment with other aqueous reagents. There is a good possibility that HNO_3/F^- solutions alone will sufficiently solubilize all sludge types.

- **Concentrated H_2SO_4 and H_3PO_4**--Either or both concentrated H_2SO_4 and H_3PO_4 solutions will dissolve ferrocyanide solids found in the SSTs. Experimental work is needed to verify this hypothesis.

- **Others**--Other highly aggressive leachants include 5 to 12 molar HCl and aqua-regia (HNO_3-HCl) in a pressurized vessel. Hydrochloric acid is used to attach iron ores for subsequent wet chemical analysis. Hot aqua-regia solution is effective in dissolving FeOOH and other metal oxides present in Hanford Site tank sludges.

Fusion entails a high-temperature (350 °C to 800 °C) reaction of all the water-washed and dried sludges with one or more fluxes (e.g., KOH, Na_2CO_3, B_2O_3). This approach converts silicate metal oxides to aqueous-soluble species. The fused reaction products, after cooling to ambient temperature, would be treated with aqueous HNO_3 to produce a feed solution suitable for subsequent TRUEX processing.

Sludge dissolution data presently available is insufficient to permit a selection between aqueous and fusion approaches. Therefore, bench-scale tests of both processes are needed with various types of tank wastes to develop information required to select the dissolution process for pilot-plant tests and eventual plant-scale implementation. The generation and treatment of secondary wastes and their impact on the separation process also must be evaluated. The elements of this development effort are as follows:

- Develop a comprehensive dissolution plan for bench-scale sequential tests with actual water-washed sludges. The goal of this plan should be to determine practical dissolution schemes that can be applied on a plant scale. This plan should address the following:
  - Nature, hierarchy, volume, and composition of reagents to be employed with each sludge type.
  - Details (e.g., time, temperature) of each sequential dissolution step.
  - Analytical procedures to measure the degree of dissolution accomplished with each reagent.
- Develop a plan for bench-scale high-temperature fusion tests with actual water-washed sludges. This plan should address the following.
  - Applicability of B_2O_3, KOH or NaOH, and Na_2CO_3 fusions to solubilize all or part of each sludge type.
  - Details (e.g., time, temperature, flux-to-sludge ratio) or each fusion.
  - Procedures for dissolving fused melts in water or HNO_3. Special attention should be paid to establish the stability of acidified solutions to the precipitation of silicic acid or other solids.
  - Analytical procedures to measure the degree of dissolution accomplished in each fusion.
- Provide for preliminary engineering evaluations of promising aqueous dissolution and fusion procedures to guide bench-scale and pilot plant-scale tests.

9.4.4.2 Clarification of Solutions. After sludge dissolution, some residual solids are expected to remain. Solid-liquid separation technology is needed to clarify the TRU partitioning process feeds. The resultant solids will be washed, and if the leaching process is successful, the solids will be transferred to the LLW disposal facility. The TRU solids will be transferred to the HLW solidification process.

It is envisioned that commercially available solid-liquid separation equipment will be available to clarify the dissolved waste feeds. Decisions must be made given the relative success of the dissolution effort and the characteristics of any residual solids to identify the appropriate technology to clarify these solutions. Because the feeds will be highly radioactive, technology alternatives will be limited to centrifugation, pressure precoat filters, internal cross flow filters, and back flushable strainers. Extensive laboratory-scale and bench-scale testing of the proposed equipment will be required using actual dissolved sludge solutions. Testing of the final equipment selected, on a full scale, with nonradioactive feeds will also be needed to verify anticipated process and design performance.

9.4.4.3 Removal of TRU Radionuclides. The decontamination of dissolved waste tank sludges by solvent extraction, ion exchange, and precipitation processes will reduce the number of HLW canisters that need to be produced. In general, solvent extraction technologies to accomplish the separation of actinides (americium, plutonium) are emerging. Ion exchange and partitioning technologies for those separations are mature, but may not offer the processing efficiency required to accomplish the waste pretreatment mission within a reasonable overall schedule. These partitioning technologies all require additional laboratory work with actual wastes to confirm the process, materials compatibility testing, evaluation of criticality, and evaluation of secondary waste impacts to the LLW disposal system.

9.4.4.3.1 TRUEX Technology Development Approach. The TRUEX process, invented at Argonne National Laboratory, has been chosen as the baseline process for partitioning TRU radionuclide from the Hanford Site tank waste. The decision to use TRUEX is based upon the maturity of this process, which has been studied by researchers both nationally and internationally in laboratory-scale radioactive testing and the ability of the TRUEX process to complete the required chemical separation necessary for pretreatment and volume reduction of tank wastes requiring vitrification. The volume reduction of the high-level TRU wastes will substantially reduce the cost of the tank waste disposal mission.

The chemistry of TRUEX, using octyl(phenyl-N,N-diisobutylcarbamoylmethylphosphine oxide (CMPO) and tributyl phosphate as extractants, is well characterized. Over 90 experiments involving small-scale batch contact testing of the TRUEX process at the Hanford Site has been performed using actual NCRW, and CC tank wastes. The testing was done to verify the feasibility of the process as a pretreatment technology. Before plant-scale implementation of the TRUEX process can occur at the Hanford Site, it must be determined how the various wastes behave when treated by TRUEX process and if the TRUEX process solvent can withstand continuous countercurrent operation. The primary goal of the planned development testing is to establish the engineering configuration of the TRUEX system for plant-scale implementation. To complete this development and engineering task, complete process testing must be done in a series of laboratory and pilot-scale test systems with actual or, in some cases, simulated waste feeds.

The historical development of solvent extraction processes for fuel reprocessing is used as a methodology to establish the engineering approach for process scaleup and verification of the TRUEX process. However, the wide variety of waste compositions that exist in the Hanford Site tanks will require a more substantial effort to ensure successful pretreatment operations on a plant scale. This engineering development methodology involves the following:

- Laboratory-scale batch and continuous countercurrent testing with actual and, in some cases, simulated radioactive wastes to verify the basic process chemistry
- Pilot-scale continuous countercurrent testing with simulated wastes to verify equipment system performance and provide data for the engineering design
- Pilot-scale radioactive testing to provide final confirmation of process scaleup, provide feed for WFQ testing of the HLW form, and meet process verification requirements for RCRA permitting.

Summarized in the following text are the basic test systems required to implement the TRUEX process and their primary objectives. The information that is to be obtained from each test system is identified in Table 9-2.

Laboratory-Scale Batch Contacts with Actual Wastes--The first step in developing a specific chemical flowsheet for the processing of a particular waste type is batch contact testing with actual waste materials. The batch contact testing will establish the basic approach to condition the wastes for pretreatment, determine feed stability, and establish batch equilibrium stage separations performance. Because of the large number and variety of Hanford Site wastes (e.g., NCRW, PFP waste, CC waste), laboratory-scale batch testing will have to be performed throughout the entire tank remediation effort. The generic TRUEX model, developed by Argonne National Laboratory, will be tested using these basic laboratory data and modified throughout the process development effort to provide a tool for process scaleup.

Laboratory-Scale Continuous Countercurrent Tests with Simulated Wastes--The primary objective of laboratory-scale testing using simulated feeds, which contain tracer levels of plutonium, americium, cesium, and strontium, is to develop a model relationship between the fully radioactive laboratory-scale test system and the pilot-scale testing system. The laboratory-scale tracer test system also confirms separations performance and can be used efficiently to test and evaluate specific process operating parameters (i.e., establishing the range of chemical operability of the process and evaluating alternative scrub and strip solutions).

Laboratory-Scale Continuous Tests with Actual Wastes--Continuous laboratory-scale testing with actual wastes is the primary means for establishing the chemical flowsheet for processing of each waste type. The major technical information to be obtained during continuous laboratory-scale testing is related to the specific process chemistry of each waste type. This information includes waste feed preparation, feed stability, range of chemical operation, separations performance, and evaluation of alternative scrub and strip solutions.

Table 9-2. Summary of Technical Information Needs for Solvent Extraction Process Testing. (sheet 1 of 2)

Technical data needs	Batch laboratory-scale radioactive	Continuous laboratory-scale tracer	Continuous laboratory-scale radioactive	Continuous pilot-scale tracer	Continuous pilot-scale radioactive
Process chemistry needs					
Dissolver solution clarification (i.e., filtration)					
- Acid solution operations				X	
- Actual waste operations verification					X
Solvent behavior studies					
- Recycle behavior				X	
- Degradation study			X		
- Waste material contamination					X
Separations performance (separation factors, capacity)					
- Preliminary scoping study	X				
- Small-scale continuous study		X			
- Small-scale minor component effects			X		
- Intermediate-scale scale-up relationship study				X	X
- Intermediate-scale verification					X
Specific waste performance					
- Preliminary scoping study	X				
- Continuous operations demonstration			X		
- Intermediate-scale verification					X
Feed stability					
- Small-scale chemical investigation	X				
- Small-scale continuous demonstration			X		
- Intermediate-scale verification					X
Range of chemical operability (due to tank or feed variability)					
- Preliminary scoping study	X				
- Effect of major components		X		X	
- Effect of minor components			X		X
Feed pretreatment/adjustment requirement					
- Preliminary scoping study	X				
- Small-scale continuous demonstration			X		
Evaluation of scrub and strip solutions					
- Preliminary scoping study	X				
- Small-scale continuous evaluation		X			
- Small-scale continuous minor component effects			X		
- Intermediate-scale verification				X	

Table 9-2. Summary of Technical Information Needs for Solvent Extraction Process Testing. (sheet 2 of 2)

Technical data needs	Batch laboratory-scale radioactive	Continuous laboratory-scale tracer	Continuous laboratory-scale radioactive	Continuous pilot-scale tracer	Continuous pilot-scale radioactive
Design engineering data					
Materials evaluation verification (RCRA)					
- Demonstration of materials in actual process solution with minor components					X
Process control development					
- Process control development				X	
- Hot cell operations verification					X
Process monitoring instrumentation (HF, F-, Zr, pH)					
- Analytical methods development	X				
- Online applications development				X	
- Remote environment equipment development					X
Centrifugal contractor performance verification (operation/lifetime)				X	
Process scale-up verification					
- Small-scale continuous operations		X			
- Small-scale hot verification			X		
- Intermediate-scale continuous operations				X	
- Intermediate-scale hot verification					X
System hydraulics verification					
- Contractor hydraulic demonstration				X	
- In-cell hydraulic verification					X
Testing of sampling and online analysis systems					
- Sampling methods development				X	
- In-cell sampling verification					X
Fluid transfer verification					
- Fluid transfer methods demonstration				X	
- In-cell operability verification					X
Staff training				X	X

RCRA = Resource Conservation and Recovery Act of 1976.

Continuous laboratory-scale testing with actual wastes using feed volumes of 5 to 10 L will be conducted throughout the development, design, and verification of the solvent extraction process. Methods will need to be developed as part of the tank waste sampling program to retrieve larger volumes of waste, up to 25 L, for process testing. Radioactive continuous testing of the TRUEX solvent extraction process will be required for each waste planned to be treated with the TRUEX process.

The baseline technology for the TRUEX process assumes that countercurrent centrifugal contactors will be used to extract TRU materials from the aqueous wastestream. Laboratory-scale testing may use other contractor configurations, such as mixer-settlers or pulsed extractors, to efficiently use the limited volume of feed material available in developing basic performance data.

Pilot-Scale Continuous Countercurrent Tests with Simulated Wastes--The majority of the technical information needed for engineering design and verification of equipment performance will originate from pilot-plant testing. This testing will be done with a complete solvent extraction process system using simulated wastes. The majority of the testing on this pilot-scale system must be completed before the start of the detailed design of the new pretreatment facility, scheduled to begin in 1998.

The scale of this continuous countercurrent pilot-plant system will be from 1/20 to 1/10 of the plant-scale system. Depending upon the specific process performance and the validity of the process scaleup model, additional testing may be done at more than one scale of pilot testing. There will also be pilot operations of specific unit operations (such as the solvent extraction contractors), which will be completed for final equipment development and process confirmation.

Pilot-scale testing will also involve the use of tracer levels of plutonium and americium, cesium, and strontium. During the later stages of using the pilot equipment for continuous extraction or sorption, processes for the recovery of cesium and strontium could be added to the pilot plant and tested for engineering design confirmation.

Nonradioactive testing of the pilot-scale process system is currently planned to be initiated in fiscal year 1994 and continued until all design data is obtained, process operational data is established, and initial training of staff is completed.

Pilot-Scale Continuous Countercurrent Tests with Actual Wastes--The primary objectives in the operation of a pilot-scale system using actual radioactive waste are to do the following:

- Verify that the TRUEX process can treat the initial DST wastes (NCRW, PFP waste, and CC waste)
- Provide treated waste for vitrification testing in a small-scale radioactive melter and thus support WFQ

- Provide final data on process and equipment system performance and thus support RCRA permitting of the new pretreatment facility and verification of the TRUEX performance model
- Support the operation of the full-scale TRUEX process.

The TRUEX pilot plant that will handle radioactive material is scheduled to be operational in fiscal year 1997 and will operate for approximately 2 yr. The detailed design of the TRUEX process will be confirmed early in the design effort for the new pretreatment facility with the testing data from the radioactive pilot plant.

9.4.4.3.2. Alternatives to the TRUEX Process. The alternatives to the TRUEX process include other solvent extraction technologies and ion exchange processes. There are several extractants that would possibly be used as alternatives to the TRUEX extractant CMPO. These are described briefly below and will be investigated as part of an integrated technology development program.

Dialkylamides--Musikas and his coworkers (1989) in France have been developing a new class of actinide extractants based on dialkylamides. Some of these extractants are true competitors to CMPO in the extraction of TRUs from highly acidic media. The most promising member of this class of extractants is N,N'-dimethyl-N,N'-di-n-butyl-2-(3-oxanonyl)-1,3-diamidepropane, $(C_4H_9CH_3NCO)_2CHC_2H_4OC_6H_{13}$. This compound has been demonstrated to extract americium (III) and plutonium (IV) from strong HNO_3 solutions. Its extraction behavior is similar to TRUEX.

Some of the advantages of N,N'-dimethyl-N,N'-di-n-butyl-2-(3-oxanonyl)-1,3-diamidepropane are as follows:

- Hydrolysis and radiolysis products do not affect the extraction and stripping properties
- Can be destroyed by incineration
- Can be employed with some paraffinic diluents.

The disadvantages of N,N'-dimethyl-N,N'-di-n-butyl-2-(3-oxanonyl)-1,3-diamidepropane are as follows:

- Hydrolyzes when in contact with aqueous HNO_3 at a much faster rate than CMPO
- Satisfactory americium extraction can be obtained only at greater than 3.5 M HNO_3 compared to greater than 1 M HNO_3 for CMPO
- Separation of iron from americium may be more difficult than in TRUEX.

Bidentate Phosphine Oxides--Chmutova et al. (1980) have investigated the use of bidentate phosphine oxide compounds in the extraction of transplutonium elements from HNO_3 solutions. The best candidate in this regard is bis(diphenylphosphino)methane dioxide (dppmO), $(Ph)_2P(O)CH_2P(O)Ph_2$. This compound does display some potential for the extraction of Americium (III) from HNO_3 solutions. For example, for an extractant solution consisting of 0.025M dppmO in chloroform, D_{Am} is reported to be ≈30 from 3M HNO_3.

Unfortunately, the only diluent used in this study was chloroform. The dppmO may not be soluble in aliphatic diluents such as normal paraffin hydrocarbons, however, the extractant might be modified so that it is soluble in normal paraffin hydrocarbons.

The extraction of plutonium (IV) was not reported.

Acyl Pyrazolone Derivatives--Ensor et al. (1990) have been studying the extraction of actinides with acyl pyrazolone derivatives. No data are available from these studies that suggest these compounds would be superior to CMPO.

The use of solid sorbents to recover TRU from alkaline and acidic waste also is a potential alternative to the TRUEX process. Titiuates and several types of macroporous anion and certain exchange resins have been tested and evaluated. The primary issues with these solid sorbents is the ability to elute the recovered material from the exchange, if it is not desired to incorporate these materials into the feedstream. Solid sorbents are viewed as an alternative to solvent extraction technologies should the needs of the remediation program change and solvent extraction not be required.

9.4.4.3.3 Removal of Additional Radionuclides. The dissolution of sludges required for TRUEX processing will solubilize other radionuclides, principally ^{90}Sr and ^{99}Tc, which are present in sludges and salt cakes. Also, these two radionuclides are present in greater concentrations in the SSTs, compared to the DSTs, for which the majority of TRUEX processing is to be conducted. Technology for the recovery of ^{90}Sr and ^{99}Tc will be investigated and included within the processing scope of the new pretreatment facility, if required. In addition, because the TRUEX flowsheet is concluded on the acid-side, technology for the recovery of ^{137}Cs from acid-side wastestreams is also highly desirable as a processing scope for the new pretreatment facility.

Technology is under development within the U.S. and internationally to continuously recover ^{90}Sr and ^{137}Cs from acid wastestreams. These technologies focus on the use of various macrocyclic polyethens (crown ethers) in solvent extraction systems. The most promising work for adaptation is being conducted at Argonne National Laboratory in which a continuous strontium extraction process and cesium extraction process are being developed (Horowitz et al. 1991). The strontium extraction process extractant is a bis-t-butyl-cis-cyclohexano-18 crown-6 which can be combined with CMPO to simultaneously extract actinides and ^{90}Sr. Other researchers in France, Czechoslovakia, and the U.S.S.R. are examining similar technologies.

The recovery of ^{99}Tc from wastestreams has not yet received great attention. An alkaline side process for the recovery of ^{99}Tc from alkaline PUREX supernatant using anion-exchange has been tested on a laboratory scale (Bray et al. 1984). Acid-side processing, using solvent extraction processes, has been conducted to a limited extent and shows promise.

The implementation of advanced processes for ^{137}Cs, ^{90}Sr, and ^{99}Tc removal will require a similar development plan to that described for TRUEX in Section 9.4.4.3.1. Continuous laboratory-scale testing using actual wastes will be needed to verify feasibility of the process. Later, larger scale continuous testing using simulants will be required to establish data for equipment design and process operations. Radioactive pilot-plant testing may be warranted, along with the TRUEX pilot plant, to provide final design confirmation. This, however, will depend upon the technical benefits to be gained and to be judged at a later date.

9.4.4.4 Destruction of Organics and Land Disposal Restricted Components. A number of the DSTs and SSTs contain high concentrations of organic complexants such as ethylenediaminetetraacetic acid (EDTA), hydroxyethylenediaminetriacetic acid (HEDTA), nitrilotriacetic acid, citrate, and glycolate and their resultant byproducts. The complexant concentrate tanks (241-SY-101 and 241-SY-103) contain organic concentrations up to 40 g/L based upon total organic carbon. This organic material may unfavorably impact the LLW form by interfering with grout-curing reactions. It may also complex with the radionuclides or other hazardous components remaining after pretreatment and, thereby, allow these radionuclides to be more leachable from the LLW form. Thus, it may be necessary to destroy the majority of this organic material.

Scoping tests have been initiated to evaluate several technologies to destroy these organics. These technologies include the following:

- Ultraviolet (UV) light-ozone/peroxide
- Electrochemical oxidation
- Supercritical water oxidation
- Reflexing peroxide
- Sonification
- Sonification - peroxide.

These scoping tests indicated that UV-ozone and UV-peroxide are potential technologies to be conducted within a large tank. However, for plant application (as in a new pretreatment facility), these technologies are too slow to achieve adequate throughput. The electrochemical destruction and refluxing peroxide technologies can potentially be employed if complete destruction is not required. Super critical water oxidation is the only process tested to date that will achieve complete destruction.

Additional scoping studies are needed to continue to evaluate and select the appropriate organic destruction technologies. Other technologies besides those listed, such as calcination, will also be examined. Following the selection of the appropriate technology, process scaleup tests will need to be conducted to verify performance and provide design data. It is planned to test and evaluate organic destruction processes in a pilot plant using radioactive wastes. To potentially support the resolution of tank safety issues such as hydrogen generation from tank 241-SY-101 and tank 241-SY-103, technology development associated with organic destruction will be emphasized in the pretreatment program.

9.5 LOW-LEVEL WASTE SOLIDIFICATION

9.5.1 Approach for Use of Grout and Alternate Low-Level Waste Forms

The grout waste form evaluated in the *Final Environmental Impact Statement, Disposal of Hanford Defense, High-Level Transuranic and Tank Waste, Hanford Site, Richland, Washington* (HDW-EIS) (DOE 1987) and identified in the record of decision (DOE 1988) as the waste form for LLW from DSTs has been shown through development of a performance assessment to be acceptable for shallow-land disposal at the Hanford Site. Thus, the tank waste disposal program will proceed with grout as the preferred LLW form. In the long-term, however, there may be opportunities to implement emerging LLW forms currently under development that could reduce disposal cost and/or improve the disposal system. Thus, the LLW form strategy will use grout initially and potentially an alternative waste form in the long term.

9.5.2 Technology Development Needs for Grout

Grout is unique relative to the HWVP in that the grout program includes a disposal action in addition to the waste form preparation while HWVP includes only the wastes form preparation action. Therefore, the grout program must also address the technology needs for the disposal system itself. The grout disposal system (vaults and barriers) has been designed and is being constructed. Some studies and analyses of system components, such as the vault design configuration, operations approach, and barrier designs are needed to ensure the longer term performance of the disposal system. There are also cost incentives to develop alternative barriers with equal or better performance than the current barriers but at a lower cost.

Work leading to the grouting of double-shell slurry and double-shell slurry feed wastes from DSTs is nearing completion. For the short term, the liquid LLW solidification process of choice is grouting. Recent studies have concluded that grouting of DST liquid LLWs should proceed. At the same time, as final preparations for the resumption of DST waste grouting are made, studies have been initiated to evaluate alternative LLW forms for SST wastes. Because the DST waste solidification mission will require more than 20 yr, some of the LLW alternatives may become available as second generation waste forms for the remaining DST wastes.

The technology needed to grout liquid LLW per the existing program is minimal. Cementitious waste forms are used extensively in the nuclear power industry for solidification of wastes. Cementitious forms have been or will soon be used for solidification of liquid LLWs from fuel reprocessing activities at the following U.S. Department of Energy (DOE) sites. At the Hanford Site, 3,800 m^3 (1 Mgal) of DST phosphate and sulfate wastes were grouted in 1988 and 1989 to form 5,300 m^3 (1.4 Mgal) of grout. At the

Savannah River Site, a cementitious waste form (saltstone) will be used to solidify their liquid LLWs. At the West Valley Demonstration Project, a cement solidification system is being used on liquid LLWs from the decontamination of an alkaline supernatant. Grouting of DST wastes at the Hanford Site is expected to resume in late 1992.

The success of the grouting mission depends on the resolution of technical issues associated with characterization, retrieval, and pretreatment of the wastes. Technology development needs for these activities were described previously. The remaining technology need for grout is the technology to support the rapid and efficient formulation of grout compositions in response to variations in waste composition. The technology is immediately applicable to DST wastes and has future application to SST wastes as well as to other wastes to be immobilized by grouting.

For each DST waste to be incorporated into grout, an existing grout formulation must be shown to yield an acceptable waste form, or an enhanced grout formulation must be developed. Currently, the estimate is that at least 1 yr is needed to accomplish this task for each tank. Technology and a supporting database must be developed to guide the formulation effort and to reduce the time to develop and/or verify the grout formulation. The technical work to be completed focuses on two objectives: (1) develop a grout formulation that can be used for a broad range of grout compositions, and (2) develop specific "rules" for formulation so that a formulation can be rapidly developed and verified in response to a measured waste composition. Extensive formulation development would not be required as long as the composition was within an acceptable range. If formulation modifications were needed, the "rules" would guide and speed the development of the modification.

9.5.3 Technology Development Needs for Advanced Low-Level Waste Forms

A number of alternative LLW forms have been identified and their suitability examined for decontaminated supernatant streams (Boomer et al. 1991).

The incentives for deploying an alternative waste form to grout for LLW at the Hanford Site are (1) decreased waste form volume, which reduces operating and disposal costs, and (2) enhanced safety. The development of an LLW alternative will begin with a laboratory evaluation of potential waste forms. Selection of waste forms for follow-on development will be coordinated with the overall Hanford Site systems analysis. In particular, different pretreatment operations can produce different types and volumes of LLW, which could impact selection of the waste form for LLW solidification.

Initial laboratory testing and evaluations of alternative waste forms are underway. Six alternatives are currently being examined. These are as follows:

- Encapsulation in polyethylene
- Conversion to glass in containers

- Conversion to glass aggregate in sulfur concrete
- Vitrification in situ
- Conversion to a low-temperature mineralized grout
- Conversion to ceramic encapsulated in portland cement.

Waste form development needs are high for the ceramic encapsulated in cement and for the mineralized grout but are low for the other alternatives. Grout is perceived to have moderate formulation development needs.

Process development needs are lowest for the polyethylene waste form; a full-scale demonstration is planned at Rocky Flats. Mineralized grout and glass in sulfur concrete are perceived to have moderate development needs because of calcining challenges and melter design, respectively. The glass-in-containers concept has high process development needs because of the scale of operation and the large number of containers to be produced. In situ vitrification is also perceived to have high process development needs because of the scale of operation. Because of the complexities of making ceramic waste forms, the ceramic in cement process is estimated to have high development needs. In comparison, grout process development needs are low.

In addition to the technologies currently being evaluated, others may also be effective alternatives to grout. For example, a glass melter that pours into a trench should also be considered. This process has the potential to deal with the scale of operations and the large number of containers to be produced when vitrifying LLW.

9.6 HIGH-LEVEL WASTE VITRIFICATION

The reference process for treating the HLW and TRU fractions of the DST waste is vitrification in the HWVP. Vitrification of radioactive waste is well developed and is being implemented worldwide. However, the diversity and large volume of Hanford Site wastes make it prudent to pursue additional technology development.

9.6.1 Waste Form Enhancement

Waste form enhancement will ensure that the HWVP has the flexibility to achieve the highest practicable waste loading with any foreseeable waste composition and yet produce glass that meets all product quality requirements. Higher waste loading increases the operating efficiency of the HWVP and decreases the amount of glass that will have to be transported from the Hanford Site to a geologic repository. Thus, the overall safety of the Hanford Site cleanup is increased.

9.6.2 Vitrification System Enhancement

The baseline program for HWVP waste form enhancement is the composition variability study (CVS). Processability data (melt viscosity, melt electrical conductivity, and liquidous temperature) and product quality data (MCC-1 and PCT leach rates, as well as T-T-T diagrams) are being obtained for the CVS. The data are being measured on a large number of laboratory-prepared glasses with statistically selected compositions. The data are used to define a range of glass compositions with satisfactory processing and product quality characteristics. The initial CVS goal was to define a compositional envelope for NCAW. This has been done. Currently, the CVS is developing a broader glass composition envelope to accommodate waste variations that may occur when other DST wastes are processed in the HWVP.

The glass composition models that are being developed from the CVS data will define the glass-making additives needed to process any DST waste in the HWVP. An important feature of these models is that the glass-making contribution of constituents in the waste is included in the model. In essence, part of the waste displaces glass frit, thus maximizing waste loading.

The approach for HWVP waste form enhancement is to continue the CVS and to supplement it in certain areas of basic glass science. Additional CVS data will be collected, particularly liquidous temperatures and T-T-T diagrams. Further development of the glass composition models will incorporate new CVS data as it is generated and will include the effects of second-order interactions between glass constituents. Higher-melting-temperature glasses will be included. Additional knowledge of basic glass science is needed in several areas including glass melting reaction kinetics, phase separation, and immiscibility. The HWVP project personnel will continue to work closely with other U.S. waste vitrification sites and the repository project on the waste form acceptance process. The waste form enhancement that made possible the CVS data, the glass composition envelope models, and the basic glass science give confidence that the HWVP product can meet acceptance requirements.

The melter is the keystone of the vitrification system; thus, melter modifications need the primary attention for vitrification system enhancement. Examples of the melter enhancements to be considered are improved melter circulation, sloped bottom, bottom drain, and overflow drain design and high-temperature melters (1500 °C).

A high-temperature melter offers the potential for higher waste loading (larger quantities of refractory waste constituents such as zirconium and aluminum can be accommodated) and higher waste processing rate. Operating reliability and flexibility could possibly increase when the melter temperature becomes an operating variable. For example, a melter designed for a 2-yr life at 1500 °C could easily have a 10- to 15-yr life if operated most of the time at lower temperatures. Yet, its higher temperature capability would be available when needed (e.g., for high zirconium or aluminum wastes or for the processing of miscellaneous material). The miscellaneous material could include such items as offstandard canisters and contaminated solid materials that may have to be treated as HLW. High-temperature glass melting is a well-proven technology; industrial glass melters routinely operate at 1500 °C to 1600 °C. Development is needed to design a high-temperature melter for the HWVP in areas such as refractory and electrode corrosion, offgas control, and melter feed system.

The glass drain is the weakest area for the existing waste melter design. Advanced construction materials that are more refractory and corrosion resistant are needed and should be investigated. Noble metals plating and subsequent shorting have been encountered in waste glass melters in Japan and Germany. Although Hanford Site wastes have lower concentrations, the total noble metal quantity to be processed per year through the HWVP is comparable to the Japanese and German experience. In addition, precipitation of other crystalline sludges is more likely in the variable Hanford Site wastes. Each of these issues can be resolved with a bottom drain that sweeps the accumulations off the bottom of the melter and into the glass canister on a continuous basis without impacting the overall quality of the product.

A slope-sided melter has applicability to implementation in the HWVP if waste feeds are found to contain unacceptable concentrations of precipitating metals. Chapman and McElroy (1989) report that a sloped-sided melter has been designed and operated at the West Valley Site, which has applicability to the processing of noble-metal containing feeds. The sloped-sided melter design concept has also been adopted by the Japanese and Germans as the reference melter design for vitrification of HLWs containing relatively high concentrations of noble metals.

9.7 REFERENCES

Boomer, K. D., S. K. Baker, A. L. Boldt, M. D. Britton, L. E. Engelsman, J. D. Galbraith, J. S. Garfield, K. A. Giese, C. E. Golberg, B. A. Higley, K. J. Hull, L. J. Johnson, R. P. Knight, J. S. Layman, R. S. Marusich, R. J. Parazin, M. G. Piepho, E. J. Slaathaug, T. L. Waldo, and C. E. Worcester, 1991, *Systems Engineering Study for the Closure of Single-Shell Tanks*, WHC-EP-0405, Vol. 1 and 2, Westinghouse Hanford Company, Richland, Washington.

Bray, L. A., L. K. Holton, T. R. Myers, G. M. Richardson, and B. M. Wise, 1984, *Experimental Data Developed to Support the Selection of a Treatment Process for West Valley Alkaline Supernatant*, PNL-4969, Pacific Northwest Laboratory, Richland, Washington.

Chapman, C. C. and J. L. McElroy, 1989, "Slurry-Fed Ceramics Melter - A Broad Accpeted System to Vitrify High-Level Waste," Pacific Northwest Laboratory, Richland, Washington, reprinted from *High-Level Radioactive Waste and Spent Fuel Management Vol. 11*, S. C. Slate, R. Kohout, and A. Suzuki, American Society of Mechanical Engineers, Book No. 10292B, New York, New York.

Charbonnel, M. C., and C. Musikas, 1989, "The Extraction by N,N'-Tetrabutyl-glutaramides II: Extraction of U(VI), Pu(IV) and Some Fission Products," *Solvent Extr. Ion Exch.*, Vol. 7, pp. 1007-1025.

Chmutova, M. K., N. E. Kochetkova, and B. F. Myasoedov, 1980, "Polydentate Neutral Organophosphorus Compounds as Extractants of Transplutonium Elements," *J. Inorg. Nucl. Chem.*, Vol. 42, pp. 897-903.

Cuillerdier, C., C. Musikas, P. Hoel, L. Nigond, and X. Vitart, 1989, "Malonamides as New Extractants for Nuclear Waste Solutions," Report CEA-CONF-10067, Commissariat a L'Energie Atomique (France).

DOE, 1987, *Final Environmental Impact Statement, Disposal of Hanford Defense, High-Level, Transuranic and Tank Wastes, Hanford Site, Richland, Washington*, DOE/EIS-0113, Vol. 1 through 5, U.S. Department of Energy, Washington, D.C.

DOE, 1988, "Final Environmental Impact Statement for the Disposal of Hanford Defense, High-Level, Transuranic and Tank Wastes, Hanford Site, Richland, Washington; Record of Decision," *Federal Register*, Vol. 53, No. 72, pp. 12449-12453, Washington, D.C.

Ecology, EPA, and DOE, 1990, *Hanford Federal Facility Agreement and Consent Order*, Vol. 1 and 2, Washington State Department of Ecology, U.S. Environmental Protection Agency, and U.S. Department of Energy, Olympia, Washington.

Ensor, D. D., D. C. Glasgow, B. F. Smith, G. D. Jarvinen, 1990, "Distribution Studies of Actinides Using a Tetradentate Extractant, 4,4'-Nonanedioyl-bis (2,4-dihydro-5-methyl-2-phenyl-3H-pyrazol-3-one)," *Sep. Sci. Technol.*, Vol. 25, pp. 1629-1639.

Hill, A. J., and R. F. Bradley, 1977, *Chemical Dissolving of Sludge from a High-Level Waste Tank at the Savannah River Plant*, DP-1471, E. I. duPont de Nemours, Inc., Aiken, South Carolina.

Hill, J. G., et al., 1991, *Waste Characterization Plan for Hanford Site Single-Shell Tanks*, WHC-EP-0210, Rev. 3, Westinghouse Hanford Company, Richland, Washington.

Horwitz, E. P., M. L. Dietz, and D. E. Fisher, 1991, "SREX: A New Process for the Extraction and Recovery of Strontium for Acidic Nuclear Waste Solutions," *Solv. Ex. Ion Exch.*, Vol. 9, pp. 1-26.

Kupfer, M.J., 1981, *Preparation of Nonradioactive Substitutes for Radioactive Wastes*, DOE/ET 41900-8, Rockwell Hanford Operations, Richland, Washington.

Miller, W. C., D. W. Hamilton, L. K. Holton, and J. W. Bailey, 1991, *Hanford Waste Vitrification Systems Risk Assessment-Final Report*, WHC-EP-0421, Rev. 0, Westinghouse Hanford Company, Richland, Washington.

Musikas, C. et al., 1989, "Results and Prospects for Some Actinide Extractants Usable in Actinide Partitioning," Report CEA-CONF-10069, Commissariat a L'Energie Atomique (France).

Resource Conservation and Recovery Act of 1976, 42 USC 6901, et seq.

Schulz, W. W., and M. J. Kupfer, 1991, *Candidate Reagents and Procedures for Dissolution of Hanford Site Single-Shell Tank Sludges*, WHC-EP-0451, Westinghouse Hanford Company, Richland, Washington (October).

Thiollet, G. and C. Musikas, 1989, "Synthesis and Uses of the Amide Extractants," *Solvent Extr. Ion Exch.*, Vol. 7, pp. 813-827.

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CONTENTS

LIST OF FIGURES

ACRONYMS

CCB	Configuration Control Board
CSCSC	cost and schedule control systems criteria
DOE	U.S. Department of Energy
Ecology	Washington State Department of Ecology
HDW-EIS	*Final Environmental Impact Statement, Disposal of Hanford Defense High-Level, Transuranic and Tank Wastes, Hanford Site, Richland, Washington*
MSA	major system acquisition
PMP	Program Management Plan
risk assessment	*Hanford Waste Vitrification Systems Risk Assessment-Final Report*
SMS	Site Management System
Tri-Party Agreement	*Hanford Federal Facility Agreement and Consent Order*
WBS	work breakdown structure

10.0 PROGRAM PLANS AND DOCUMENTATION

This section describes plans and documentation that will be prepared for the tank waste disposal program including the following specific program elements:

- The basic organizational structure of the program (Figure 10-1)
- The program work breakdown structure (WBS) that provides a basic structure for the program documents (Figure 10-2)
- A general overview of the relationship between the program documents (Figure 10-3)
- How the program baselines will be established and controlled.

The program documentation will be based on the tank waste disposal program plan and the program management plan. These two plans will be structured to conform to cost and schedule control systems criteria (CSCSC), U.S. Department of Energy (DOE) Order 2250.1C (DOE 1988a), DOE Order 4700.1 (DOE 1987a), and the Site Management System (SMS) now being developed for the Hanford Site. Conformance to these DOE orders and the SMS will provide uniformity and consistency of structure that will ensure effective integration of the program elements. Integration provides a common base for management systems, establishing plans, providing direction, organization, activity implementation, reporting, analyzing, and controlling program activities.

10.1 PROGRAM PLAN

10.1.1 Program Plan Overview

The tank waste disposal program plan provides a summary of the program's initial dimensions, technical scope, cost, and schedule baselines. The program plan is an evolving document and will require annual review and updating to reflect changes in the tank waste disposal program.

10.1.2 Program Plan Annotated Outline

The following annotated outline of the program plan provides the sections to be incorporated along with a short statement of the text for each section.

1. Program Need and Objectives

   The need for the tank waste disposal program has been established in several documents, e.g., the *Final Environmental Impact Statement, Disposal of Hanford Defense High-Level, Transuranic and Tank Wastes, Hanford Site, Richland, Washington* (HDW-EIS) (DOE 1987b), the record of decision (DOE 1988b) associated with the HDW-EIS, and the *Hanford Federal Facility Agreement and Consent Order* (Tri-Party Agreement) (Ecology et al. 1990).

Figure 10-1. Defense Waste Remediation Division.

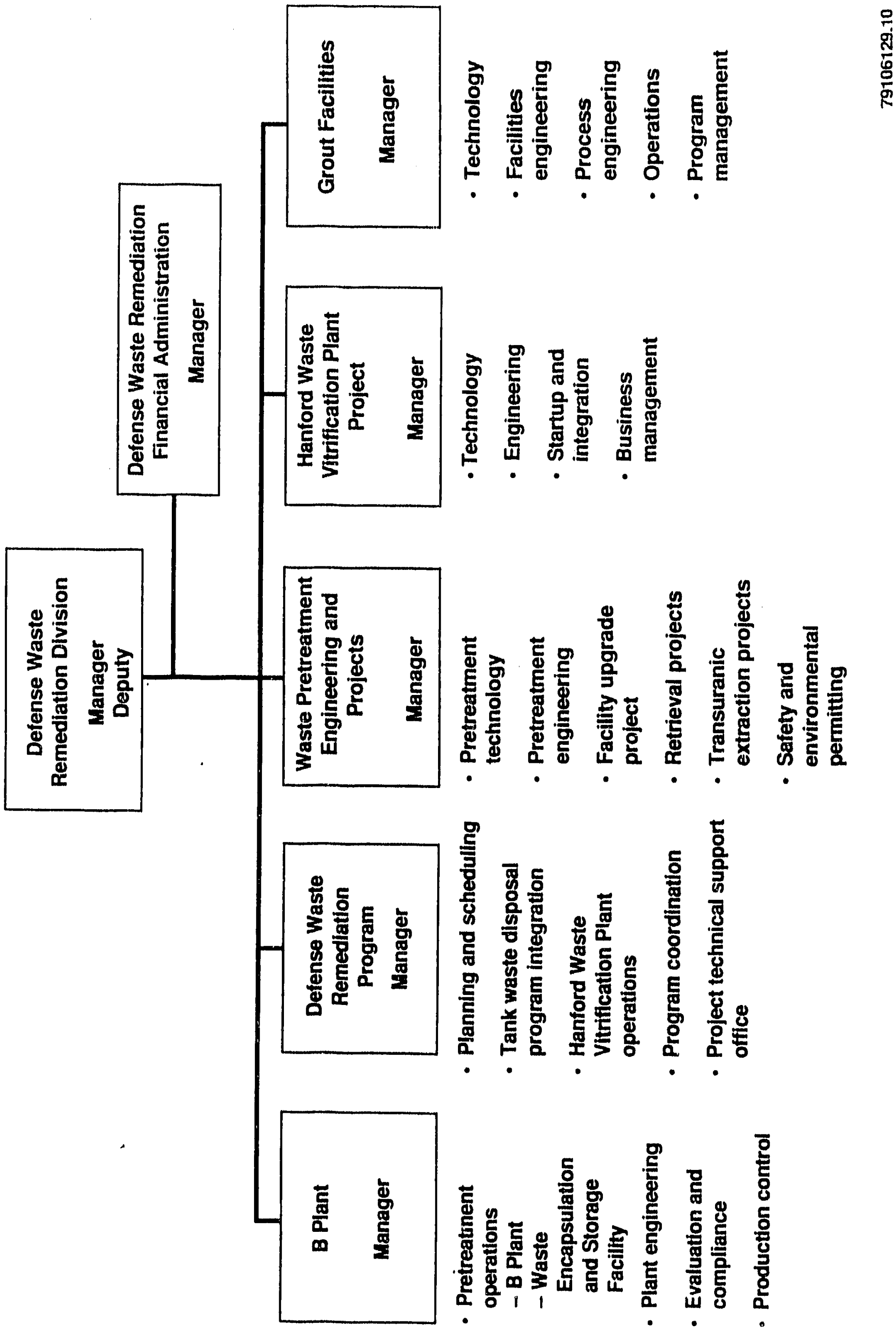


Figure 10-2. Double-Shell Tank and Single-Shell Tank Waste Disposal Program Summary Work Breakdown Structure.

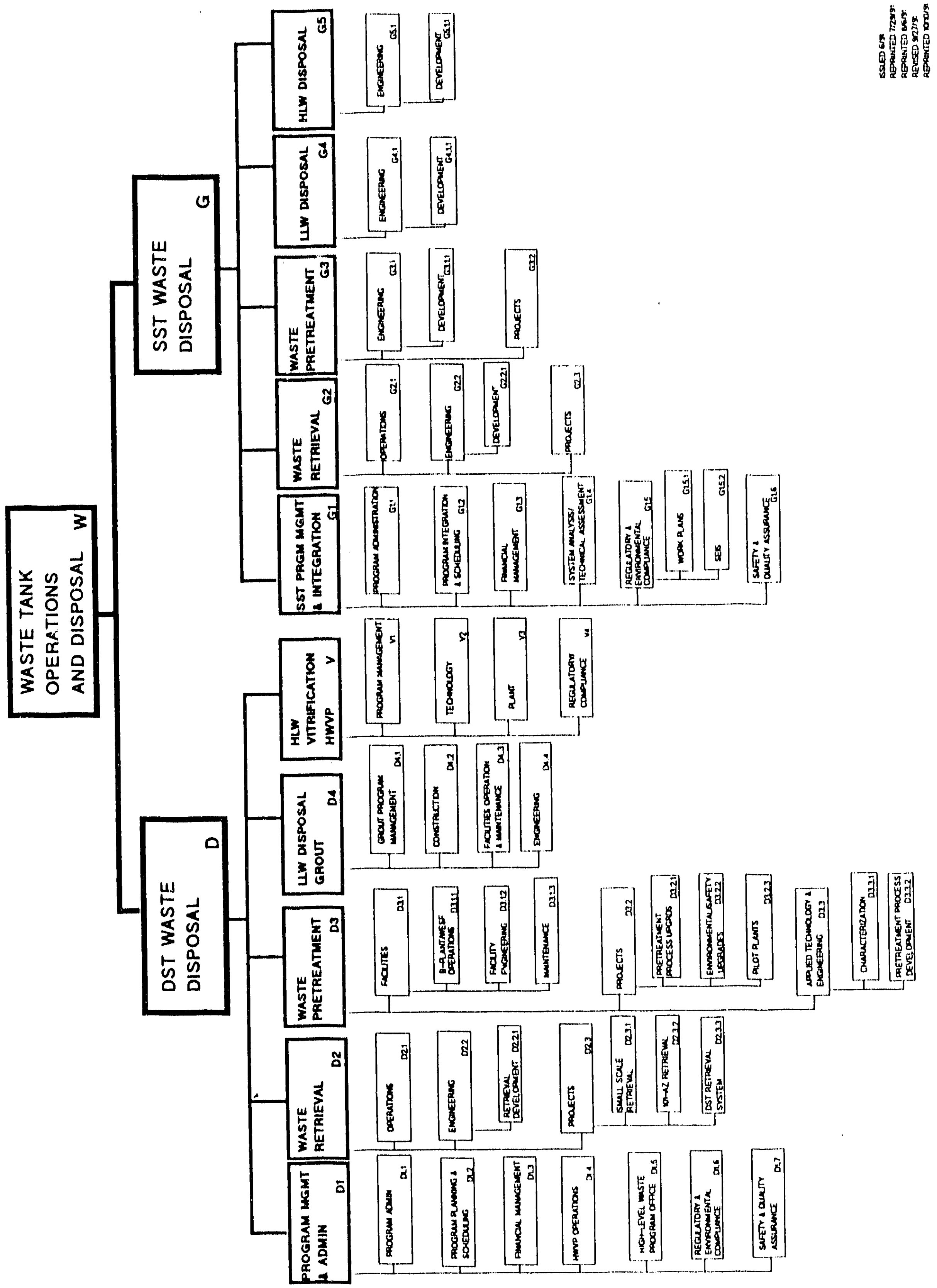
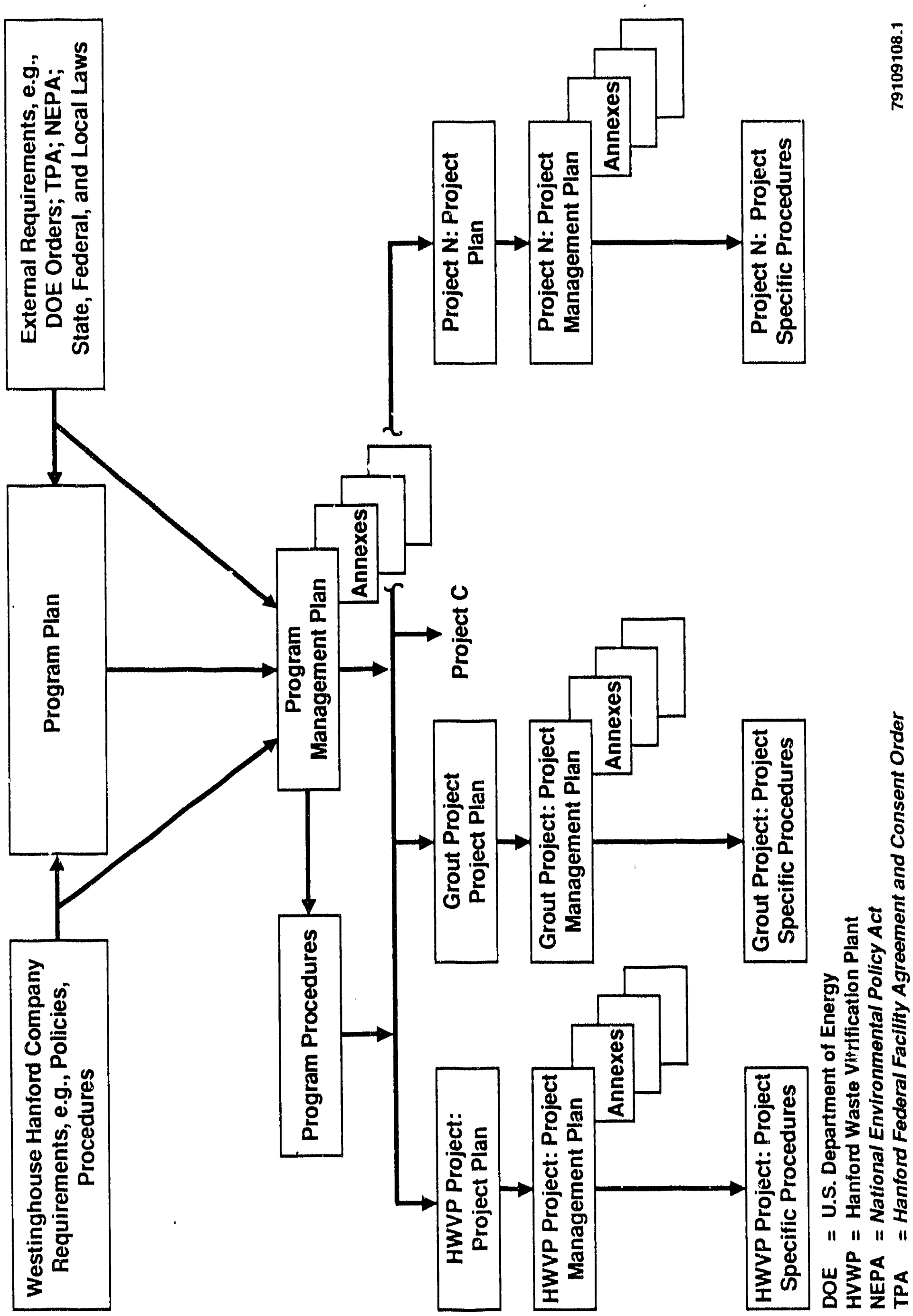


Figure 10-3. Tank Waste Disposal Program Documentation Relationships.



Specific measurable program objectives will be delineated in this section.

2. Technical Plan

This section describes what is going to be done, the selected alternative, and how the chosen solution is going to be accomplished. Also, this section provides a brief discussion of the status of the chosen technology, each phase of the program, a WBS (see Figure 10-2), and a flow diagram showing the relationships of the program's diverse projects.

3. Risk Assessment

This section provides an assessment of the program risks that identify critical projects, facilities, systems, and other factors requiring focused work and resolution. The results of the *Hanford Waste Vitrification Systems Risk Assessment-Final Report* (risk assessment) (Miller et al. 1991) will provide the basis of this section.

4. Management Approach

The tank waste disposal program's management approach will be addressed in this section. The organizational structure, management control systems, decision delegations, and where the responsibility for program funds lies will be detailed in this section. The tank waste disposal program's organization chart (Figure 10-1) is an integral part of this section.

5. Acquisition Strategy

The program's acquisition strategy is the underlying concept for management of the program; it reflects the interrelationships of mission, technical, business, and management objectives.

This section contains brief descriptions of the management concepts to be used in directing and controlling the program. It identifies how the work is to be accomplished (e.g., operation funds versus capital funds, site forces versus major system acquisition (MSA), and cost-plus incentive fee contracts versus lump-sum fixed-price contracts) and the applicable controls for those funds and contracts.

6. Program Schedule

This section contains the program schedule displayed in a bar chart format. The schedule contains key program activities, key phases of the program described in the technical plan (in Section 2), appropriate measurable milestones, and key decisions by the program's sponsoring organization(s).

7. Resources Plan

   This section states the program's estimated total costs along with any necessary qualifying statements. The total cost estimate will be broken down in to its yearly increments and displayed as a cumulative S-curve for the program's life. Displayed in the same format on this graph will be a curve of the yearly budget authorizations necessary to support the program.

   The estimated management staff (per year) will be provided in a tabular format.

8. Controlled Items

   Controlled items are the program's established technical, cost, and schedule parameters. This section describes the controlled items and indicates the authorized limits.

9. Schedule Decision Points

   This section provides tables showing all authorizing agencies and executive management decisions for the program and other pertinent major decision points in the program's life.

10. Program Charter

    The program charter delineates management responsibility, authority, and accountability for the program. This section contains the responsible managing organization, the support to be furnished by other organizations, the authorities of the program manager, and any special instructions or delegations of authority necessary to facilitate the program.

10.2 PROGRAM MANAGEMENT PLAN

10.2.1 Program Management Plan Overview

The tank waste disposal program management plan identifies the program's authorizing agents and documents as well as the plans, organizations, and systems that those responsible for managing the program will use. In addition, this plan provides the basic format that each project in the program will use when preparing a project management plan.

10.2.2 Program Management Plan Annotated Outline

The following annotated outline provides the sections to be incorporated into the program management plan along with a short description of the text.

1. Introduction

   This section of the program management plan (PMP) describes in general terms the program's authorization, purpose, scope, and primary participants. It cites other program documentation that will be developed or that exists (e.g., quality assurance plan, program procedures, configuration management plan, and the Hanford Waste Vitrification Plant project office management plan).

2. Objectives

This section expands upon specific measurable objectives delineated in the tank waste disposal program strategy plan, including measurable technical, economic, schedule, and cost objectives by levels 1, 2, and 3 of the program WBS.

3. Management Organization and Responsibilities

This section contains descriptions and organization charts, such as Figure 10-1, of the significant program interfaces as well as lines of authority, responsibility, accountability, and communication.

4. Work Plan

This section describes what is planned to be accomplished in terms of the program's three upper levels of the WBS and relates in detail the major projects, facilities, and systems. This section also addresses the interfaces and coordination with quality control and quality assurance.

5. Program Work Breakdown Structure

This section discusses the role of the WBS in the management of the program and its various projects (e.g., the Hanford Waste Vitrification Plant). In addition, the program WBS, dictionary, and element definition from level 1 to level 3 is provided.

6. Schedule

This section expands upon the program schedule provided in the tank waste disposal program plan and shows an integrated program schedule corresponding to level 3 of the program WBS.

7. Logic Diagram

This section contains the logic diagram upon which the work plan in Section 4 and the schedule in Section 6 are based. This logic diagram highlights the program's critical paths.

8. Performance Criteria

The performance criteria contained in this section is an expansion of the technical objectives contained in the program plan. Typical performance criteria are (1) kilograms of output per unit of time, (2) repository requirements for acceptance of waste, and (3) description of the processes to be used. These criteria are detailed, at a minimum, at level 2 of the program WBS.

9. Cost and Manpower Estimates

   This section provides cost and manpower estimates for each element at levels 2 and 3 of the program WBS by fiscal year. This section is consistent with the cost objectives stated in the program plan.

10. Program Function Support Requirements

    This section provides in greater detail the information contained in the program charter. Items covered are the program's functional organization structure, lines of authority, areas of responsibility, and procedures for resolution of conflict between responsible organizations.

11. Program Management, Measurement, and Planning Control Systems

    This section describes the integrated systems that are used to manage the cost, schedule, and technical performance parameters of the program. These systems contain essential elements of the SMS and additional elements that enhance the SMS.

12. Information and Reporting

    This section provides a brief summary of existing major program documentation, describes reporting requirements for program projects and contractors, and establishes the frequency of program reviews.

13. Systems Engineering Management

    This section will describe the extent to which systems engineering will be used, how the process will be managed, and who will be responsible for the various aspects of management. For an example of the information presented here, see the Single-Shell Tank Systems Technical Support Program Plan in Section 3.

14. Configuration Management

    This section details the technical interface arrangements and controls necessary for effective configuration management (e.g., configuration identification, recording, and reporting of product interface and construction data). In particular, this section addresses the establishment and operation of a Configuration Control Board (CCB) and how the CCB functions to ensure continuity of the program's configuration documentation.

15. Contingency

    This section outlines the conditions and approvals required for the use of contingency.

16. Quality Assurance and Safety

    This section provides the elements necessary for quality assurance and safety functions of the tank waste disposal program. Specific elements identified and described include audits and surveillances, nonconformance reports, and corrective actions.

17. Utility Services

    This section defines the specific actions to be taken to ensure the availability of reliable utility services during both construction and operations.

18. Responsibility Matrix

    This section contains a two-dimensional matrix of program actions and decisions versus responsible person and organization. This matrix is at WBS level 2, the same level as the schedule provided in Section 6.

19. Annexes

    The annexes to this program management plan include, as a minimum, an Information Resource Management plan, a Quality Assurance plan, a Records Management plan, and a Document Control plan. Other plans will be included as deemed necessary by management.

10.3 OTHER PROGRAM DOCUMENTATION

The program plan and the program management plan will require other program documentation to be produced to provide the specific details and processes necessary to implement required functions. Specific functions that are not adequately addressed in Westinghouse Hanford Company corporate plans or procedures will be expanded to provide the necessary details. Examples of the documents that may need to be produced are tank waste disposal program data management plan, tank waste disposal program, Information Resource Management execution plan, and program procedures providing overall direction to and integration of the program's projects in specific areas such as scheduling and estimating.

Program-level procedures may require extensive documentation, depending upon the documentation prepared in support of the SMS. These program procedures will describe the interfaces between the projects within the program and the program management as well as provide basic structures for records management systems, databases, and activity coding schemes.

Another area of documentation within the tank waste disposal program will be the project plans, project management plans, and project procedures that are required of those program projects designated as a MSA or major project by the DOE. This documentation will be done more expeditiously and cost effectively because the structure and major portions of the text will already be prepared with the program level of documentation. The end result is program documentation that conforms to the requirements of CSCSC and DOE Order 4700.1 (DOE 1987a) throughout the program and in all the program's projects.

10.4 REFERENCES

DOE, 1987a, *Project Management System*, DOE Order 4700.1, U.S. Department of Energy, Washington, D.C.

DOE, 1987b, *Final Environmental Impact Statement, Disposal of Hanford Defense High-Level, Transuranic and Tank Wastes, Hanford Site, Richland, Washington*, DOE/EIS-0113, Vol. 1 through 5, U.S. Department of Energy, Washington, D.C.

DOE, 1988a, *Cost and Schedule Control System Criteria*, DOE Order 2250.1C, U.S. Department of Energy, Washington, D.C.

DOE, 1988b, "Final Environmental Impact Statement for the Disposal of Hanford Defense High-Level, Transuranic, and Tank Wastes, Hanford Site, Richland, Washington," *Federal Register*, Vol. 53, No. 72, pp. 12449-12453, U.S. Department of Energy, Washington, D.C.

Ecology, EPA, and DOE, 1990, *Hanford Federal Facility Agreement and Consent Order*, Vol. 1 and 2, Washington State Department of Ecology, U.S. Environmental Protection Agency, and U.S. Department of Energy, Olympia, Washington.

Miller, W. C., D. W. Hamilton, L. K. Holton, and J. W. Bailey, 1991, *Hanford Waste Vitrification Systems Risk Assessment-Final Report*, WHC-EP-0421, Rev. 0, Westinghouse Hanford Company, Richland, Washington.

APPENDIX A

RELATED CORRESPONDENCE

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This appendix contains copies of correspondence between the U.S. Department of Energy Field Office, Richland (RL) and Westinghouse Hanford Company (Westinghouse Hanford).

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Department of Energy
Richland Operations Office
P.O. Box 550
Richland, Washington 99352

90-VDB-062

NOV 7 1990

President
Westinghouse Hanford Company
Richland, Washington

Dear Sir:

DOUBLE SHELL TANK (DST) WASTE TREATMENT AND DISPOSAL ENGINEERING STUDIES

As part of our efforts to evaluate the current approach to the DST waste treatment and disposal program, we are working with your staff to develop a range of engineering studies. Our objective for these studies is to perform a detailed technical analysis of selected elements of the program to support decision-making on alternatives to the current approach.

The project team has identified six basic areas for analysis, including:

- Pretreatment Program: evaluate waste pretreatment and vitrification processes to identify optimum process technology, facility configuration, and location.

- Grout Program: evaluate current grout acceptance specification, identify technology and process changes to improve treatment of hazardous and radioactive constituents, and evaluate current grout vault design.

- PUREX Applications: evaluate utilization of PUREX for pretreatment of post-NCAW waste.

- Waste Characterization Program: review current approach, including the number of samples, schedule, sampling equipment, and analytical capability to assure that the sample information will support the pre-treatment program.

- Melter: evaluate second-generation melter technology and disposal of current melter.

- Cesium and Strontium Capsule Storage: evaluate options for near-term capsule storage, and long-term capsule treatment and disposal.

90-VDB-062
WHC

NOV 7 1990

Westinghouse Hanford Company (WHC) has been assigned the responsibility to coordinate, develop, and integrate the effort for the engineering studies. As a first step, we request that you develop the preliminary strategy for the engineering studies, including scope, sequence, cost estimates, and schedules. A key assumption for development of the preliminary strategy is that the current program and project milestones remain unchanged. Please present your preliminary strategy to this office by mid-November.

If you have any questions on this effort, please direct them to R. W. Brown, Deputy Project Manager, on 376-7391.

Sincerely,

John H. Anttonen, Project Manager
Vitrification Project Office

VPO:LE

cc: C. M. Cox, WHC
R. A. Smith, WHC
G. A. Meyer, WHC

Westinghouse
Hanford Company

P.O. Box 1970 Richland, WA 99352

9004995 R1

Mr. J. H. Anttonen, Project Manager
Vitrification Project Office
U.S. Department of Energy
Richland Operations Office
Richland, Washington 99352

Dear Mr. Anttonen:

DOUBLE-SHELL TANK (DST) WASTE TREATMENT AND DISPOSALS ENGINEERING STUDIES

Reference: Letter, J. H. Anttonen, DOE-RL to President, WHC, same subject, 9004995B, dated November 1, 1990

In response to the referenced letter, Westinghouse Hanford Company (WHC) has met with you and your staff to develop a preliminary strategy for program-related engineering studies which will support decision-making associated with our current program baseline and possible alternatives to the current approach.

We believe that the studies should be keyed to our current baseline plans for retrieval, pretreatment, grout, and vitrification. A simplified baseline plan indicating major program milestones is attached. This plan will be enhanced to show decision points relating to the engineering studies.

The referenced letter identified six basic areas for analysis. Our discussions over the past few weeks have examined those areas and have resulted in recognizing a need for additional studies and plans. This letter summarizes our agreed-upon preliminary strategy for developing a set of engineering studies for the Double-Shell Tank Waste Disposal Program.

The following are recommendations for performing the studies.

1. <u>Pretreatment Program</u> - Perform a facility configuration and location study based on the current waste pretreatment flowsheets to support a Fiscal Year (FY) 1993 design-only line item request. The facility configuration requirements will include substantial flexibility to accommodate incorporation of potential technology developments. This study cost is estimated at $1.0M in FY 1991 and we anticipate the use of an outside Architect/Engineer.

   A plan for a disciplined approach to the evaluation and assessment of new technology developments and incorporation into the current baseline will be developed by WHC over the next few weeks.

2. Grout Program - Perform a study to identify the feasibility of technology and process changes associated with further removal of radioactive and hazardous waste constituents from grout feed. Perform a conceptual design report for improved grout vault design based on concepts identified in a value engineering study (February 1990). The cost of these studies is estimated at $1.0M in FY 1991. Based on the results of these studies a decision will be made to evaluate the current grout feed specification and the grout waste disposal performance assessment.

3. PUREX Applications - Perform a brief assessment for evaluating the placement of pretreatment processes in the PUREX plant. This study would be completed in April 1991 at an estimated cost of $150K. A more detailed evaluation of the use of PUREX will be considered later in the year.

4. Waste Characterization Program - Review and analyze the current methodology of the characterization program to assure adequacy for supporting technology development and waste form qualification needs. This study will be completed in May 1991 at a cost of approximately $150K.

   Westinghouse Hanford Company will develop a work plan for a more detailed study of the characterization program to include both single-shell and double-shell tanks. The schedule and cost for this plan is still to be determined.

5. Melter - The WHC Projects Technical Support Office (PTSO) is coordinating a response to a U.S. Department of Energy-Headquarters inquiry concerning potential capabilities of alternative melter technology. This response will recommend a joint proposal, with participation by the Savannah River Laboratory, Pacific Northwest Laboratory, the Defense Waste Processing Facility, and the Hanford Waste Vitrification Plant (HWVP), for development and demonstration of a second-generation melter. We recommend support of this proposal to be followed by a HWVP second-generation melter study in FY 1992. We further recommend that a study for melter disposal be deferred to FY 1992.

6. Cesium and Strontium Capsule Storage - Complete and issue the study for long-term capsule treatment and disposal, prepared by PTSO, which is currently in the review cycle. We recommend deferral of the evaluation of options for near-term storage based on the fact that there are no unresolved issues with the continued use of the Waste Encapsulation and Storage Facility (WESF). Results of the Vitrification Program Risk Assessment will establish a basis to resolve disposal plans and the need for future evaluation of alternate storage of capsules.

J. H. Anttonen
Page 3

9004995 R1

Our list of recommendations continues with those studies and plans which are in addition to those identified in the referenced letter.

7. <u>Capital Project Studies</u> - Proceed with the preparation of documentation for validation of: B-Plant Upgrade Line Item; AR-Vault Upgrade Line Item; TRUEX MSA; Retrieval MSA. These studies are estimated at $500K each during FY 1991.

8. <u>WESF Support Annex</u> - Upon completion of the Vitrification Program Risk Assessment, if applicable, a study to define the services and facilities necessary to operate WESF independent of B-Plant will be performed. Schedule and cost information will be provided as required.

9. <u>B-Plant Shutdown Plan</u> - Upon completion of the Vitrification Program Risk Assessment, if applicable, a plan to effect the orderly shutdown, decontamination, and decommissioning of B-Plant will be performed. Schedule and cost information to be determined.

We further recommend that these studies be integrated with the activities currently underway in the Hanford Strategic Analysis Study Plan and the Program and Facility Options - Hanford, The Next Seven Years. We have initiated discussions to assure proper coordination.

Please note that our current budget planning to Case 5 does not provide adequate funding for these studies. An additional $3.1M is estimated to cover these studies in FY 1991.

Should you have any questions regarding this effort, please direct them to Mr. G. A. Meyer, Vitrification Program Manager, on 373-1810.

Very truly yours,

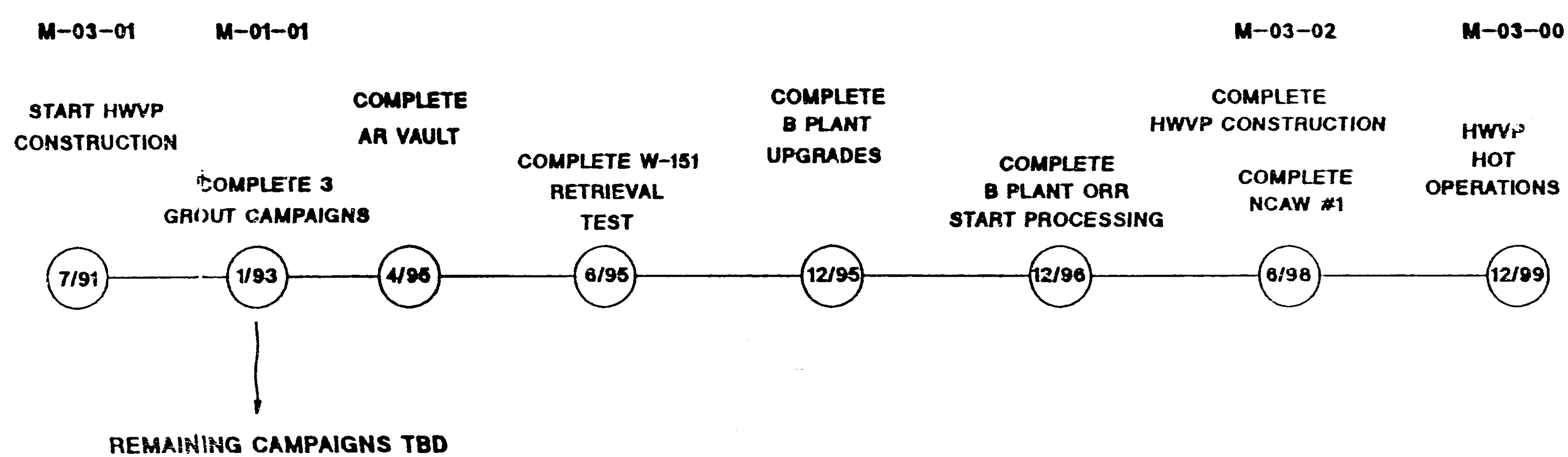
C. M. Cox, Manager
Waste Vitrification Division

djl

Attachment

DOE-RL - R. O. Puthoff (w/o attachment)

DST WASTE DISPOSAL BASELINE SCHEDULE
MAJOR MILESTONE SUMMARY



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Westinghouse
Hanford Company

P.O. Box 1970 Richland, WA 99352

February 15, 1991

RECEIVED
M. A. CAHILL
FEB 21 '91
File
Hold
Return To
Circulate To

9151291

Mr. J. P. Hamric, Deputy Manager
for Operations
U.S. Department of Energy
Richland Operations Office
Richland, Washington 99352

Dear Mr. Hamric:

DOUBLE SHELL TANK WASTE DISPOSAL PROGRAM

Reference: Recommendations for Incremental Fiscal Year 1991 Reprogramming Funds, informally transmitted February 13, 1991, to the U.S. Department of Energy-Richland Operations Office Budget Division.

During the past few weeks, our respective Defense Waste Remediation (DWR) program staffs have been working closely together to identify issues and concerns with regard to Double Shell Tank (DST) waste pretreatment processing and facilities, and to structure an integrated issues and risk resolution program. This integrated resolution program is contained within this letter and its attachments. Westinghouse Hanford Company (WHC) strongly recommends that the actions presented be implemented immediately so that issue resolution can be achieved in a timely manner and a revised DST disposal plan can be adopted. WHC further recommends that $1,825K of reprogramming funds be made available immediately for performing these studies. This funding was included within our overall WHC reprogramming request submitted to you by the above reference.

BACKGROUND

The Record of Decision (ROD) for the Environmental Impact Statement for Disposal of Hanford High-Level, Transuranic, and Tank Waste (HDW-EIS) documented the Department of Energy's (DOE) decision to proceed with disposal of DST waste. This waste was designated to be separated into a low-level fraction for disposal as grout in near surface concrete vaults, and a high-level fraction for vitrification in the Hanford Waste Vitrification Plant (HWVP) with subsequent disposal in a geologic repository. Separation of DST waste into low- and high-level fractions (i.e., pretreatment) was designated to take place in an existing facility, "... currently planned to be the Hanford B Plant."

Because of concerns with the age of B Plant and its ability to comply with environmental regulations, codes, and standards, several studies have been conducted (1983, 1988, 1990) to evaluate alternatives for pretreating double-shell tank waste. These studies consistently selected B Plant as the preferred option, over other existing facilities or a new pretreatment

Mr. J. P. Hamric
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facility, primarily due to cost and schedule considerations. Thus, the baseline DST disposal program has up to this time planned to use B Plant for pretreatment processes.

DISCUSSION

The use of B Plant as a pretreatment facility for DST waste continues to be questioned as reported in the preliminary findings of the Hanford Waste Vitrification Systems Risk Assessment. These questions center around the age of the facility and its ability to meet current (1990's) environmental regulations and design criteria. In addition, recent (December 1990) information derived from the pretreatment technology development program indicates a potential B Plant pipe materials compatibility problem (i.e., excessive corrosion rates) with the TRUEX process planned to be employed for pretreatment of Neutralized Cladding Removal Waste (NCRW). Because of the continuing concerns with the viability of B Plant and the recent identification of the pipe corrosion problem, an integrated risk resolution plan has been developed. This plan, which is presented in a summary schedule in Attachment 1, will address the following:

1. B Plant Risk Assessment
    a. Secondary Containment Equivalency
    b. Seismic Design Criteria Compliance
    c. Closed Loop Cooling Regulatory Compliance
    d. AR Vault Secondary Containment Equivalency

2. B Plant Processing Options
    a. Corrosion Chemistry Study
    b. Pipe Replacement/Repair Feasibility
    c. Alternative Pretreatment Processing Options
    (Note: This information would also be used in the alternative facilities options identified below.)

3. Alternative Facility Options
    a. HWVP Pretreatment
    b. PUREX Pretreatment

4. New Pretreatment Facility Scoping Studies
    a. DST and SST Combination
    b. DST Only

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A detailed scope of work and schedule for each task identified has been prepared and informally provided to your staff for their use. A summary level schedule identifying interim milestones and deliverables is presented in Attachment 2. In addition, the decision logic diagram which was developed as an aid in identifying the decisions which must be made in developing a new DST pretreatment strategy is also included as Attachment 3. It is our intention to provide a final pretreatment recommendation to the U.S. Department of Energy-Richland Operations Office by the end of the fiscal year (FY).

The incremental FY 1991 funding ($1,825K for Priority 1 and 2 items) required for performing this plan is presented in Attachment 4. Current funding for the DWR program does not include funds for this effort. These funds are included in our reprogramming request contained in the referenced transmittal. It should be noted that as part of the integrated risk resolution plan additional funding needs were also identified for performing engineering studies and functional design criteria preparation for a new pretreatment facility and/or B Plant upgrades. These are identified as a lower priority and can be deferred until final reprogramming approval and until some of the decisions with regard to TRUEX processing, B Plant, PUREX, and HWVP are made.

Severe FY 1991 funding reductions and resulting programmatic impacts have already been experienced by the DWR program. The Environmental Restoration and Waste Management Case 5 budget contained $121.3M for DWR programs. That has now been reduced to $97.5M based on current guidance. The problem is further exacerbated by the fact that the DWR program expenditure rate for the first four months of the fiscal year was at the Case 5 level. This problem will be further aggravated if supplemental funding is not provided for this issue/risk resolution plan.

With regard to the issue of pipe corrosion associated with the TRUEX process, WHC is assembling a team of technical experts to assist in this evaluation. On the chemistry side, Drs. W. W. Schulz (retired WHC scientist) and P. Horowitz (Argonne) will be brought on board. Both of these individuals have been associated with TRUEX development from inception. In addition, WHC is making arrangements to acquire the services of WINCO personnel familiar with corrosion in fluoride processes.

Mr. J. P. Hamric
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WHC appreciates greatly the close working relationship that was demonstrated by our respective staffs in developing this proposal. Our staff continues to be immediately available to further discuss or develop this proposal, if necessary. Since time is critical, please provide us your direction by February 22, 1991.

Very truly yours,

R. J. Bliss
Vice President
Restoration and Remediation

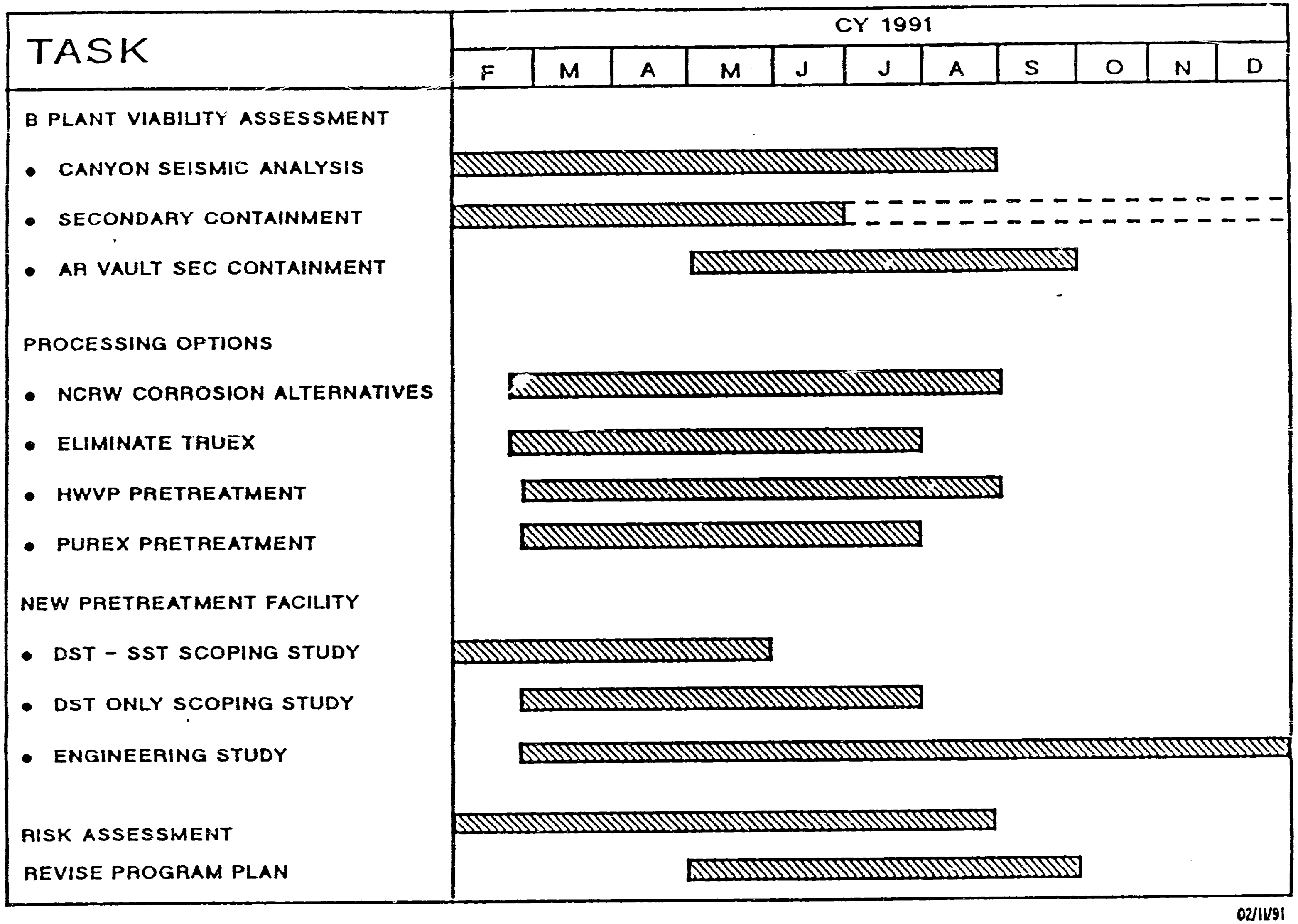
llm

Attachments (4)

DOE-RL K. W. Bracken
J. R. Hunter
R. O. Puthoff (w/o attachments)

Attachment 1
9151291

DEFENSE WASTE REMEDIATION PROGRAM RE-DEFINITION



Attachment 2
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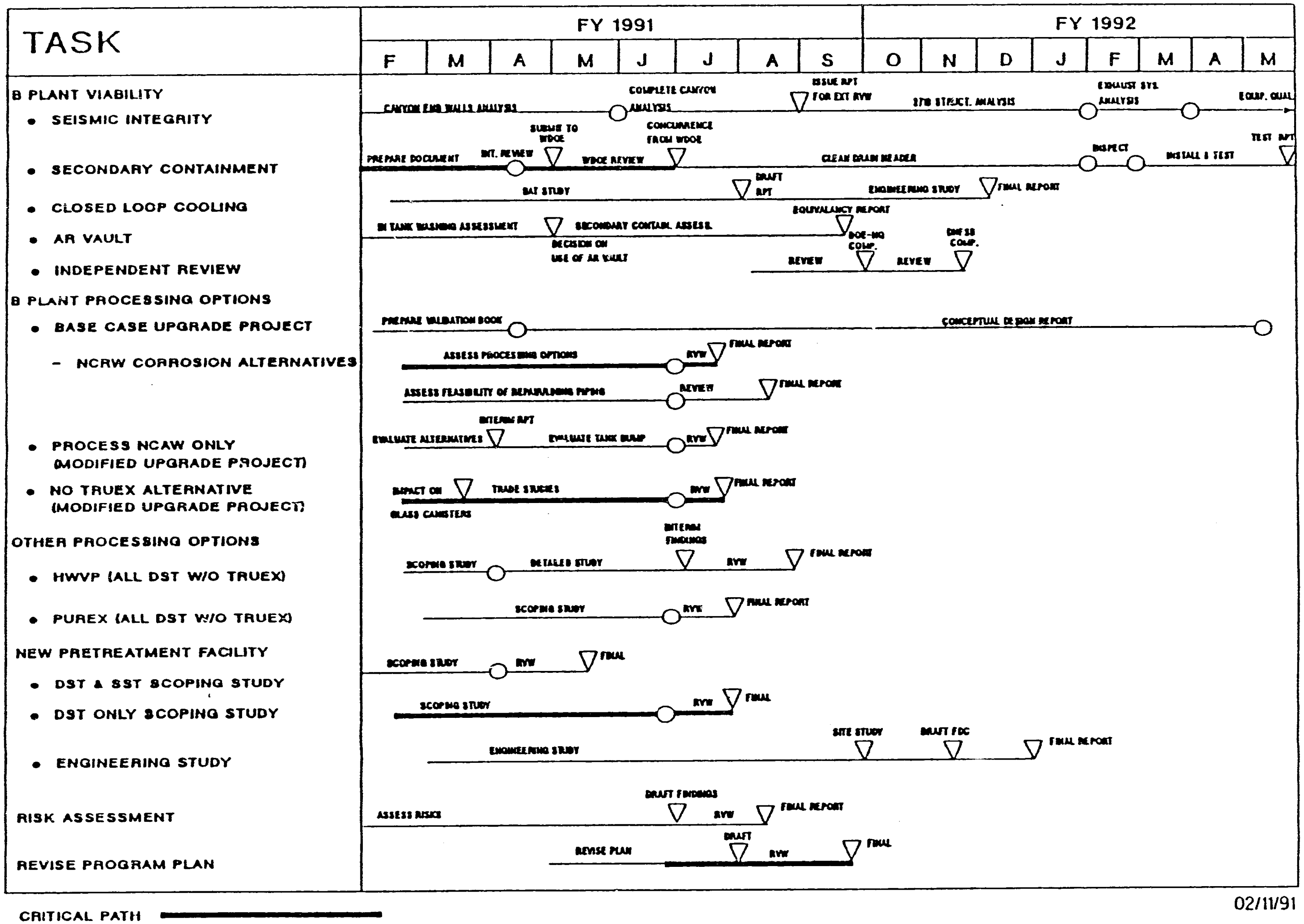
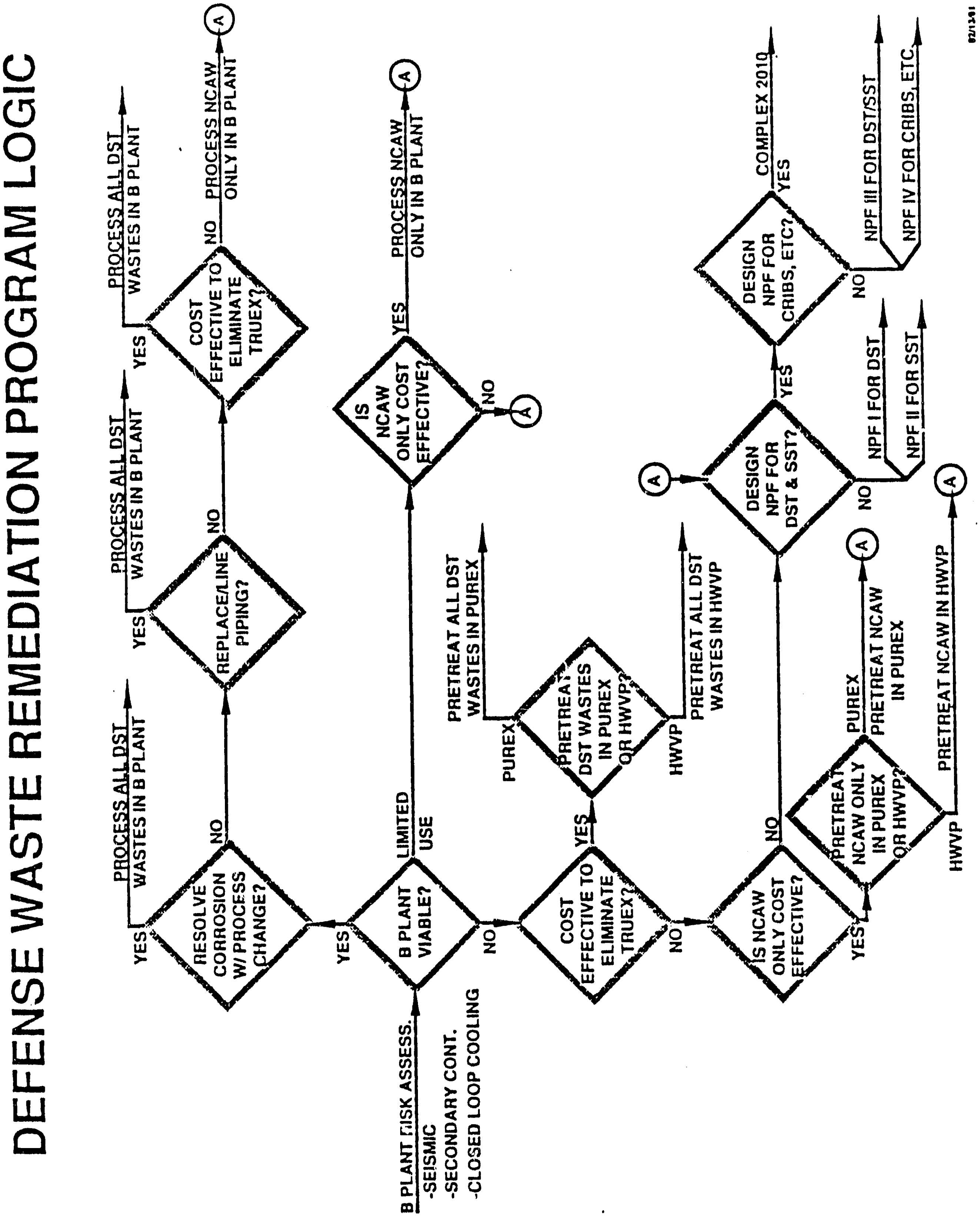
DEFENSE WASTE REMEDIATION PROGRAM RE-DEFINITION



02/11/91

Attachment 3
9151291



Attachment 4.
Page 1 of 2
9151291

Defense Waste Remediation Program Risk Resolution Incremental Funding Summary

	Incremental FY 1991 ($K)	Priority*
B PLANT RISK		
• Seismic analysis	800	1
• Secondary containment equivalency	225	1
• Closed loop cooling	50	1
• AR Vault secondary containment equivalency	200	2
B PLANT PROCESSING OPTIONS		
• Accelerate major upgrade project	500	3
• Post NCAW corrosion assessments	250	1
• Pipe repair feasibility study	75	1

* "1" is highest priority

Attachment 4
Page 2 of 2
9141291

Defense Waste Remediation Program Risk Resolution Incremental Funding Summary (contd)

	Incremental FY 1991 ($K)	Priority*
OTHER PROCESSING OPTIONS		
• Process alternatives study	75	1
• HWVP pretreatment option	545**	1
• PUREX pretreatment option	150	1
NEW PRETREATMENT FACILITY		
• DST and SST scoping study	Funded	1
• DST only scoping study	200	1
• NPF engineering study/FDC initiation	1,500	3
TOTAL REQUIRED	$1,825 for Priority 1 & 2	

* "1" is highest priority
** Funded by HWVP; not included in Total Required

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RECEIVED
M. A. CAHILL
MAR 29 '91

Department of Energy
Richland Operations Office
P.O. Box 550
Richland, Washington 99352

9101524B

MAR 21 1991

MAR 27 1991

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91-WOB-071

Mr. T. M. Anderson, President
Westinghouse Hanford Company
Richland, Washington

Dear Mr. Anderson:

DEFENSE WASTE REMEDIATION RISK RESOLUTION STUDIES

Please proceed to initiate the studies described in the February 15, 1991, WHC letter (#9151291) from R. J. Bliss to J. P. Hamric (subject: DOUBLE SHELL TANK WASTE DISPOSAL PROGRAM) and in the supplemental February 11, 1991, briefing entitled "Defense Waste Remediation - Double Shell Tank (DST) Waste Program Redefinition". You should assume that funding will be available no later than June 1, 1991, from reprogramming actions currently underway. However by April 5, 1991, you should provide an impact analysis detailing scope reductions (Level IV Plans) that will be required assuming that reprogramming actions are delayed or are not approved.

As general guidance for these studies, the B Plant Closed Loop Cooling Study and all Priority 2 and 3 studies should be deferred. In addition, life-cycle costs should be developed as bases for recommendations, and uncertainties in results should include associated confidence ranges, where appropriate. Furthermore, since the above-mentioned letter and presentation contain only summary descriptions of work scope, we are requesting additional detail on the deliverables. Clarification is needed on what comprises an "analysis of potential alternatives", an "assessment", a "white paper", a "feasibility study", etc. Please provide this information by March 29, 1991.

Detailed planning of the required studies should provide for early resolution to the issue of whether or not pretreatment of Double-Shell Tank (DST) Waste should include TRUEX (and if this option is attractive only if the availability of a new TRUEX facility for Single-Shell Tank (SST) Waste is assumed.) The outcome of this study will likely depend on the programmatic viability of disposing of certain DST waste canisters in the Waste Isolation Pilot Plant (WIPP) as a relatively inexpensive alternative to disposal in a commercial geologic repository. Therefore, by April 12, 1991, WHC is requested to develop brief technical descriptions of the reference DST wastes, the approximate number and contents of canisters from these wastes (considering the latest characterization data and glass composition limits), and proposed designation of canisters for WIPP disposal. We intend to utilize this information in soliciting guidance from DOE-HQ on the location and costs to be assumed for disposal of waste canisters in the evaluation of the need for a TRUEX facility for DST wastes.

Mr. T. M. Anderson -2- MAR 2 1 1991

In performing these pivotal, decision-making studies, you should plan and execute them with an attitude of "doing it right the first time". Please help us to avoid a rush to judgement which is not founded on solid technical bases. We endorse the "Total Quality" approach we have collectively used in the last couple of weeks, and we believe it is shows promise of great payback.

Questions regarding this latter should be addressed to Mr. K. W. Bracken of my staff at 376-6621.

Sincerely,

J. P. Hamric, Deputy Manager
for Operations

WMD:JCP

cc: G. A. Meyer, WHC
C. M. Cox, Jr., WHC

Westinghouse
Hanford Company

P O Box 1970 Richland, WA 99352

March 29, 1991

9101524B R1

Mr. J. P. Hamric, Deputy Manager
Operations
U.S. Department of Energy
Richland Operations Office
Richland, Washington 99352

Dear Mr. Hamric:

DEFENSE WASTE REMEDIATION RISK RESOLUTION STUDIES

Reference: Letter, J. P. Hamric, DOE-RL, to T. M. Anderson, WHC, same subject, WMD:JCP, dated March 21, 1991.

The referenced letter requested Westinghouse Hanford Company (WHC) to clarify a variety of terms used to describe the deliverables associated with the risk resolution studies.

We have met with members of your staff and discussed in detail the studies and the deliverables. Please refer to the attached Double-Shell Tank Waste Disposal Program Redefinition Studies Scope of Work statement which provides a description of the studies and deliverables.

We have attempted to format the studies in accordance with approved WHC procedures and believe that this response meets your request to provide clarification information by March 29, 1991.

Should you have any questions regarding this matter, please contact either Mr. M. A. Cahill (3-5370) or Mr. G. A. Meyer (3-1810) of my staff.

Very truly yours,

C. M. Cox

C. M. Cox, Manager
Defense Waste Remediation Division

fl

Attachment

DOE-RL - K. W. Bracken
J. C. Peschong
R. G. Puthoff (w/o attachment)

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Attachment A
Page 1 of 11

DOUBLE-SHELL TANK WASTE DISPOSAL PROGRAM REDEFINITION STUDIES SCOPE OF WORK

Background

The Record of Decision for the Environmental Impact Statement for Disposal of Hanford High-Level, Transuranic, and Tank Waste documented the Department of Energy's decision to proceed with disposal of double-shell tank (DST) waste. This waste was designated to be separated into a low-level fraction for disposal as grout in near surface concrete vaults, and a high level fraction for vitrification in the Hanford Waste Vitrification Plant (HWVP) and subsequent disposal in a geologic repository. Waste pretreatment (separation into low- and high-level fractions) was designated to take place in an existing facility, "...currently planned to be the Hanford B Plant".

Due to concerns with the age of B Plant and its ability to comply with environmental regulations, codes and standards, several studies have been conducted (1983, 1988, 1990) to evaluate alternatives for pretreating double-shell tank waste. These studies have consistently selected B Plant as the preferred option over other existing facilities or a new pretreatment facility, primarily due to cost and schedule considerations. Thus, the baseline DST disposal program has, up to this time, planned to use B Plant for pretreatment processes.

The use of B Plant as a pretreatment facility for DST waste continues to be questioned, as reported in the preliminary findings of the Hanford Waste Vitrification Systems Risk Assessment. These questions center around the age of the facility and its ability to meet current environmental regulations and design criteria. In addition, recent information derived from the pretreatment technology development program indicates a potential B Plant pipe materials compatibility problem (excessive corrosion rates) with the TRUEX process planned for pretreatment of Neutralized Cladding Removal Waste (NCRW).

Due to the continuing concerns with B Plant viability and the recently identified pipe corrosion problem, an integrated risk resolution plan has been developed. This plan involves conducting several studies that will evaluate B Plant viability issues and pretreatment processing/facility options. A decision logic diagram (Attachment 1) was developed as an aid in identifying the decisions required for developing a new DST pretreatment strategy. The outcome of the studies will provide resolution on B Plant pretreatment processing viability, and will provide a basis for the resulting redefinition of the Double-Shell Tank Waste Disposal (DSTWD) program. In addition to these studies, a study evaluating the benefits of additional removal of radionuclides and chemical constituents from grout feed wastes will be conducted.

DST WASTE DISPOSAL PROGRAM REDEFINITION STUDIES
SCOPE OF WORK
(Continued)

Scope of Work

The DSTWD program redefinition studies will be managed by the Waste Pretreatment Engineering and Projects (WPEP) organization within the DWR Division. The organization chart (Attachment 2) provides the management structure for these studies. The studies to be conducted are summarized as follows:

B Plant Viability Assessment

- Seismic Design Criteria Compliance
- Secondary Containment Equivalency
- TRUEX Feasibility

Processing/Facility Options

- TRUEX versus No-TRUEX
- B Plant/AR Vault, Baseline
- B Plant/DST
- PUREX/DST
- New Pretreatment Facility
- HWVP/DST

Grout Study

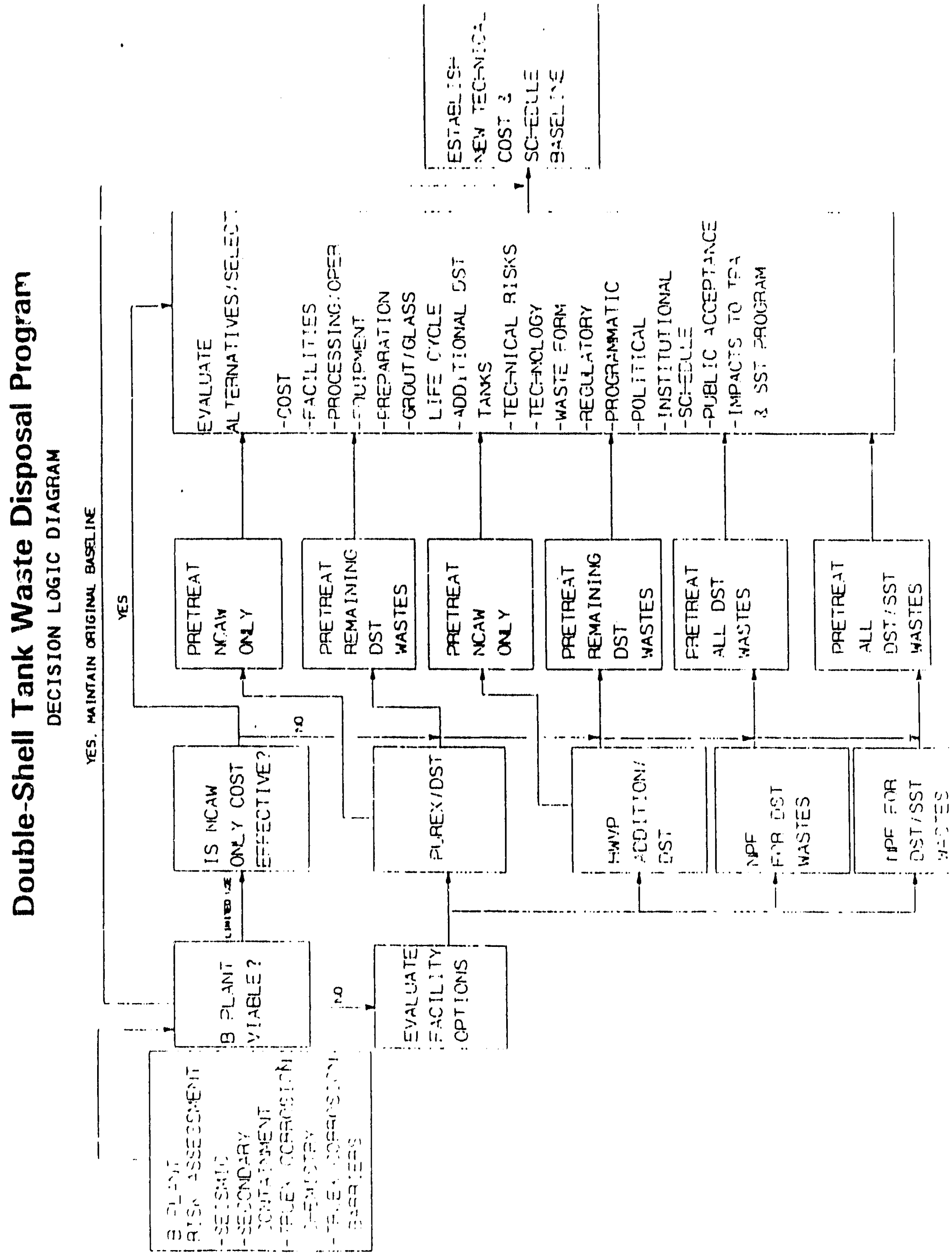
- Grout Feed Contaminant Removal

Detailed scope statements for these studies are provided in Attachment 3.

Approach

The Hanford Waste Vitrification Systems Risk Assessment will identify and evaluate uncertainties, quantify potential consequences from these uncertainties, and identify the risks to successful completion of the Hanford vitrification mission. DOE-RL approval of the final report is expected in August 1991. Results from the program redefinition studies will be used to update the risks and mitigating strategies contained in the risk assessment.

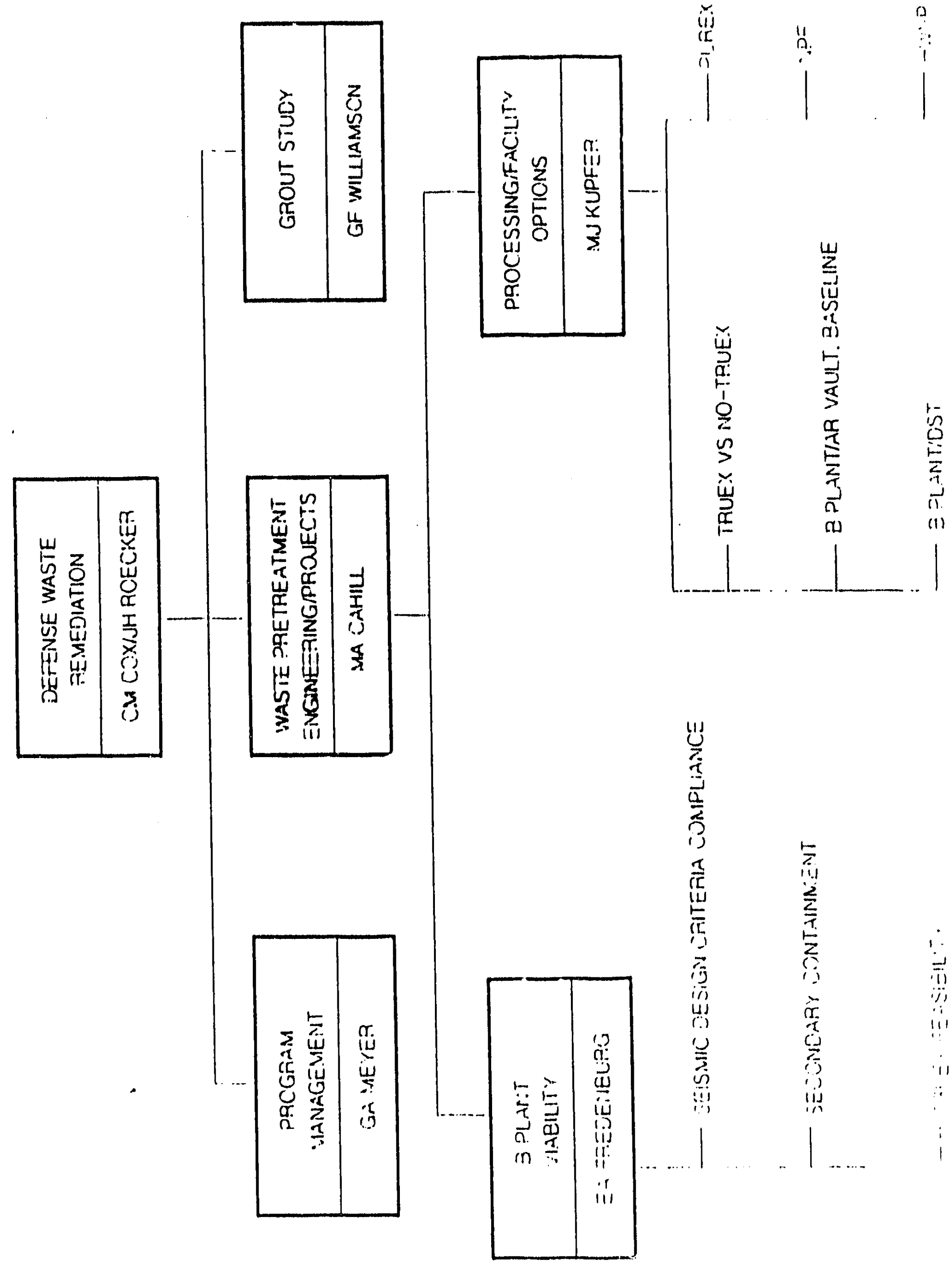
ATTACHMENT 1



9101524B R1
ATTACHMENT A
Page 4 of 11

ATTACHMENT 2

DEFENSE WASTE REMEDIATION REDEFINITION STUDIES



ATTACHMENT 3

SEISMIC DESIGN CRITERIA COMPLIANCE

Planned July 1991 deliverables resulting from the B Plant seismic viability assessment will consist of letter reports with seismic analyses attached. These reports will summarize the analytical approach, models, assumptions, data, calculation results, and conclusions, with qualitative description of confidence level, in five principal areas that address all major suspect structural elements in B Plant, as follows:

1. Canyon End Wall Study. This study will develop a structural model of the unreinforced concrete end wall and a portion of the interconnecting side walls of the B Plant canyon. The structural adequacy of the end walls, shear keys that laterally support the end walls, and other structural elements will be evaluated.

2. Canyon Confinement Boundary Study. This study will involve a field inspection and engineering drawing study to identify canyon boundary elements whose structural failure during an earthquake could potentially compromise the confinement boundary integrity. This will include such items as the railroad door, and other access doors to the canyon. Items identified will be structurally analyzed for expected seismic forces and building displacements.

3. Construction Joint Displacement Study. This study will evaluate effects of construction joint rotation, displacement, and deformation to quantify the degree of separation or opening, if any, expected at locations in the canyon boundary where yielding of reinforcing bar is expected from a postulated design basis earthquake of 0.2 g horizontal acceleration. The study will include evaluation of representative published data addressing structural failures from earthquakes.

4. Building Interface Study. This study will consist of an investigation of interface conditions between the 221-B canyon structure and adjacent structures, and a dynamic analysis to assess the effects of any resulting structural interaction on the 221-B canyon structure.

5. Canyon Exhaust Ductwork and Filter Preliminary Study. This study will be a preliminary assessment of the underground tunnel and filter structures between the canyon building and the main exhaust stack to identify potential problem areas requiring further detailed analysis. A realistic schedule and budget will be developed for additional analyses required. The scope of this preliminary assessment includes the underground HVAC ducting, retired filters A, B, C, and D, the sand filter, and active filters E and F.

9101524B R1
ATTACHMENT A
Page 6 of 11

ATTACHMENT 3

SECONDARY CONTAINMENT

B Plant has been selected for pretreatment of double-shell tank wastes and, as such, must comply with Washington Administrative Code (WAC) 173-303 for Dangerous Waste Systems. To demonstrate compliance with WAC 173-303, the following studies will be conducted:

- Secondary Containment System Description

  Washington Administrative Code 173-303-640 requires that tank systems used for managing dangerous waste be provided with secondary containment which must include one or more of the following: a liner, a vault, a double walled tank, or an equivalent device as approved by the Washington State Department of Ecology (WDOE). Westinghouse Hanford Company (WHC) is requesting the U.S. Department of Energy (DOE) and WDOE to accept the B Plant secondary containment system as compliant with the requirements from WAC 173-303-640. WHC is preparing a document, B Plant Secondary Containment System Description and Analysis Document, to submit to DOE and WDOE that describes the secondary containment system design.

  This document will provide a description of the B Plant secondary containment system and compare it to the requirements from WAC 173-303-640. Based on the system design and this analysis, WHC will request DOE and WDOE to concur that the system complies with WAC 173-303-640. This document will be submitted to DOE-RL for review and comment by May 17, 1991.

- Cell Drain Header Structural Analysis

  The cell drain header (CDH) is an integral part of the B Plant tank system. As such, it must meet the structural requirements from Washington Administrative Code 173-303-640(4)(b) and DOE Order 6430.1A. This structural analysis will be performed to determine if the CDH will continue to perform its designed function. This structural analysis will be approved by WHC and submitted to DOE-RL by July 31, 1991.

- Cell Drain Header Cleaning/Inspection

  Integrity of the CDH will be assessed via remote inspections scheduled to begin in fiscal year 1991. This will include an initial water jet cleaning followed by remote video inspection, and, assuming favorable video results, an integrity examination. These activities will be completed in fiscal year 1992.

ATTACHMENT 3

TRANSURANIC EXTRACTION (TRUEX) FEASIBILITY

1. Corrosion Chemistry

The corrosion chemistry evaluation deals with the identification of possible solutions to the expected corrosion of B Plant embedded piping (304L stainless steel) by neutralized cladding removal waste (NCRW) pretreatment process solutions. The study consists of three steps. The first step is the identification of possible process conditions which will minimize precipitation and would minimize corrosion. Precipitation of solids would foul pretreatment equipment. This step will involve convening a group of process and corrosion specialists from Hanford, Savannah River Site, Argonne National Lab, Idaho National Engineering Lab, and independent consultants to brainstorm possible favorable process conditions. The possible conditions will be ranked by likelihood of success. The second step is to conduct preliminary lab tests on these process conditions to determine if precipitation can in fact be avoided. The third step is to prepare a supporting-document report which discusses the findings of the testing. This report will be completed by June 30, 1991. If satisfactory results are achieved from these preliminary tests, it is expected that extensive additional follow-up tests will be necessary to verify proper operations of the process over the wide range of waste compositions found in the double-shell tanks and to verify that the process conditions do in fact reduce the potential corrosion problem. These follow-on tests are not included in the scope of the work proposed to support the short-term goal of determining if the NCRW pretreatment process is viable in B Plant.

2. Corrosion Barriers

Perform a study which will establish the feasibility of performing TRUEX processes in B Plant in light of recent process development studies which show excessively high corrosion rates for 304L stainless steels. The study would assume existing B Plant embedded piping (304L stainless steel), which must be used for the TRUEX process, is not acceptable and must be replaced. The study would include the following:

a. Establish the feasibility of removing unsuitable piping and replacing it with suitable piping. Necessary considerations would include:

- Ventilation/contamination control schemes.
- Can the work area be decontaminated to a level required so that hands-on work can take place?
- Can the job be accomplished remotely?

3-

ATTACHMENT 3

TRUEX FEASIBILITY

2. Corrosion Barriers (Continued)

a.

- Can embedded piping be replaced with slip-through piping or must all existing piping be replaced with new corrosion resistant piping?

- Is the plant geometry suitable for installing new corrosion resistant piping?

b. Establish from the above an upper and lower bound of the cost for performing these activities taking into account existing contamination within B Plant.

c. Produce a report documenting the above by July 30, 1991.

Follow-on engineering activities are expected to develop an accurate cost estimate and schedule for implementation of recommended options. These follow-on engineering activities are not included in the scope of the work proposed to support the short-term goal of determining if the TRUEX process is feasible in B Plant.

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ATTACHMENT A
Page 9 of 11

ATTACHMENT 3

DOUBLE-SHELL TANK WASTE PROCESSING AND FACILITY ALTERNATIVES

The study will reassess process and facility alternatives to the present baseline for pretreatment of double-shell tank (DST) wastes. The present baseline process and facility scheme for DST waste pretreatment includes water washing and filtration of neutralized current acid waste (NCAW) sludge solids in AR Vault and B Plant, and acidification of neutralized cladding removal waste (NCRW), Plutonium Finishing Plant (PFP), and complex concentrate (CC) wastes followed by transuranic (TRU) removal (using the transuranic extraction process) in B Plant. In addition, CC waste will be treated to remove ^{137}Cs and to destroy organic complexants.

The key process alternatives to be addressed include solid-liquid separations and water washing of solids versus acidification of waste and fractionization of TRU-components using the transuranic extraction (TRUEX) process. The potential advantages of reducing schedule gaps and avoiding expensive facility upgrade costs by foregoing the TRUEX process will be weighed against the economic disadvantages of increasing the mass of waste feed to Hanford Waste Vitrification Plant (HWVP). As a basis for this evaluation, the latest available waste characterization, waste volume projections, and laboratory TRUEX process development information will be utilized for evaluation of the process alternatives and the HWVP canister projections that result from these processes.

The pretreatment facility options will include the present baseline facilities (B Plant and AR Vault), DSTs, the Plutonium-Uranium Reduction Extraction (PUREX) facility, HWVP, and a new processing facility. The following are descriptions of the process/facility options that will be compared to the present baseline.

B Plant/DST

This analysis will examine the use of solids washing as the primary waste treatment method for NCAW and post NCAW. The TRUEX process is not used for pretreatment of DST waste. In this option NCAW solids washing and removal of cesium using ion exchange technology are performed in the B Plant. The NCRW and PFP sludges are washed in DSTs. Complexants in CC waste are destroyed to precipitate the actinide (TRU) components. Two options are considered for performing the complexant destruction process: (a) In-Tank destruction processes with cesium removal in B Plant, and (b) a New Processing Facility that performs complexant destruction and cesium removal using ion exchange.

PUREX Facility

This analysis will examine the placement of processing capability in the PUREX plant to support pretreatment of NCAW and post NCAW. The scope of the processes to be used include solids washing of DST wastes; ion exchange removal of cesium from NCAW and CC wastes; and destruction of complexants in the CC waste. In another PUREX option, use of the TRUEX process for removing actinides from post NCAW will also be examined.

ATTACHMENT 3

DOUBLE-SHELL TANK WASTE PROCESSING AND FACILITY ALTERNATIVES

New Facility

This alternative uses a New Processing Facility to support pretreatment of both NCAW and post NCAW. Such pretreatment for NCAW involves application of the TRUEX process to remove actinides, application of SREXprocess to remove ^{90}Sr and ion exchange removal of cesium. These additional pretreatment processes for NCAW are intended to reduce radionuclides present in the low-level waste fraction of NCAW (i.e., grout feed) and minimize the mass of feed to HWVP. Pretreatment of post NCAW (PFP, CC, and NCRW) includes application of the TRUEX process to remove actinides. Pretreatment of the CC waste also involves removal of cesium and destruction of complexants.

DST/New Facility

In this case NCAW is washed in a DST and the supernate is st red for future solids filtration and cesium removal in a New Processing Facility that does not utilize the TRUEX process. This facility will have capabilities for sludge washing, destruction of complexants in CC, and cesium ion exchange from CC. The NCRW and PFP wastes are washed in the new facility or DSTs. Complexants in CC waste are destroyed to precipitate the actinide components, and ion exchange methods are used to remove cesium.

HWVP/DST

This analysis will examine solids washing for both NCAW and post NCAW. In this option the HWVP facility will be used for solids washing of NCAW and cesium removal from NCAW supernate liquid using ion exchange. The NCRW and PFP wastes are washed in DSTs. Complexants in the CC waste are destroyed to precipitate the actinides. Complexant destruction options considered are: (a) In-Tank processes and (b) a New Processing Facility that performs only complexant destruction operations. Cesium is removed from CC waste using ion exchange in the HWVP. This option will be performed using Fluor Daniel, Inc. A detailed study, including facility layouts, will be provided. Results will be integrated into the overall systems study by WHC.

A screening process will be utilized for identifying the most promising processing and facility alternatives. The alternatives will be assessed against key evaluation criteria including technical feasibility, regulatory compliance, schedule compatibility, and costs. The most promising options will be examined in more detail to define simplified flow diagrams, projected material balances, and mission treatment and disposal costs. Important elements in this assessment include a qualitative evaluation of tank space requirements, consideration of Waste Isolation Pilot Plant versus deep geologic repository disposal for PFP and NCRW waste forms, and the capability and impacts of processing SST wastes.

The deliverable for this study is a report to be completed August 31, 1991. A preliminary description of the approximate number of canisters of glass for the TRUEX and non-TRUEX approach will be provided by April 15, 1991.

ATTACHMENT 3

GROUT FEED CONTAMINANT REMOVAL

The performance assessment of grout as a material for near-surface disposal of low-level waste is strongly influenced by the presence in the wastes of ^{99}Tc, ^{129}I, NO_2, NO_3. In addition, the State of Washington and Oregon Department of Ecology have petitioned the Nuclear Regulatory Commission about the allowable quantities of ^{137}Cs and ^{90}Sr in wastes to be grouted. This study will evaluate benefits, issues, and impacts associated with additional removal of selected radionuclides and chemical constituents feed wastes from the grout. Separations technology for removal of the components of concern will be evaluated. In addition to evaluating pretreatment methods for removing waste stream components, alternate low-level waste disposal forms which would fix certain elements to non-leachable forms will also be evaluated.

A preliminary assessment of alternatives will be based on perceived need, efficiency, probability of success, cost, and fit into the overall site retrieval and disposal program and the Hanford Federal Facility Agreement and Consent Order (Tri-Party Agreement).

The approach for this study will be as follows:

- Identify and document goals
- Determine separation/removal requirements
  - Establish source term reduction needs through removal of ^{137}Cs and ^{90}Sr
  - Use Performance Assessment process and models to determine removal needs for long-lived radionuclides and hazardous waste constituents such as NO_2 and NO_3.
- Investigate available and advanced separation technologies and alternate waste forms required to meet the goals:
  - Technical merit
  - Cost/schedule impacts
  - Impact to HWVP and pretreatment facilities
  - Impact to tank space availability

The deliverable for this study is a report to be completed July 19, 1991, that will provide information to allow a decision on whether to proceed with an engineering study to investigate additional removal of radionuclides and hazardous material from grout feeds.

Westinghouse
Hanford Company

P.O. Box 1970 Richland, WA 99352

9101524B R5

April 19, 1991

Mr. J. P. Hamric, Deputy Manager
for Operations
U.S. Department of Energy
Richland Operations Office
Richland, Washington 99352

Dear Mr. Hamric:

DEFENSE WASTE REMEDIATION RISK RESOLUTION STUDIES

Reference: Letter, J. P. Hamric, DOE-RL, to T. M. Anderson, WHC, same subject, WMD:JCP, dated March 21, 1991.

The reference letter requested Westinghouse Hanford Company (WHC) to provide the approximate number and contents of canisters from Double-Shell Tank Wastes and proposed designation of canisters for Waste Isolation Pilot Plant disposal. This information is provided in the attachment.

Questions regarding this matter, should be addressed to G. A. Meyer of my staff on 373-1810.

Very truly yours,

D. J. Newland, Manager
Defense Waste Remediation Division

mjs

Attachment

DOE-RL K. W. Bracken
R. W. Brown
J. C. Peschong
R. O. Puthoff (w/o attachment)

9101524B R5

REVISED CANISTER PROJECTIONS

REFERENCE

Integrated Data Base for 1990: U.S. Spent Fuel and Radioactive Waste Inventories, Projections, and Characteristics, DOE/RW-0006, Revision 6, prepared for the U.S. Department of Energy Office of Civilian Radioactive Waste Management by Oak Ridge National Laboratory, Oak Ridge, Tennessee, October 1990.

BACKGROUND

Earlier canister estimates were provided in the reference Integrated Data Base (IDB). As a basis for the IDB canister estimates, the present baseline processing assumptions were used for the four double-shell tank (DST) waste types:

- Neutralized current acid waste (NCAW) sludge is washed with water to remove soluble salts and ^{137}Cs is removed from NCAW supernate using ion exchange. The washed sludge and ^{137}Cs fraction provide feed to the vitrification facility.

- Neutralized cladding removal waste (NCRW) sludge, Plutonium Finishing Plant (PFP) sludge, and Complexant Concentrate (CC) wastes are acidified and the transuranic (TRU) elements are removed from the acid solution using the transuranic extraction (TRUEX) process. In addition, ^{137}Cs is removed from CC waste using ion exchange. Undissolved sludges, the TRU fraction from TRUEX, and the cesium fraction constitutes feed to vitrification.

REVISED CANISTER ESTIMATE RESULTS

Table 1 summarizes revised canister production estimates for both the baseline TRUEX pretreatment approach and a "sludge washing" approach, described below. These canister estimates make use of additional recent waste characterization information and results from laboratory-scale pretreatment testing at Pacific Northwest Laboratory (PNL). The revised canister estimates provided herein also reflect the above baseline pretreatment processes. In addition, projections are provided for an all sludge washing approach (i.e., no TRUEX process). In this latter approach, NCRW and PFP sludge are washed with water to remove soluble salts. The CCwaste is treated to destroy the organic complexants which precipitates the complexed iron and scavenges the TRU elements. The precipitated sludge and other CC solids are washed with water. The ^{137}Cs is also removed from CC supernatant using ion exchange.

TABLE 1
CANISTERS OF GLASS (ESTIMATED)

	PROCESS OPTIONS	
DST WASTE	SLUDGE WASHING	TRUEX
NCAW	580 - 1030[a]	[b]
NCRW	3000-4500[c]	150-230[d]
PFP	980-4600[e]	440[f]
CC	1600-5200[g]	470[h]

[a] Lower value = no future PUREX; no 102-AY heel; 12 percent solids. Upper value = future PUREX (via Zirflex); 102-AY heel; 20 percent solids.
[b] TRUEX process option not in present baseline for NCAW.
[c] Lower number assumes no additional processing in PUREX. Waste loading in glass is limited to 16 wt% due to zirconium limit.
[d] See footnote C; 95 percent solids dissolution assumed.
[e] 980 canisters based on 25 wt% loading in glass. May be 4600 canisters if limited by chromium content (approximately five times HWVP feed specification).
[f] Approximately 80 percent solids dissolution assumed. Waste loading is limited by chromium content.
[g] 1600 canisters based on 25 wt% loading on glass. May be 5200 canisters if limited by chromium content (approximately three times HWVP feed specification).
[h] Approximately 70 percent solids dissolution assumed.

BASIS FOR PFP, CC, AND NCRW GLASS CANISTER PROJECTIONS

Information from recent core samples of PFP waste (Tank 102-SY) and NCRW wastes (Tanks 103-AW and 105-AW) has been included in these estimates. The recent TRUEX process development tests and sludge washing experiments at PNL provided information for preparation of preliminary conceptual flowsheets for NCRW and PFP waste and, thus, enable better estimates of pretreated waste compositions and volumes. In addition, a detailed evaluation of laboratory data for CC samples from Tanks 101-SY and 103-SY was performed to estimate the canister contributions from these tanks. Atpresent, insufficient characterization of CC waste is available for providing accurate canister estimates.

BASIS FOR NCAW GLASS CANISTER PROJECTIONS

Previous projections for glass to be generated from sludge-washed NCAW has been estimated at 480 canisters. This estimate was made before tank core sample analytical data was available and assumed that post-1986 PUREX operation would be optimized to reduce the addition of inert chemicals into the second and subsequent tanks to a value of about 30 kg waste oxides per

MTU, or less. Today, however, core sample data for Tank 101-AZ suggest that the oxide factor in that tank may range from 35 to 50 kg oxides/MTU, depending on the uncertain range of total solids present in the tank. Preliminary analytical data for the Tank 102-AZ core sample suggest an even higher oxide factor (possibly 100 kg oxides/MTU), presumably the consequence of PUREX rework processing during 1986 and later.

Glass canister projections for NCAW derived from Tanks 101-AZ, 102-AZ, and a possible third tank (future N-fuel processing) are summarized in Table 1, based on recent preliminary core sample data. All NCAW cases assume a 25 percent waste loading in glass. The canister range for NCAW glass reflects the uncertain solids content in the air-lift circulated tanks, as well as the uncertainty in future PUREX operations. The minimum of the NCAW canister range (580 cans) is based on the assumptions of: 1) 12 vol% total solids in Tank 101-AZ; 2) no suspended solids in Tank 102-AZ; 3) no heel solids in pretreated waste receiver Tank 102-AY (i.e., the heel is removed); and 4) no future PUREX operation.

The maximum value of the canister range (1030 cans) assumes: 1) 20 vol% total solids in Tank 101-AZ; 2) no suspended solids in Tank 102-AZ; 3) blending with heel solids currently existing in Tank 102-AY; and 4) future processing of 2100 MTU N-fuel in PUREX using the existing Zirflex decladding process.

DISCUSSION OF CANISTER PROJECTIONS

The canister estimates given in Table 1 illustrate the potential effectiveness of acidification and TRUEX processing for reducing the volume of vitrified waste as compared to the sludge washing approach. Compared to earlier canister estimates, the revised estimates for use of the TRUEX process have been reduced primarily as a result of laboratory evidence that higher percentages of sludge are dissolved when acidified.

For the sludge washing approach, the number of canisters for PFP and CC wastes are potentially high because of substantive evidence from laboratory experiments that chromium cannot be washed from these sludges. Thus, the volume of glass to contain water washed PFP and CC sludges could be relatively high due to a low tolerance for chromium in the glass. Laboratory tests are presently underway to test methods for oxidizing Cr^{3+} to Cr^{6+} in the sludges to allow removal by water washing. Thus, Table 1 shows canister estimates for PFP and CC sludges both with and without chromium removal.

Based on projected costs for storage of high-level waste (HLW) canisters in a geologic repository, pretreatment methods that reduce the volume of glass for final disposal remain attractive. It is significant to note, however, that based on the source term definition for HLW, both PFP and NCRW wastes are not HLW and glass from these wastes could potentially be disposed of at a lower cost in the Waste Isolation Pilot Plant repository. This disposal alternative should be explored further.

WASTE VOLUME PROJECTIONS

The waste volumes assumed for the canister estimates reflect two PUREX plant operating scenarios: 1) no further PUREX operation; and 2) future PUREX operations to process N-Reactor basin fuel. The waste volumes for the PUREX operating scenarios are consistent with those used for the assumptions in the Operational Waste Volume Projection reports. The estimated volumes of DST waste requiring pretreatment are listed in Table 2 below.

TABLE 2
DST WASTE VOLUMES

	MILLIONS OF LITERS (MILLIONS GALLONS)	
WASTE TYPE	WITHOUT PUREX	WITH PUREX
NCAW	5.3 (1.4)	7.6 (2.0)
NCRW	3.0 (0.8)	4.5 (1.2)
PFP WASTE	1.5 (0.4)	1.5 (0.4)
CC WASTE	18 (4.8)	18 (4.8)

It must be noted that these canister estimates are still very preliminary and are subject to change as additional core sample data and laboratory pretreatment development tests are completed. Laboratory development efforts will also evaluate mitigating strategies for resolving the issue of chromium limits in glass. For example, methods for removing chromium from the waste for the sludge washing approach will continue. Other mitigating strategies, such as increasing the glass waste loadings and waste blending scenarios, will also be addressed.

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Table A-1. B Plant Environmental and Safety Modifications.

Project	Description
W-002	This projects upgrades/replaces the 34-metric ton capacity 221-B canyon crane. The existing canyon crane is over 50 years old and maintainability has diminished.
W-003	This project provides effluent monitoring and replacement of an older portion of the treated chemical sewer effluent drainage pipe. An elemental neutralization system for the 217-B demineralized water unit is also provided.
W-004	Secondary containment, enhanced instrumentation and controls and replacement of the concrete floor for 8 of the chemical make up tanks within 271-B Building is provided by this project.
W-008	An elemental neutralization system is provided for the chemical sewer effluent by this project.
W-010 HEC	This project provides engineered barriers to prevent or mitigate releases of hazardous chemicals to the environment from the 211-B bulk chemical storage tanks and 221-B gallery scale tanks.
W-094	Instrumentation for the 291-B exhaust ventilation control system is enhanced by this project.
W-098	An interim storage facility for hazardous waste is provided by this project.
W-104	Upgrades to facility infrastructure, including roads, parking areas, and septic tank system are provided by this project.
W-163	Enhanced instrumentation and control systems for the secondary containment system drainage collection vessel (TK-10-1) and the 221-B canyon process vessel ventilation system are provided by this project.
W-206	This project provides a permanent operations support facility in place of several trailers, which currently house personnel.
W-207	This project is a compilation of sub-elements required for support of WESF and the TRUEX Pilot Plant and includes: • Modernization of the 271-B ventilation system, • Process valves and instrumentation replacement • Expanded maintenance and control room facilities • Effluent treatment systems for steam condensate and heavy metals in the chemical sewer system.

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APPENDIX B

HISTORY AND BACKGROUND

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CONTENTS

LIST OF TABLES

ACRONYMS

CC	complexant concentrate
CERCLA	*Comprehensive Environmental Response, Compensation and Liability Act of 1980*
DOE	U.S. Department of Energy
DST	double-shell tank
Ecology	Washington State Department of Ecology
EPA	U.S. Environmental Protection Agency
HDW-EIS	*Final Environmental Impact Statement, Disposal of Hanford Defense High-Level, Transuranic and Tank Wastes, Hanford Site, Richland, Washington*
hexone	methyl isobutyl ketone
HLW	high-level waste
HWVP	Hanford Waste Vitrification Plant
LLW	low-level waste
NCAW	neutralized current acid waste
NCRW	neutralized cladding removal waste
PFP	Plutonium Finishing Plant
PUREX	Plutonium-Uranium Extraction
RCRA	*Resource Conservation and Recovery Act of 1976*
REDOX	Reduction-Oxidation
ROD	record of decision
SST	single-shell tank
TRU	transuranic
TRUEX	transuranic extraction
WESF	Waste Encapsulation and Storage Facility
Westinghouse Hanford	Westinghouse Hanford Company

APPENDIX B
HISTORY AND BACKGROUND

B1.0 INTRODUCTION

Generation of waste at the Hanford Site began in December 1944 when plutonium from the Hanford Site production reactors was first recovered and isolated by processing irradiated uranium in chemical processing plants. Recovery of plutonium for use in fabrication of nuclear weapons and in other national defense activities continued through 1972. At that time, the backlog of spent fuel from shutdown Hanford Site production reactors had been processed and the Plutonium-Uranium Extraction (PUREX) Plant was placed in standby condition (i.e., nothing is processed in the plant but it is maintained and can be restarted). The PUREX Plant was reactivated in November 1983 to process a backlog of spent fuel from N Reactor operations. The PUREX Plant operated until 1988 and is presently in the standby condition pending the preparation of an environmental impact statement and a decision on the processing of the remaining N Reactor fuels.

The tank systems and contents, production processes that resulted in the generation of tank wastes, previous studies regarding the disposition of tank wastes, and the evolution of regulatory jurisdiction over the Hanford Site are summarized in the following sections.

B2.0 DESCRIPTION OF TANK SYSTEMS AND CONTENTS

B2.1 PREVIOUS REPROCESSING MISSIONS AND PROCESSES

B2.1.1 Bismuth Phosphate Separations Process (B and T Plants)

B Plant was constructed between August 1943 and February 1945 and was operated until 1952. T Plant was constructed between June 1943 and October 1944 and operated until 1956. These plants separated plutonium from uranium and the bulk of the fission products in irradiated fuel by coprecipitating the plutonium with bismuth phosphate. This was done in a uranyl nitrate solution. Then, plutonium was further separated from fission products by successive precipitation cycles using bismuth phosphate and lanthanum fluoride. The plutonium was isolated as a peroxide and, after being dissolved in nitric acid, was concentrated as plutonium nitrate.

The waste, which contained the uranium, from the separation of plutonium was made alkaline (neutralized) and stored in underground single-shell tanks (SST). This process also generated other acid waste (which included a large quantity of fission products) that was neutralized and stored in other SSTs. The specific volume of neutralized waste stored in SSTs was large, up to 40 m^3/t of irradiated uranium processed.

B2.1.2 Uranium Recovery Process (U Plant)

The recovery process, which operated from 1952 to 1958, resulted in an increase in nonradioactive salts and a small increase in waste volume. Uranium waste from the bismuth phosphate process was first stored in SSTs. Later, it was mined by sluicing, dissolved in nitric acid, and processed through a solvent extraction process (tributyl phosphate in kerosene was the solvent). The process was similar to that used later in the PUREX process (see Section B2.1.4) except, in this case, plutonium was not recovered. The acid waste from the uranium recovery process was made alkaline and returned to SSTs.

B2.1.3 Reduction-Oxidation Extraction Process (S Plant)

The Reduction-Oxidation (REDOX) Plant was built between May 1950 and August 1951 and operated until July 1967.

The REDOX extraction process was the first process to recover plutonium and uranium. It used a continuous solvent extraction process to extract plutonium and uranium from dissolved fuel by using a methyl isobutyl ketone (hexone) solvent. The plutonium and uranium are moved to the solvent. The slightly acidic waste from this process contained the fission products and large quantities of aluminum nitrate, which was used to promote the extraction. This waste was neutralized and stored in SSTs. The volume of high-level waste (HLW) from this process was much smaller than that from the bismuth phosphate process but larger than that from the PUREX process (see the next section).

B2.1.4 Plutonium-Uranium Extraction Process (PUREX Plant or A Plant)

The PUREX Plant was operated between October 1955 and 1972. It started operating again in November 1983 and was shut down in December 1988 pending a revised mission for waste management activities.

The PUREX process is an advanced solvent extraction process that uses a tributyl phosphate-in-kerosene solvent to recover uranium and plutonium from nitric acid solutions. The solutions contain nitric acid because it was used in other processes instead of metallic nitrates (e.g., aluminum nitrate) to promote the extraction of uranium and plutonium from an aqueous phase to an organic phase. Most of the nitric acid in the waste was recovered by distillation and reused. The waste, containing residual nitric acid, was neutralized and stored in underground tanks. Initially, SSTs were used for this purpose. Later, double-shell tanks (DST) were used for storing newly generated and future PUREX Plant waste. The volume of HLW per unit amount of fuel processed by the PUREX process was small compared to earlier processes.

B2.1.5 Thorium Extraction Process

Special processing campaigns in the PUREX Plant recovered ^{233}U (a fissionable isotope of uranium) from thorium, which had been irradiated in the Hanford Site reactors. The thorium also was extracted and partially decontaminated. The waste composition was similar to that from the PUREX process except that it contained small quantities of thorium and ^{233}U instead of uranium and plutonium. Two campaigns were conducted between 1966 and 1971.

B2.1.6 Plutonium Recovery and Finishing Operations (Z Plant)

The Z Plant, now called the Plutonium Finishing Plant (PFP), began operating in late 1949 to process plutonium and prepare plutonium products. (Before 1949, all plutonium nitrate solutions had been shipped offsite for further processing.) Waste from this plant contained minor amounts of fission products, low concentrations of plutonium and other transuranic (TRU) elements, and had a high concentration of metallic nitrates. Initially, this waste was discharged via cribs to soil columns, which absorbed the TRU elements and retained them close to the point of discharge. Later, waste from the PFP was stored along with other waste in underground tanks.

B2.1.7 Waste Fractionation Plant (B Plant)

The radionuclides ^{90}Sr and ^{137}Cs and their decay products were the major sources of heat in Hanford Site HLW after about 5-yr decay (ERDA 1975). Some of the strontium and cesium fission products were removed (fractionated) from the waste and isolated separately. This was done so that heat generation would not limit the technology that could be applied to the Hanford Site's program of in-tank immobilization. B Plant, one of the original bismuth phosphate process facilities, was modified in 1968 to permit removal of these fission products by a combination of precipitation, solvent extraction, and ion exchange steps. The residual acid waste from the processing was neutralized and stored in SSTs.

B2.1.8 Waste Encapsulation and Storage Facility

The Waste Encapsulation and Storage Facility (WESF), which began operations in 1974, converted solutions of strontium and cesium nitrates recovered at B Plant to strontium fluoride and cesium chloride solids that were put in metal capsules and stored in a water basin. Although these materials have potential beneficial use as heat and/or irradiation sources, they were considered, solely for purposes of the *Final Environmental Impact Statement, Disposal of Hanford Defense High-Level, Transuranic and Tank Wastes, Hanford Site, Richland, Washington* (HDW-EIS) (DOE 1987), to be waste that required disposal. In the event of commercial use of these sources, they would, at the end of their useful life, be considered as wastes and would require disposal.

B2.1.9 Past Waste Management Experience

As a result of the several plutonium recovery processes used at the Hanford Site and past practices in the management of tank waste, the chemical and radionuclide compositions of the tanks are quite varied. Volumes and compositions were strongly dependent upon the separations process used in generating the waste, as noted previously. Also, methods for treating the waste in the tanks have had major impacts on the compositions of tank contents. These treatment methods have included the following:

- In-tank scavenging of strontium and cesium by the precipitation of strontium phosphate and cesium ferrocyanide to reduce the concentration of ^{90}Sr and ^{137}Cs in the supernatants and disposal of the supernatants as low-level waste (LLW)

- Removal of ^{90}Sr and ^{137}Cs at B Plant to reduce in-tank heat generation and allow the remaining wastes to be concentrated

- Concentration of tank contents by evaporation of water to crystallize the waste as a salt cake.

Tank contents were mixed by transferring solutions and slurries among tanks and tank farms during the above treatments.

B2.2 TANK WASTES

B2.2.1 Waste Types

Four waste types have been currently identified as feed for vitrification. Each of these four waste types has certain chemical properties and constituents that require specialized pretreatment to reduce the disposal cost. Pretreatment is accomplished by separating these wastes into a low-volume, high-level and TRU waste fraction, and a relatively high-volume, low-level waste fraction. The waste types and quantities for pretreatment are described as follows.

- Neutralized current acid waste (NCAW) is a high-heat, first-cycle waste from the PUREX process. The NCAW is an iron-hydroxide sludge (20% volume) contaminated with actinides and strontium. The supernatant also contains aluminum and sodium salts. The alkaline supernatant is contaminated with ^{137}Cs. Currently, 5,300 m^3 (1.4 Mgal)of NCAW is stored on the Hanford Site.

- Neutralized cladding removal waste (NCRW) is waste from the PUREX cladding dissolution cycle. The NCRW is a zirconium-containing sludge contaminated with TRU elements. The alkaline supernatant is an LLW. Currently, 3,300 m^3 (0.875 Mgal) of sludge is stored on the Hanford Site.

- PFP waste is a low-heat, high-TRU waste generated by PFP operations. The sludge is principally metallic compounds. The TRU elements that are in the sludge are insoluble compounds. The alkaline supernatant is a LLW. Currently, 500 m^3 (133,000 gal) of PFP waste is stored on the Hanford Site.

- Complexant concentrate (CC) comes from previous strontium and cesium recovery operations. The sludge contains metal compounds, degraded complexants, and precipitated TRU elements. The alkaline supernatant contains cesium and TRU elements solubilized with complexants. Currently 16,300 m^3 (4.3 Mgal) of CC waste is stored on the Hanford Site. Future saltwell pumping from SSTs will add 1,900 m^3 (0.5 Mgal).

B3.0 EARLY STUDIES

The use of tanks to store radioactive waste generated by the operation of processing plants began in the 1940's. Until the early 1970's, most processing wastes were stored in SSTs. A total of 149 SSTs, having capacities from 200 m^3 to 3,800 m^3 (55,000 gal to 1 Mgal), were constructed between 1943 and 1964. While these tanks are no longer in active service, they contain 165,000 m^3 (43 Mgal) of radioactive wastes that may require retrieval, pretreatment, and solidification for disposal.

Since 1971, newly generated processing wastes have been stored in DSTs. Twenty-eight DSTs were constructed between 1970 and 1985, each having a nominal capacity of 3,800 m^3 (1 Mgal). Four tanks (241-AZ-101, 241-AZ-102, 241-AY-101, and 241-AY-102) are equipped with airlift circulators. These tanks are used for storage (aging) of high-heat wastes from the PUREX process. By 1981, large quantities of liquid wastes had been removed from SSTs and placed in DSTs.

From 1968 to 1985, HLW from SSTs was reprocessed to remove heat-generating radionuclides. The radionuclides were solidified into cesium and strontium salts, sealed in capsules, and stored in water basins in the WESF, which is adjacent to B Plant. Some capsules were leased for beneficial use but are being returned to the Hanford Site because of concerns about potential capsule failures.

B3.1 PRE-1983

In 1977, the Energy Research and Development Administration issued a report, ERDA 77-44 (ERDA 1977), on technical alternatives for long-term management of the Hanford Site HLW. This report contained preliminary cost estimates and an analysis of near-term risks associated with the alternatives for treatment, long-term storage, and disposal of the waste, stored in the underground tanks, and the strontium and cesium capsules. The report provided a preliminary basis for discussion and judgement in future decision making. No selection or recommendation of an alternative for implementation was made.

In 1980, as an expansion of these studies, a series of reports was issued exploring alternatives for long-term storage and/or disposal of the Hanford Site HLW (RHO 1980a, 1980b, 1980c). These studies provided a basis for comparing environmental aspects of implementing any of a broad range of technical alternatives.

The four general alternatives addressed in this series were:

Alternative A Near-Term Geologic Disposal of Stored Waste	Remove wastes from the tanks, immobilize, package, and dispose of in a geologic repository. Remove encapsulated cesium and strontium from the storage basins, package, and dispose of in a geologic repository.
Alternative B Deferred Geologic Disposal of In-Tank Waste	Solidify the residual slurry but defer removal of in-tank waste for about 250 yr to allow fission products to decay to lower levels: proceed as in alternative A. Remove encapsulated cesium and strontium from storage basins, package, and dispose of in a geologic repository as soon as one exists.
Alternative C In Situ Disposal of In-Tank Waste	Solidify residual slurry and leave all waste in existing tanks. Fill the tanks with sand or gravel and install a confinement barrier and protective earth cover over the tanks. Remove encapsulated cesium and strontium from the storage basins, package, and dispose of in a geologic repository as soon as one exists.
Alternative D Continue Present Action for Stored Waste	Solidify residual slurry and continue surveillance, monitoring, and maintenance of the in-tank waste storage system. Continue water basin storage of encapsulated waste for about 60 yr (until the heat content is significantly reduced by radioactive decay); remove the package capsules and store in a dry, passively cooled facility.

The near-term geologic disposal of stored waste described in these studies involved vitrifying the retrieved in-tank waste, followed by disposal in a geologic repository.

B3.2 1983 STUDY

An engineering study (Schulz et al. 1983) was performed in 1983 to define and evaluate alternatives for preparing tank wastes for immobilization (vitrifying or incorporation into grout); preferred feed preparation processes, facilities, and schedules were determined. Significant findings included the following.

- Most of the tank wastes require special feed preparation to make them suitable for vitrification or incorporation into grout. The necessary feed pretreatment could be performed in an upgraded B Plant or a new feed pretreatment facility. For cost and schedule reasons, B Plant was preferred.

- Several tank wastes could be incorporated into grout for near-surface disposal. The NCRW could be disposed of in grout if the TRU elements were removed from it. This was identified as a top priority; destroying the organics in complexed concentrate feed was the next priority.

- A vitrification plant coupled to B Plant was preferred to a standalone facility for cost and schedule reasons.

The study selected B Plant as the preferred facility for pretreatment because of the following advantages:

- Minimum commitment of capital funds

- Earliest compliance with national criteria for disposal of HLW and TRU waste

- Size allowing for pretreatment flexibility

- Availability of trained personnel

- Similarity of pretreatment to previous B Pla t missions

- Recent successful operation of cesium and strontium recovery mission

- Availability of the facility for a new mission.

B3.3 FINAL ENVIRONMENTAL IMPACT STATEMENT, DISPOSAL OF HANFORD DEFENSE HIGH-LEVEL, TRANSURANIC AND TANK WASTES, HANFORD SITE, RICHLAND, WASHINGTON AND RECORD OF DECISION

In April 1988, the record of decision (ROD) (DOE 1988) on the HDW-EIS (DOE 1987) was handed down as follows:

> ". . . The decision is to implement the "Preferred Alternative" as discussed in DOE/EIS-0113 (hereafter referred to as the HDW-EIS). The Department of Energy (DOE) has decided to proceed with disposal activities for the following defense wastes at the Hanford Site: double-shell tank wastes, retrievably stored and newly generated transuranic (TRU) waste, and only pre-1970 buried suspect TRU-contaminated solid waste site outside the central (200 Area) plateau, and strontium and cesium encapsulated wastes.
>
> To process existing and future wastes from the double-shell storage tanks at Hanford for final disposal, the DOE will design, construct, and operate the Hanford Waste Vitrification Plant (HWVP); complete the necessary pretreatment modifications and operate the pretreatment facility, currently planned to be the Hanford B Plant; and utilize the Hanford Transportable Grout Facility. The radioactive high-level waste fraction will be processed into a borosilicate glass waste form and stored at the HWVP until a geologic repository is built and ready to receive this waste.

The low-activity fraction will be solidified as a cement-based grout and disposed of near surface at Hanford in preconstructed, lined concrete vaults. Existing and future double-shell tank waste will be characterized for hazardous chemical constituents, as well as other chemical constituents that might affect glass or grout formulation, before processing. . .

Encapsulated cesium and strontium wastes will continue to be stored safely until such time as a geologic repository is ready to receive this waste for disposal. Prior to shipment to a geologic repository, these wastes will be packaged in accordance with repository waste acceptance specifications.

For the remainder of the waste classes covered in the HDW-EIS (single-shell wastes, TRU-contaminated soil sites and pre-1970 buried suspect TRU-contaminated solid waste within the 200 Area plateau), the DOE has decided to conduct additional development and evaluation before making decisions on final disposal. This development and evaluation effort will focus both on methods to retrieve and process these wastes for disposal as well as to stabilize and isolate the wastes near surface. Results from this work will be publicly available. Prior to decisions on final disposal of these wastes, the alternatives will be analyzed in subsequent environmental documentation, including a supplement to the HDW-EIS for decisions on disposal of the single-shell tank wastes. . ."

With regard to the Hanford Site vitrification program, the ROD accomplishes the following:

- Establishes the bases for final disposal of existing and future DST wastes
- Calls for the continued storage of encapsulated cesium and strontium pending availability of a geologic repository (the repository waste acceptance criteria and potential for capsule failures were not known in April 1988)
- Defers the decision on final disposal of SST wastes pending additional development and evaluation efforts and preparation of a supplement to the HDW-EIS (DOE 1987).

The record of decision (DOE 1988) also states that "the HWVP, in addition to vitrifying double-shell tank waste, will be designed with sufficient flexibility to accommodate all single-shell tank waste should the decision be made to recover the waste."

B3.4 1988 STUDY

In 1988, an assessment of facility and process alternatives for treating Hanford Site tank waste for immobilization and final disposal was prepared (Kupfer et al. 1989). This assessment was an update of the earlier study described previously (Schulz et al. 1983).

Hanford Site DST wastes (NCAW, complexant concentrate waste, PFP sludges, and NCRW) were studied. The impact of a decision to retrieve and process SST wastes on the DST waste pretreatment program was also addressed. Two processing alternatives were considered for the wastes:

- Separation of solids or sludges from supernatants and washing the solids with water to remove soluble salts
- Solid-liquid separation and reduction of the volume of waste requiring vitrification by dissolving the sludges and removing TRU components from the acidic wastes solutions using the transuranic extraction (TRUEX) process.

The recommendations from this study were the following:

- Sludge wash NCAW in B Plant
- Install a larger, 100 kg/h, melter at the Hanford Waste Vitrification Plant (HWVP) at startup and maximize the TRUEX process capacity at B Plant
- Resolve problems for in-tank washing of NCAW
- Perform laboratory studies and engineering analyses to reduce the radionuclide concentration in LLW grout.

B Plant was supported as the preferred pretreatment facility because of schedule constraints, and because, of the alternatives, it had the lowest capital costs and the lowest life-cycle costs.

B3.5 1989 STUDY

Concern about the ability of B Plant to perform the DST pretreatment mission without significant risks to HWVP operations led to an assessment (WHC 1990) of these concerns:

- The ability of B Plant and supporting tank farm facilities to withstand design basis accidents
- The comparison of B Plant and supporting tank farm facilities to current codes and standards
- The risks associated with extended B Plant operations
- The ability of technology development to support the pretreatment mission
- The integrated cost and schedule for performing the DST waste pretreatment and vitrification mission.

The suitability and viability of the pretreatment alternatives were examined for existing tank farms, the 244-AR Vault, and B Plant. A new standalone pretreatment facility was also considered. Costs and availability were considered along with the advantages and disadvantages of alternative facilities for use in pretreatment operations.

Three pretreatment facility and process alternatives were considered worthy of analysis and examination.

Alternative A B Plant Baseline	All pretreatment will be done in B Plant. Operations will begin by October 1995. The TRUEX process will be operational in October 2001.
Alternative B B Plant and 244-AR Vault	The NCAW will be washed in the 244-AR Vault or a DST by October 1995. The TRUEX process in B Plant will be accelerated to October 1997.
Alternative C New Standalone Facility and 244-AR Vault	The NCAW will be washed in the 244-AR Vault or a DST by October 1995. The TRUEX process will be operational in a new facility by April 2000.

The study recommended alternative B based primarily on the importance given to achieving the December 1999 HWVP startup with NCAW and the uninterrupted processing of other DST waste. Alternative B, with NCAW sludge washing in the 244-AR Vault and early TRUEX operation, was envisioned as providing significantly greater ensurance of uninterrupted feed to HWVP during the entire DST waste vitrification campaign than alternatives A and C. Retention of nominal contingency time was possible in alternative B, but no flexibility was seen to exist in recovering any of schedule delays with the other alternatives.

Another study done in 1989 (Ludowise 1989) assessed B Plant's ability to meet the currently imposed U.S. Department of Energy (DOE) orders, U.S. Nuclear Regulatory Commission regulatory guides, seismic resistance requirements, and applicable State and Federal environmental regulations. The assessment concluded that although B Plant is generally in compliance with current codes and standards, several areas require either further study to show compliance or require upgrades.

B3.6 EVOLUTION OF U.S. ENVIRONMENTAL PROTECTION AGENCY AND U.S. DEPARTMENT OF ENERGY JURISDICTION

B3.6.1 Environmental Activities at the Hanford Site 1986 to 1989

In March 1986, the DOE Field Office, Richland established an Environmental Compliance Task Force to identify and characterize all Hanford Site wastestreams.

The DOE-Headquarters issued a memorandum that mixed waste is subject to the *Resource Conservation and Recovery Act of 1976* (RCRA) regulations. This was a direct result of the *Leaf versus Hodel* case in Tennessee.

In June 1986, in a letter to all Hanford Site contractors, the DOE Field Office, Richland reemphasized the need to comply with RCRA and the need to characterize all wastestreams for hazardous components.

In November 1986, the DOE Field Office, Richland assessed the Hanford Site environmental management needs and established the Hanford Site environmental management program to bring the Hanford Site into compliance with all applicable environmental regulations.

In February 1987, discussions were initiated with Washington State on a potential agreement on cleanup of the Hanford Site. The agreement was to be patterned after a similar agreement in Idaho.

In April 1987, Rockwell Hanford Operations [prior contractor to Westinghouse Hanford Company (Westinghouse Hanford)] initiated a series of self-assessments of their operating facilities against the major environmental statutes [i.e., RCRA, *Comprehensive Environmental Response, Compensation and Liability Act* (CERCLA), *Clean Air Act* and *Clean Water Act*]. The self-assessment identified any potential deficiencies with the environmental laws, identified and scheduled necessary corrective actions, and aggressively brought the facilities into full compliance with environmental regulations. The self-assessments were necessary to baseline the environmental status of the key facilities.

On June 29, 1987, Westinghouse Hanford assumed responsibility for the Operations and Engineering contract at Hanford Site. At that time, they assumed responsibility for management of the N Reactor, chemical processing operations, waste management operations, operational support services, and the associated Hanford Site services.

The DOE rulemaking for byproduct waste determined that all radioactive waste that also contained hazardous constituents would be subject to RCRA.

In August 1987, the U.S. Environmental Protection Agency (EPA) performed its annual hazardous waste inspection of Hanford Site facilities. Problems requiring correction were identified in all areas of the Hanford Site.

In November 1987, the HDW-EIS was signed by DOE-Headquarters and submitted to the EPA for a final record of decision.

In recognition of the expanding responsibility for environmental issues at the Hanford Site, Westinghouse Hanford agreed to cosign all RCRA Part A and Part B permit applications to Washington State as "co-operator" of its treatment, storage, and disposal facilities. The DOE Field Office, Richland signed as "owner" and "co-operator." By cosigning as operator, Westinghouse Hanford committed to a much more active role in management of the Hanford Site environmental programs.

Washington State was delegated authority for regulation of all mixed waste on the Hanford Site. Because these wastes had been previously excluded from regulation by the State under the "byproduct rule," it was necessary to submit new Part A permit applications for the Hanford Site treatment, storage, and disposal facilities handling mixed waste. The revised Part A permits were due within 180 days (May 1988).

In February 1988, negotiations began in earnest between DOE, EPA, and the Washington State Department of Ecology (Ecology) on a mutual agreement on cleanup of the Hanford Site. Westinghouse Hanford personnel provided direct support to DOE Field Office, Richland in the negotiations process. All three parties agreed that an agreement would be beneficial and that they would commit the necessary resources to accomplish such an agreement.

In March 1988, in recognition of the expanding environmental requirements and in recognition of the need to provide better focus to environmental activities, Westinghouse Hanford formed a new Environmental Division that reports directly to the president of Westinghouse Hanford. All environmental activities were centralized within the new division including the following:

- Regulatory analysis
- Environmental engineering and technology
- Environmental assurance and overview
- Environmental operations and cleanup
  - Decontamination
  - Decommissioning.

The new division also became the focal point on interactions with EPA and the State with particular emphasis in support of negotiating an agreement between the three parties for cleanup of the Hanford Site.

The DOE Field Office, Richland formed the Environmental Restoration organization to focus on and manage operational environmental activities. Responsibilities of the new division included management of environmental policy and permitting and management of environmental restoration activities including decontamination and decommissioning. (The environmental oversight function remained with DOE Field Office, Richland's Assistant Manager for Safety, Environmental, and Security).

In April 1988, the record of decision was issued on the HDW-EIS (DOE 1987). The decision recommended that the Hanford Site proceed with final treatment and disposal of three of its wastes (DST waste, cesium and strontium capsules, and retrievably stored TRU-contaminated waste) while deferring action on three other wastestreams (SST waste, pre-1970 TRU waste, and TRU-contaminated soil sites) until further characterization work was done. The record of decision allowed the Hanford Site to move from <u>storage</u> of nuclear wastes to <u>disposal</u> of the wastes.

In June 1988, at the request of DOE Field Office, Richland, the Hanford Site was nominated for the EPA's National Priorities List. The Site was divided into four specific areas [the 100 Area (former reactor sites), 200 Area (waste management and chemical processing), 300 Area (fuel fabrication and laboratory operations), and the 1100 Area (site support and vehicle maintenance)]. Once placed on the National Priorities List by EPA, remedial investigation and/or feasibility studies must be initiated in each of the four areas within 6 months.

In August 1988, the annual EPA hazardous waste inspection of the Hanford Site facilities was performed. Although there were significant areas of improvement throughout the Site, problems requiring corrective action were still identified.

In September 1988, Westinghouse Hanford issued a revised *Environmental Compliance Manual* (WHC-CM-7-5) (WHC 1988) that established requirements and guidelines to be used to ensure that all operations were being performed in an environmentally safe manner. This manual replaced the previous manuals in effect for the previous three contractors and brought uniformity to environmental operations across the Site.

In October 1988, the Hanford Environmental Management Board was formed. The board was composed of key environmental program managers from Westinghouse Hanford, Pacific Northwest Laboratory, Hanford Environmental Health Foundation, Kaiser Engineers Hanford, and DOE Field Office, Richland. The purpose of the board was to share insights and lessons learned on environmental activities and to provide more uniform management of environmental activities across the Hanford Site. The board has contributed to significantly improved working relationships between the contractors in environmental areas.

In February 1989, a notice of intent to execute an agreement on cleanup of the Hanford Site was signed by DOE, EPA, and Ecology representatives. The agreement established an enforceable schedule on compliance actions and a 30-yr timeframe for cleanup of the Site.

In April 1989, the facility environmental self-assessments against RCRA were completed for the 23 operating treatment, storage, and disposal facilities at the Hanford Site and were submitted to EPA and Ecology. The assessments identified potential deficiencies and proposed corrective actions. As part of the Tri-Party Agreement, the DOE Field Office, Richland agreed to negotiate enforceable completion dates for each of the corrective actions.

B3.7 HANFORD FEDERAL FACILITY AGREEMENT AND CONSENT ORDER

In May 1989, the DOE, EPA, and Ecology signed the Tri-Party Agreement (Ecology et al. 1990). The Tri-Party Agreement established enforceable milestones for specific cleanup actions identified in the record of decision. Major milestones established for the disposal of DST wastes are shown in Table B-1.

Table B-1. Double-Shell Tank Waste Major Milestones.

Number	Milestone	Due Date
M-01-00	Complete 14 grout campaigns of DST waste and maintain currency with waste feed thereafter	September 1994
M-01-01	Complete three grout campaigns of DST wastes (including one campaign of phosphate and sulfate waste)	September 1991
M-01-02	Complete six grout campaigns of DST wastes	September 1992
M-01-03	Complete 10 grout campaigns of DST wastes	September 1993
M-01-04	Complete 14 grout campaigns of DST wastes	September 1994
M-01-05	Commitments for additional grout campaigns after September 1994 will be incorporated as interim milestones	Biannually beginning in September 1994
M-02-00	Initiate B Plant operations for pretreatment of DST waste	October 1993
M-02-01	Initiate pretreatment of neutralized current acid waste	October 1993
M-02-02	Commitments for pretreatment of additional tank wastes will be incorporated as interim milestones	Biannually beginning in calendar year 1992
M-03-00	Initiate Hanford Waste Vitrification Plant operations	December 1999
M-03-01	Initiate Hanford Waste Vitrification Plant construction	July 1991
M-03-02	Complete Hanford Waste Vitrification Plant construction	June 1998

DST = Double-shell tank.

The Tri-Party Agreement established a timetable for implementing the record of decision and established milestones for closure of SSTs, as shown in Table B-2.

Table B-2. Single-Shell Tank Waste Milestones.

Number	Milestone	Due Date
M-09-00	Complete closure of all 149 SSTs Closure and removal of required waste from the 149 SSTs will be affected in accordance with the approved closure plan(s). As stated in the *Final Environmental Impact Statement, Disposal of Hanford Defense High-Level, Transuranic and Tank Wastes, Hanford Site, Richland, Washington; Record of Decision*,* a supplemental EIS will be prepared before making any final decisions regarding disposal of SST waste. The final closure plan(s) will address the recommendations of the supplemental EIS.	June 2018
M-09-01	Complete preparation of the supplemental EIS and issue a draft for public review.	June 2002

*DOE 1987.
DST = Double-shell tank
EIS = Environmental impact statement
SST = Single-shell tank.

B3.8 HANFORD WASTE VITRIFICATION SYSTEMS RISK ASSESSMENT-FINAL REPORT

In October 1990, the U.S. DOE Field Office, Richland directed Westinghouse Hanford to perform a risk assessment to identify and evaluate all significant uncertainties associated with the vitrification of the Hanford Site HLW and TRU wastes. The principal findings and recommendations from the *Hanford Waste Vitrification Systems Risk Assessment-Final Report* (risk assessment) (Miller et al. 1991) are discussed in the following sections.

B3.8.1 Findings

The baseline plan (December 1990) to process HLW waste and TRU wastes stored in DSTs at the Hanford Site contains a number of uncertainties. Although many of the uncertainties have minor consequences, the cumulative impact could result in substantial risk to the program. The viability of B Plant as a mixed waste pretreatment facility is questionable because of concerns about the facility's ability to comply with regulations and facility integrity concerns. Additional waste characterization data are needed to complete the development of retrieval, pretreatment, and vitrification processes. Schedule delays associated primarily with retrieval and pretreatment activities could prevent startup of the HWVP in December 1999 and result in several years of outage during its operating lifetime.

Significant delays in the schedule and an increase in the total cost of the program could result from uncertainties about the following:

- Waste characterization
- Development and implementation of waste retrieval and pretreatment processes and facilities
- Construction and operation of the HWVP
- Design, construction, and operation of the TRUEX pilot plant.

The most probable collective impact of these uncertainties is a delay of up to 7 yr in completing vitrification of the DST wastes. A total life-cycle cost increase of up to $2 billion (in 1991 dollars) for the DST waste treatment program was estimated to result from these combined uncertainties and associated schedule delays, assuming B Plant is used. The cost of the program could be substantially greater ($1 billion increase or more) if B Plant is eliminated from the program and a new pretreatment facility has to be constructed.

These and other uncertainties identified in the risk assessment (Miller et al. 1990) must be addressed in the development of a revised program strategy for the treatment of DST wastes to mitigate the program risks. Construction of the HWVP on the baseline schedule is appropriate only if the program redefinition resolves the most significant risks in a manner that will ensure timely and nearly continuous feed to the HWVP.

It is highly probable that HWVP will be capable of supporting future processing missions for SST wastes and cesium and strontium capsules based on scoping assessments performed to date. The plant has been designed with sufficient capacity, and pretreatment technologies appear feasible for providing suitable feed for vitrification, assuming waste fractionation processes such as TRUEX are implemented.

Additional DSTs are needed to store wastes to be generated during DST and SST waste stabilization, treatment, and disposal to avoid major delays in the pretreatment and vitrification operations.

Lack of integration of the DST and SST waste treatment programs could extend the time necessary for cleanup of the Hanford Site and result in substantial costs, which may be avoidable. The current schedule for preparation of environmental and regulatory documentation will, most likely, not support closure of the SSTs by the year 2018 as currently identified in the Tri-Party Agreement (Ecology et al. 1990). If the SST wastes are vitrified, costly and redundant pretreatment facilities may need to be constructed. Operation of the HWVP also may have to be curtailed up to 10 yr between the DST and SST vitrification campaigns. Recovery from an outage of this length could be difficult and costly because of the potential for changing regulatory requirements.

B3.8.2 Recommendations

Pretreatment alternatives that do not require the use of B Plant or the 244-AR Vault should be investigated because of the uncertainties in obtaining dangerous waste permits for these facilities. Alternate waste types, such as tank 241-C-106 which can be pretreated with mature, simple processes, should be evaluated as feed alternatives to minimize HWVP standby during the DST campaign.

Construction of the HWVP should not be initiated until a revised tank waste disposal program strategy is accepted by all responsible agencies because implementation of some pretreatment alternatives could substantially delay supplying feed to the HWVP. At the extreme, delivery of pretreated feed to the HWVP could be delayed up to 10 yr if all waste types are to be processed in a new facility.

Delaying the start of HWVP hot operations may be appropriate if the likelihood of substantial interruptions in the supply of feed to the HWVP cannot be eliminated through the implementation of alternate pretreatment strategies or technologies. A delay of 2 to 4 yr would reduce, and perhaps eliminate, the HWVP standby periods projected in the December 1990 baseline plans.

Integrated planning for characterization of tank wastes to resolve tank safety issues and support waste stabilization and remediation should be expedited. New sampling and support equipment should be procured, and additional laboratory capabilities should be made available.

Activities necessary to retrieve the initial waste type to support the startup of pretreatment and the HWVP should receive higher priority for funding and staffing. Laboratory- and full-scale retrieval process testing of subsequent waste types should be expedited.

The supplemental environmental impact statement for the closure of the SSTs should be targeted for completion earlier than currently planned. This will improve the probability of completing the milestone for closure of the tanks by 2018 and assist in the integration of the DST and SST waste treatment programs.

B4.0 REFERENCES

Clean Air Act of 1977, 42 USC 7401, et seq.

Clean Water Act of 1977, 33 USC 1251, et seq.

Comprehensive Environmental Response, Compensation and Liability Act of 1980, 42 USC 9601, et seq.

DOE, 1987, *Final Environmental Impact Statement, Disposal of Hanford Defense High-Level, Transuranic and Tank Wastes, Hanford Site, Richland, Washington*, DOE/EIS-0113, Vol. 1 through 5, U.S. Department of Energy, Washington, D.C.

DOE, 1988, "Final Environmental Impact Statement for the Disposal of Hanford Defense High-Level, Transuranic, and Tank Wastes, Hanford Site, Richland, Washington; Record of Decision," *Federal Register*, Vol. 53, No. 72, pp 12449-12453, U.S. Department of Energy, Washington, D.C.

Ecology, EPA, and DOE, 1990, *Hanford Federal Facility Agreement and Consent Order*, Vol. 1 and 2, Washington State Department of Ecology, U.S. Environmental Protection Agency, and U.S. Department of Energy, Olympia, Washington.

ERDA, 1975, *Final Environmental Impact Statement on Waste Management Operations, Hanford Operations*, ERDA-1538, Vol. 1 and 2, Energy Research and Development Administration, Washington, D.C.

ERDA, 1977, *Alternatives for Long-Term Management of Defense High-Level Radioactive Waste*, ERDA 77-44, Energy Research and Development Administration, Richland, Washington.

Kupfer, M. J., A. L. Boldt and J. L. Buelt, 1989, *Process and Facility Options for Pretreatment of Hanford Tank Waste*, SD-WM-TA-015, Westinghouse Hanford Company, Richland, Washington.

Ludowise, J. D., 1989, *B Plant Compliance Assessment*, SD-WM-TI-383 Draft, Westinghouse Hanford Company, Richland, Washington.

Miller, W. C., D. W. Hamilton, L. K. Holton and J. W. Bailey, 1991, *Hanford Waste Vitrification Systems Risk Assessment-Final Report*, WHC-EP-0421, Rev. 0, Westinghouse Hanford Company, Richland, Washington.

Resource Conservation and Recovery Act of 1976, 42 USC 6901, et seq.

RHO, 1980a, *Technical Status Report On Environmental Aspects of Long-Term Management of High-Level Defense Waste at the Hanford Site*, RHO-LD-139, Rockwell Hanford Operations, Richland, Washington.

RHO, 1980b, *Environmental Aspects of Long-Term Management Alternatives for High-Level Defense Waste at the Hanford Site*, RHO-LD-140, Rockwell Hanford Operations, Richland, Washington.

RHO, 1980c, *Technical Aspects of Long-Term Management Alternatives for High-Level Defense Waste at the Hanford Site*, RHO-LD-141, Rockwell Hanford Operations, Richland, Washington.

Schulz, W. W., M. J. Kupfer and J. P. Sloughter, 1983, *Evaluation of Process and Facility Options for Treatment of Double-Shell Tank Wastes*, SD-WM-ES-023, Rockwell Hanford Operations, Richland, Washington.

WHC, 1988, *Environmental Compliance Manual*, WHC-CM-7-5, Westinghouse Hanford Company, Richland, Washington.

WHC, 1990, *Assessment of Double-Shell Tank Waste Pretreatment Options*, WHC-SP-0464, Rev. 1, Westinghouse Hanford Company, Richland, Washington.

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APPENDIX C

DEFENSE WASTE REMEDIATION STRATEGY REVISION ATTRIBUTES

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Defense Waste Remediation Strategy Revision Attributes

Contribution to Missions

1. **Stored irradiated fuel**--measured with a constructed scale, this subattribute assesses the potential to process the irradiated fuel for disposal. This subattribute is measured on the extent of the contributions (facilities, technology, etc.).

2. **Contribution to single-shell tank (SST) mission**--measured with a constructed scale, this subattribute assesses the potential to contribute to the remediation of the single-shell tanks. This subattribute is measured on the extent of the contributions (facilities, technology, etc.).

3. **Cesium and strontium capsules**--measured with a constructed scale, this subattribute assesses the potential to contribute to (or interfere with) processing cesium and strontium capsules.

Technology Assurance

1. **Technical maturity**--measured with a constructed scale, this subattribute assesses the maturity of the processing technologies that comprise the strategy alternatives. This characterization is meaningful for measuring the risk to timely hot startup of Hanford Waste Vitrification Plant (HWVP), continuity of feed to HWVP, and minimization of downtime as a result of operating disruptions and process upsets.

2. **Technical adaptability**--measured with a constructed scale, this subattribute assesses the ability of the strategy alternatives to accommodate changes, such as variability in feed type and composition, additional radiological and/or chemical removal requirements, additional regulatory requirements, and design modifications.

3. **Technical reliability**--measured with a constructed scale, this subattribute assesses the reliability and forgiveness of the technologies that comprise the strategy alternatives. This characterization is meaningful for measuring the ability of the alternative to provide continuity of feed to HWVP and minimization of downtime as a result of equipment failures.

4. **HWVP operating continuity**--measured in number of months, this subattribute provides the length of downtime of HWVP as a result of the lack of available pretreated feed to HWVP.

Health and Safety

Public Health Attributes

1. **Radiological accidents**--measured using standard Hanford Site environmental impact calculations, this subattribute assesses, in fatalities, the likelihood and radiological effect on the general public, of accidents associated with a specific strategy alternative.

2. **Nonradiological (chemical) accidents**--measured using standard Hanford Site environmental impact calculations, this subattribute assesses, in total probability of an individual fatality, the likelihood and chemical effects on the maximum exposed individual member of the general public of accidents involving the chemicals used in a specific strategy alternative.

3. **Radiological-routine shipments**--measured using standard Hanford Site environmental impact calculations, this subattribute assesses the number of fatalities in the general public that may result from routine offsite shipments.

4. **Radiological-transportation accidents**--measured using standard Hanford Site environmental impact calculations, this subattribute assesses the number of fatalities in the general public that may result from routine offsite shipments that manifest into vehicle accidents that are estimated to occur during the lifetime of the strategy alternative and result in a radiation release offsite.

5. **Nonradiological-transportation accidents**--measured using standard Hanford Site environmental impact calculations, this subattribute assesses the number of fatalities in the general public that may result from traffic accidents during a routine offsite rail shipment of canisters.

Worker Safety

1. **Radiological risk from routine work**--measured using standard Hanford Site environmental impact calculations, this subattribute assesses, in fatalities, the radiological effect on the Hanford Site workforce during construction, transportation and operation of a specific strategy alternative.

2. **Nonradiological (chemical) accidents**--measured using standard industrial calculations, this subattribute assesses, in total probability of an individual fatality, the chemical effect on the maximum exposed Hanford Site worker for a specific strategy alternative and incorporates the likelihood and consequences of nonradiological accidents.

3. **Radiological accidents**--measured using standard Hanford Site environmental impact calculations, this subattribute assesses, in rem, the effects of radiological accidents on the maximum exposed Hanford Site worker for a specific strategy alternative.

4. **Nonradiological-industrial accidents**--measured using standard industrial accident calculations, this subattribute assesses the number of fatalities resulting from industrial accidents during construction, operations, and transportation.

Environmental **Impact Attributes**

1. **Routine and nonroutine effluents**--measured with a constructed scale, this subattribute assesses the strategy alternative for:
(a) the ability to provide additional engineered barriers
(b) the inclusion of human factors engineering
(c) the ability to minimize routine releases, and
(d) its operational complexity (i.e., number of facilities used).

2. **Solid waste**--this subattribute measures the amount of low-level solid waste generated over the life of the strategy alternative.

3. **Number of grout vaults**--this subattribute measures the number of grout vaults produced as a result of following the strategy alternative.

4. **Number of glass canisters**--this subattribute measures the number of glass canisters produced as a result of following the strategy alternative.

5. **Land use**--this subattribute measures the land which would require restricted use at the completion of the mission.

6. **Reduced potential for leakage to the environment**--this subattribute predicts the additional number of leaking single-shell tanks resulting from the timing of the strategy alternative against the earliest opportunity to initiate single-shell tank pretreatment.

Schedule **and Compliance Attributes**

1. **Compliance with regulations**--measured with a constructed scale, this subattribute assesses the difficulty and uncertainty in obtaining compliance with all applicable regulations.

2. **HWVP start date**--measured as a date, this subattribute assesses the date for hot startup of HWVP given that pilot plant data is available Jan. 1998 for definitive design of new facilities, new facilities are 1997 line items, existing facilities are 1998 line items, new double-shell tanks are not used to store retrieved waste, waste is pretreated as it is retrieved, and double-shell tank waste is processed before single-shell tank waste.

3. **Single-shell tank closure date**--measured as a date, this subattribute assesses the date for hot startup of HWVP given the same assumptions listed in attribute 16 **plus**, the decision to process single-shell waste will be made in 1994 and the supplemental environmental impact statement record of decision will be complete in 1996.

4. **Double-shell tank mission completion date**--measured as a date, this subattribute assesses the date for completion of vitrification of double-shell tank waste.

5. **Single-shell tank mission completion date**--measured as a date, this subattribute assesses the date for completion of vitrification of single-shell tank waste.

Cost Attribute

1. **Double-shell tank life cycle cost**--measured in fiscal year (FY) 1993 (expense) dollars and FY 1991 (capital) dollars, this subattribute provides the double-shell tank mission capital and expense cost of each strategy alternative.

2. **Peak annual cost**--measured in FY 1993 (expense) dollars and FY 1991 (capital) dollars, this subattribute provides the maximum fiscal year double-shell tank cost during the mission period for each strategy alternative.

Cost Profile Attributes

1. **Average annual mission cost increase**--measured in FY 1993 (expense) dollars and FY 1991 (capital) dollars, this subattribute provides the average annual double-shell tank mission cost increase for each strategy alternative.

2. **Maximum annual Site cost increase**--measured in FY 1993 (expense) dollars and FY 1993 (capital) dollars, this subattribute provides the maximum annual Hanford Site budget increase given a constant Hanford Site budget of $1.5 billion for each strategy alternative.

Community Economic Impact

1. **Community economic impact**--measured in the number of people working, this subattribute assesses impact of construction and operations of each strategy alternative on the community and regional economy. The subattribute provides the maximum reduction in the labor force for each strategy alternative.

APPENDIX D

CALCULATION OF ENVIRONMENT, SAFETY, AND HEALTH ATTRIBUTES FOR DOUBLE-SHELL TANK REMEDIATION ALTERNATIVES

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CONTENTS

LIST OF TABLES

ACRONYMS

ALARA	as low as reasonably achievable
D&D	decontamination and decommissioning
DOE	Department of Energy
DST	double-shell tank
ERPG	emergency response planning guideline
HDW-EIS	*Final Environmental Impact Statement, Disposal of Hanford Defense High-Level, Transuranic and Tank Wastes, Hanford Site, Richland, Washington*
HEPA	high-efficiency particulate air
HLW	high-level waste
HWVP	Hanford Waste Vitrification Plant
LHE	latent health effect
LLW	low-level waste
NPF	new pretreatment facility
PUREX	Plutonium-Uranium Extraction
SST	single-shell tank
SW	sludge washing
TRU	transuranic
TRUEX	transuranic extraction

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CALCULATION OF ENVIRONMENT, SAFETY, AND HEALTH ATTRIBUTES FOR DOUBLE-SHELL TANK REMEDIATION ALTERNATIVES

This appendix describes the bases, assumptions, approach, and results of the calculations that were performed to characterize environment, safety, and health attributes for each double-shell tank (DST) remediation alternative. Quantitative impact measures are developed in this appendix for two attributes:

1. Public Health: This attribute measures the impact of the strategy alternatives on public health. Impacts resulting from construction and routine and accident situations are included and are measured for each alternative relative to the other alternatives. This attribute is important to ensure that potential impacts to the public health are quantified. Alternatives that have low probability for health risks due to accidents and routine operations would score high. This attribute encompasses the following subattributes:

   a. The effect of an alternative on the maximum and other credible accidents and the resulting health risks (separate calculations are performed for the radiological effects of accidents and the effects of exposures to accidents involving hazardous chemicals).

   b. Onsite and offsite transportation effects.

2. Worker Safety: This attribute measures the occupational, health, and safety impacts of the strategy alternatives over the period of their construction, transportation, operation, and decontamination and decommissioning (D&D). Worker safety is important to the evaluation of the strategy alternatives because it measures an important element of safety and health. The preferred alternatives are those that minimize the occupational risks. This attribute is influenced by the amount of construction involved, age of infrastructure, types of processes used, danger of materials being handled, and as low as reasonably achievable (ALARA) considerations. The attribute encompasses the following subattributes:

   a. Worker fatality rates over construction, transportation, and operation periods

   b. Radiological routine doses to workers during construction, operation, and transportation activities and resulting health hazard

   c. Chemical hazard to the worker and resulting health hazard.

The calculational procedures that were performed to quantify each of the subattributes are discussed in this appendix.

An important premise of this analysis is that all environment, health, and safety requirements will be met by all facilities associated with DST remediation. All of the facilities, processes, and activities will be constructed and operated within an "acceptable risk envelope." This means that, if unacceptable risks or impacts are identified, facility designs and/or operating strategies will be modified to mitigate the risks to an acceptable level. This may involve process or design changes to reduce the probabilities of accidents or to minimize the consequences of routine emissions and/or exposures and accidental releases. Many of the DST remediation facilities are conceptual and little or no facility design information is available. In addition, facility startup dates are many years in the future. There is ample opportunity to identify and correct unacceptable risks before facility startup dates. Consequently, the quantitative environment, safety, and health attribute values calculated in this study, to some degree, are a measure of the difficulty in achieving reductions in risks relative to current perceptions of DST remediation risks and the existing programs designed to minimize environment, safety, and health impacts.

D1.0 RADIOLOGICAL ACCIDENT IMPACTS

This section describes the analyses that were performed to develop quantitative comparisons of the radiological risks to workers and the general public that could result from accidents during DST remediation. Risk, as defined here, is the product of the frequencies of accidents and its radiological consequences. At this time, there is little applicable risk information on potential DST remediation facilities and operations. Comprehensive risk analyses have not been performed for these operations. For this reason, the risk values developed in this study are considered very preliminary and should not be taken as the absolute risks of any of the DST remediation facilities.

D1.1 BASES AND APPROACH

Existing analyses of the frequencies and consequences of radiological accidents were reviewed to develop the bases for this attribute. The facilities for which accident risk information was collected include waste storage tanks, pretreatment facilities, and the Hanford Waste Vitrification Plant (HWVP). Information was not collected on waste retrieval systems because it is believed that the accident frequencies and consequences for this function are equivalent for all alternatives. Similarly, DST in-tank pretreatment operations are common to all alternatives (except alternative 1 in which the 244-AR Vault is used and alternative 16 in which all pretreatment operations are performed in a new pretreatment facility). No risk information was developed for these systems.

Several basic assumptions were made to develop the risk estimates for this analysis:

- The planned upgrades to the existing facilities [i.e., B Plant and the Plutonium-Uranium Extraction (PUREX) Plant] are assumed to bring the structures, systems, and components of the existing facilities to equivalent capabilities for accident prevention and mitigation relative to a new facility. This is based on the assumption that the upgrades to existing facilities will bring them into compliance with current regulatory requirements and design criteria. The upgrades include such projects as seismic hardening of the B Plant exhaust stack, wall linings to increase earthquake resistance, cell lining to provide double containment, and installation of closed-loop cooling systems.

- Accident risks associated with cesium ion exchange activities, regardless of the facility in which this function is performed, are common to all alternatives.

- Design and operation of secondary waste treatment facilities, such as low-level waste (LLW) evaporators, do not differ substantially among the facility alternatives. No significant risk differences among pretreatment alternatives were attributed to secondary waste treatment.

- Where possible, similar assumptions will be used to characterize the locations of onsite and offsite individuals exposed to radioactive releases.

- Differences among pretreatment facilities will be identified and evaluated wherever possible. The primary differences between pretreatment processes [transuranic extraction (TRUEX) versus sludge washing (SW)] appear to be in the concentrations of radionuclides in the product streams and the acid dissolution operation performed in the TRUEX process that is not done at SW facilities.

- Risk is defined here as the product of accident frequencies and consequences.

A list of the studies from which accident frequency or consequence information was extracted is presented in Section D6.0, "References." A list of accidents and the frequencies and consequences were developed for this study. Each of these accidents is discussed briefly below and summarized in Table D-1.

Table D-1. Radiological Accident Frequencies and Consequences.

Facility		Accident scenario	Frequency		Maximum individual dose (rem)		
			Per year	Source	Onsite	Offsite	Source
Tank storage	1.	Ferrocyanide explosion	1 E-06	Est.	670-6720	0.2-148	Peach 1990
Pretreatment TRUEX alternatives	1.	Blowback into operating gallery	3 E-08	Marusich 1989	4.9	9.2	Marusich 1989
	2.	Hydrogen explosion	1 E-05	Est.	Neg.	0.03	Marusich 1989
	3.	Ion exchange column explosion	1 E-05	Est.	2.1	0.03	Marusich 1989
	4.	Solvent fire	1 E-05	Est.	0.02	0.9	Marusich 1989
	5.	Seismic event; blowback and fire	1 E-05	Marusich 1989	4.9	10	Marusich 1989
	6.	Explosion in dissolver	1 E-04	Est.	6 E-04	1 E-05	Calc.
	7.	Explosion in TRU product storage tank	1 E-05	Est.	3 E-03	6 E-05	Calc.
Pretreatment sludge wash alternatives	1.	Blowback into operating gallery	3 E-08	Marusich 1989	4.9	9.2	Marusich 1989
	2.	Hydrogen explosion	1 E-05	Est.	Neg.	0.03	Marusich 1989
	3.	Ion exchange column explosion	1 E-05	Est.	2.1	3.9	Marusich 1989
	4.	Solvent fire	1 E-05	Est.	0.02	0.9	Marusich 1989
	5.	Seismic event; blowback and fire	1 E-05	Marusich 1989	4.0	10.0	Marusich 1989
	6.	Explosion in sludge tank	1 E-05	Est.	7 E-04	1 E-05	Calc.
	7.	Explosion in dewatered solids tank	1 E-05	Est.	1 E-03	2 E-05	Calc.
HWVP	1a.	TRUEX product storage tank explosion	1 E-05	Est.	3 E-03	6 E-05	Calc.
	1b.	SW product tank explosion	1 E-05	Est.	1 E-03	2 E-05	Calc.
	2.	Loss of filters	1 E-05	Est.	2 E-03	4 E-05	Mishima et al. 1986

Calc. = Calculated
Est. = Estimated
HWVP = Hanford Waste Vitrification Plant
Neg. = Negligible
SW = Sludge washing
TRU = Transuranic
TRUEX = Transuranic extraction.

The general equation used to calculate the risk attributes for each alternative is shown below:

$$R = \sum_f \sum_i N_f * F_{i,f} * C_{i,f}$$

where:

R = Risk attribute
N_f = Number of operating years for each facility
$F_{i,f}$ = Frequency of accident "i" at facility "f"
$C_{i,f}$ = Radiological consequences of accident "i" at facility "f."

As shown, the approach was to multiply the frequencies (F) and radiological consequences (C) of accidents at each facility to develop an annual "risk" value for each accident. These values were then multiplied by the number of years that the respective facilities will be in operation (N). This step results in the total life-cycle risk of each potential accident. For example, the annual frequency of an accident involving a hydrogen explosion in a pretreatment facility storage tank was multiplied by the number of years of pretreatment facility operation in order to factor into the analysis the length of time that the public and workers would be exposed to this accident. The final step was to sum over all the accidents at each facility and then sum over all facilities to obtain the risk attribute for each alternative.

A goal of this analysis was to present this attribute in terms of the projected number of health effects in the exposed population. As shown later, the accident consequence data in the literature focused exclusively on the radiological doses to the maximum exposed onsite and offsite individual. Therefore, additional consequence calculations were performed using the GENII computer code (Naiper et al. 1988) and radionuclide release quantities given in the literature to develop population dose estimates (i.e., integrated doses to entire exposed population in units of person-rem). The population doses were converted to health effects using a health effects conversion factor of 2×10^{-4} latent health effects (LHE) per person-rem. However, this is not possible for the radiological consequences to workers (worker population onsite is not well characterized in terms of location and emergency evacuation effectiveness). Consequently, it was decided to leave the radiological accident consequences to workers in units of rem to the maximum exposed individual. This still results in a quantitative attribute for comparison purposes, but it is not directly comparable to the public accident risk values.

D1.2 DISCUSSION OF ACCIDENT SEQUENCES, FREQUENCIES, AND CONSEQUENCES

This section describes the results of a review of the information in the literature related to the frequencies and consequences of potential accidents at DST remediation facilities. These data formed the basis for the subsequent radiological accident risk calculations for each alternative. Accidents involving single-shell tanks (SST) are discussed first, followed by DST pretreatment facilities and then the HWVP.

D1.2.1 Tank Waste Storage

The risks associated with continued storage of tank wastes until pretreatment facilities become available are discussed in this section. Previous safety analyses have identified and evaluated a number of different types of tank waste accidents, such as ventilation and/or filtration system failures, tank pressurizations or "bumps," and heat removal system failures. These accidents are, in general, low-consequence events and are not likely to contribute significantly to the overall risks of tank waste storage operations. It is assumed here that the risk associated with tank storage at the Hanford Site is dominated by potential ferrocyanide explosions that could occur in some of the SSTs. Peach (1990) forms the basis for the tank storage risk estimates. Peach (1990), which produces significantly higher consequence estimates for the ferrocyanide explosion than were presented by DOE (1987), suggests that additional analyses are necessary to more accurately estimate the consequences. Therefore, the uncertainties associated with the results presented by Peach (1990) and DOE (1987) are considered to be high. In light of this large uncertainty, the accident risk values developed below should be considered highly speculative and should not be used as an absolute measure of the risk of a ferrocyanide explosion in a SST.

- **Ferrocyanide Explosion in Single-Shell Tanks**--A number of SSTs at the Hanford Site contain significant concentrations of ferrocyanide precipitates and sodium nitrate. The combination of these materials is potentially explosive, although the waste temperatures are believed to be significantly below the temperature required to initiate the explosive reaction. Because of the low waste temperatures, it is believed that the probability of an explosion is extremely unlikely; however, the possibility of such a reaction cannot be dismissed. Based on the statement that the probability is extremely unlikely, a frequency of 1×10^{-6}/yr is assigned to this accident scenario.

  Peach (1990) was used as the basis for the consequences of a tank explosion. It was stated in Peach (1990) that the offsite consequences of a tank explosion used in this analysis ranged from 0.2 to 148 rem for the maximum exposed individual. This individual was assumed to be located on the site boundary 20 mi northwest of the tanks ($\chi/Q = 2.2 \times 10^{-5}$ s/m^3). The maximum individual onsite dose was estimated to be in the range 670 to 6,720 rem. This individual was assumed to be located 0.5 mi from the tanks ($\chi/Q = 1 \times 10^{-3}$ s/m^3). Ground-level releases were assumed. Doses were calculated for the inhalation pathway only (breathing rate = 2.3×10^{-4} m^3/s).

  Although the present study deals with pretreatment alternatives for DST wastes, the schedules for the DST pretreatment alternatives differ. Since SST waste pretreatment is assumed to follow the DST wastes, the alternatives that complete faster pretreatment of DST wastes are able to begin treatment of SST wastes sooner than the alternatives that treat DST wastes on a slower schedule. This means that there is a potential risk savings that results from

The risks of ferrocyanide explosions in SSTs is believed to be significantly higher than the risks associated with waste storage in DSTs. As a result, the potential risk reduction associated with faster treatment of SST wastes will dominate the risks of DST waste storage. Any risk increases or reductions associated with DST storage will be small in comparison with SST waste storage risks.

D1.2.2 Double-Shell Tank Waste Pretreatment

A study by Marusich (1989) provides the basis for most of the accident frequencies and consequences associated with DST waste pretreatment facilities. Some additional calculations were performed to highlight the differences in risks between the TRUEX and SW alternatives.

- **Blowback into Operating Gallery**--This accident scenario involves pressurization of a tank in the pretreatment facility and simultaneous rupture of a line from the operating gallery into the tank (e.g., chemical addition line or instrument dip tube). Such accidents are prevented by maintaining the vessel ventilation system, backflow preventers or seal pots, and by reducing the pressure in pressurized lines (e.g., steam lines) entering the tanks. Marusich estimated the frequency of such events at 3×10^{-8}/yr. The consequences were calculated for the maximum onsite individual to be 4.9 rem and for the maximum offsite individual to be 9.2 rem. A release quantity of 1,153 Ci of ^{137}Cs was calculated. No differences in probabilities and consequences were identified for SW versus TRUEX processes because this accident occurs in the cesium concentrator which is present in both SW and TRUEX facilities.

- **Hydrogen Explosion**--Hydrogen generated by radiolysis of solutions in process tanks may build to explosive concentrations if vessel vent flow is interrupted for a period of time. The frequency of such an event is believed to be unlikely because the time required to generate sufficient hydrogen would allow sufficient time to recover the vessel vent system in most cases. Therefore, a frequency of 1×10^{-5}/yr was assigned to this accident.

  Calculations performed by Marusich indicated that the pressure increase that would result from a hydrogen explosion is not sufficient to fail the high-efficiency particulate air (HEPA) filters. Therefore, only a small fraction of the radioactive material (1 part on 50,000) was estimated to be released through the facility's ventilation system. A total of 4.2 Ci was calculated to be released. The maximum individual onsite dose from this accident was calculated to be negligible. The maximum individual offsite dose was calculated to be 0.03 rem. As with the blowback accident, no significant differences between the TRUEX and SW processes were identified.

- **Ion Exchange Column Explosion**--Dilute nitric acid is pumped from a batch tank through an ion exchange column to remove sodium and cesium from the resin. If concentrated nitric acid is pumped through the column, a rapid chemical reaction occurs. There are specific gravity and conductivity monitoring instruments in the batch tank to alert operators of the nitric acid concentrations. Both instruments are interlocked to the pump. Therefore, for this accident to occur, an operator must inadvertently pump concentrated nitric acid into the column and at least two independent instrument errors must occur. The frequency of this accident was estimated to be about 1×10^{-5}/yr.

  The consequences of this accident were estimated by Marusich (1989) as follows. The maximum individual onsite dose was estimated to be 2.1 rem. The maximum individual onsite dose was estimated to be about 3.9 rem. These doses were calculated based on a release quantity of about 500 Ci of ^{137}Cs. No differences between TRUEX and SW processing were identified.

- **Solvent Fire**--A number of organic solvents are currently in B Plant. Additional organics will be added to B Plant if the TRUEX process is implemented there. Little or no flammable organics will be required for the SW process. The situation is similar if the PUREX Plant is used for pretreatment of DST wastes; for example, solvents are currently at the PUREX Plant and the TRUEX process requires more organic materials than SW. If a new pretreatment facility (NPF) is constructed, there will not be a pre-existing inventory of flammable organic materials. Therefore, from this standpoint, an NPF would present a smaller hazard in terms of solvent fires than would the PUREX Plant or B Plant.

  Marusich (1989) concluded that the primary concern of this accident involves release through the filters (i.e., breakthrough) should a solvent fire occur. The quantity of material released was estimated to be 198 Ci. The maximum individual onsite dose was calculated to be 0.02 rem. The maximum individual offsite dose was calculated to be 0.9 rem.

- **Seismic Event - Blowback and Fire**--This event is similar to the blowback accident described above except that it is initiated by a seismic event. The frequency of the seismic event was estimated by Marusich (1989) to be 1×10^{-4}/yr. A factor of 0.1 representing the conditional probability that the seismic event causes the component failures that result in the blowback accident was multiplied by the seismic event frequency to calculate the frequency of this accident. Therefore, the frequency of the seismic event/blowback/fire accident was estimated to be 1×10^{-5}/yr.

  The consequences of this accident were given by Marusich (1989) as follows. The maximum individual onsite dose was calculated to be 4 rem. The maximum individual offsite dose was calculated to be 10 rem. No differences between TRUEX and SW processing were identified.

- **Explosion in Dissolver (TRUEX) and Dewatered Storage Tank (SW)**--The frequency and consequences of this event were estimated in this study to illustrate the differences in accident risks between TRUEX and SW processing. One major processing difference is that the DST sludges are dissolved in nitric acid in the TRUEX process. This presents the potential for a vigorous chemical reaction within the dissolver or radiolytic decomposition of the dissolver solution and generation of hydrogen gas. Either scenario presents the potential for an explosion within the dissolver. Hydrogen gas generation could potentially produce an explosion within the dewatered solids storage tank used in the SW process. The dewatered solids storage tank was chosen for this analysis because it contains the solution with the highest concentration of radionuclides in the SW processing step. A frequency of 1×10^{-4}/yr was estimated for the TRUEX dissolver explosion scenario. A frequency of 1×10^{-5}/yr was estimated for the SW sludge tank explosion. The TRUEX explosion frequency was judged to be higher than the SW explosion because of the addition of nitric acid to the TRUEX dissolver.

  The consequences of these events were estimated using the methods and data described in Peach (1990) for the ferrocyanide explosion. All of the radioactive constituents in the dissolved DST sludge and dewatered solids solutions were included in the analysis. The calculations are shown in Tables D-2 and D-3. As shown, the maximum individual onsite dose for TRUEX dissolver accident was calculated to be 6×10^{-4} rem, and the maximum offsite dose was 1×10^{-5} rem. For the dewatered solids explosion, the maximum individual onsite dose was calculated to be 7×10^{-4} rem and the maximum offsite dose was calculated to be 1×10^{-5} rem.

- **Explosion in TRUEX and SW Product Storage Tank**--A second major difference between TRUEX and SW processing is the makeup of the product streams. The TRUEX process produces a concentrated TRU stream whereas the SW process produces a larger volume of product that has lower concentrations of TRU radionuclides. As a result, the frequencies and consequences were developed for a severe accident (explosion) involving storage tanks for the products from the two processes, such an explosion could be caused by a buildup of hydrogen gas from radiolytic decomposition of the product within the tank. The frequencies of both accidents were estimated to be 1×10^{-5}/yr. It was judged that the frequencies were approximately equal because it appears that radiolytic generation of hydrogen gas is the only mechanism that results in a potential for explosion in both types of tanks (i.e., organic contents are low; pH approximately the same).

  The consequences of these accidents were estimated in the same manner as those estimated for the TRUEX dissolver and SW tanks. These calculations are presented in Tables D-4 and D-5. For the TRUEX product accident, the maximum individual onsite and offsite doses were calculated to be 3×10^{-3} and 6×10^{-5} rem, respectively. For the SW product accident, the onsite and offsite doses were calculated to be 1×10^{-3} and 2×10^{-5} rem, respectively.

Table D-2. Consequences of Explosion in Transuranic Extraction Dissolver.

Radionuclide	Tank inventory (Ci)	Explosion release fraction[a]	Release quantity (Ci)	χ/Q (sec/m^3)[b]		Dose conversion factor (rem/μCi)[c]	Breathing rate[b] (m^3/sec)	Maximum individual dose (rem)	
				Onsite	Offsite			Onsite	Offsite
^{60}Co	4.14 E+00	6.0000 E-09	2.48 E-08	1.00 E-03	2.20 E-05	3.00 E-02	2.30 E-04	1.71 E-10	3.77 E-12
^{63}Ni	1.26 E+02	6.0000 E-09	7.56 E-07	1.00 E-03	2.20 E-05	3.00 E-03	2.30 E-04	5.22 E-10	1.15 E-11
^{90}Sr	2.07 E+03	6.0000 E-09	1.24 E-05	1.00 E-03	2.20 E-05	1.30 E+00	2.30 E-04	3.71 E-06	8.17 E-08
^{99}Tc	6.21 E+00	6.0000 E-09	3.72 E-08	1.00 E-03	2.20 E-05	3.20 E-05	2.30 E-04	2.74 E-13	6.03 E-15
^{106}Ru	4.14 E+01	6.0000 E-09	2.48 E-07	1.00 E-03	2.20 E-05	4.40 E-01	2.30 E-04	2.51 E-08	5.53 E-10
^{125}Sb	4.14 E+01	6.0000 E-09	2.48 E-07	1.00 E-03	2.20 E-05	9.80 E-03	2.30 E-04	5.60 E-10	1.23 E-11
^{134}Cs	5.22 E-02	6.0000 E-09	3.13 E-10	1.00 E-03	2.20 E-05	4.70 E-02	2.30 E-04	3.38 E-12	7.44 E-14
^{137}Cs	1.08 E+02	6.0000 E-09	6.48 E-07	1.00 E-03	2.20 E-05	3.20 E-02	2.30 E-04	4.77 E-09	1.05 E-10
^{144}Ce	4.14 E+01	6.0000 E-09	2.48 E-07	1.00 E-03	2.20 E-05	3.50 E-01	2.30 E-04	2.00 E-08	4.40 E-10
^{152}Eu	4.14 E+00	6.0000 E-09	2.48 E-08	1.00 E-03	2.20 E-05	7.60 E-04	2.30 E-04	4.34 E-12	9.55 E-14
^{154}Eu	4.14 E+01	6.0000 E-09	2.48 E-07	1.00 E-03	2.20 E-05	2.60 E-01	2.30 E-04	1.48 E-08	3.27 E-10
^{155}Eu	4.14 E+01	6.0000 E-09	2.48 E-07	1.00 E-03	2.20 E-05	3.90 E-02	2.30 E-04	2.23 E-09	4.90 E-11
^{237}Np	2.86 E-02	6.0000 E-09	1.71 E-10	1.00 E-03	2.20 E-05	7.10 E-02	2.30 E-04	2.80 E-12	6.15 E-14
^{239}Pu	1.28 E+02	6.0000 E-09	7.70 E-07	1.00 E-03	2.20 E-05	5.10 E+02	2.30 E-04	9.03 E-05	1.99 E-06
^{240}Pu	4.72 E+01	6.0000 E-09	2.83 E-07	1.00 E-03	2.20 E-05	5.10 E+02	2.30 E-04	3.32 E-05	7.31 E-07
^{241}Am	6.02 E+02	6.0000 E-09	3.61 E-06	1.00 E-03	2.20 E-05	5.20 E+02	2.30 E-04	4.32 E-04	9.50 E-06
^{244}Cm	1.70 E+00	6.0000 E-09	1.02 E-08	1.00 E-03	2.20 E-05	2.70 E+02	2.30 E-04	6.32 E-07	1.39 E-08

[a]Source: Mishima et al. 1986.
[b]Source: Peach 1990.
[c]Source: DOE 1988. Consequences were calculated for the inhalation pathway only.

Table D-3. Consequences of Explosion in Sludge Washing Sludge Storage Tank.

Radionuclide	Tank inventory (Ci)	Explosion release fraction[a]	Release quantity (Ci)	χ/Q (sec/m^3)[b]		Dose conversion factor (rem/μCi)[c]	Breathing rate[b] (m^3/sec)	Maximum individual dose (rem)	
				Onsite	Offsite			Onsite	Offsite
^{60}Co	4.96 E+00	6.0000 E-09	2.98 E-08	1.00 E-03	2.20 E-05	3.00 E-02	2.30 E-04	2.05 E-10	4.52 E-12
^{63}Ni	1.47 E+02	6.0000 E-09	8.82 E-07	1.00 E-03	2.20 E-05	3.00 E-03	2.30 E-04	6.09 E-10	1.34 E-11
^{90}Sr	2.39 E+03	6.0000 E-09	1.44 E-05	1.00 E-03	2.20 E-05	1.30 E+00	2.30 E-04	4.29 E-06	9.45 E-08
^{99}Tc	1.47 E+00	6.0000 E-09	8.82 E-09	1.00 E-03	2.20 E-05	3.20 E-05	2.30 E-04	6.49 E-14	1.43 E-15
^{106}Ru	4.96 E+01	6.0000 E-09	2.98 E-07	1.00 E-03	2.20 E-05	4.40 E-01	2.30 E-04	3.01 E-08	6.62 E-10
^{125}Sb	4.96 E+01	6.0000 E-09	2.98 E-07	1.00 E-03	2.20 E-05	9.80 E-03	2.30 E-04	6.71 E-10	1.48 E-11
^{129}I	2.05 E-03	6.0000 E-09	1.23 E-11	1.00 E-03	2.20 E-05	1.80 E-01	2.30 E-04	5.10 E-13	1.12 E-14
^{134}Cs	1.23 E+00	6.0000 E-09	7.39 E-09	1.00 E-03	2.20 E-05	4.70 E-02	2.30 E-04	7.99 E-11	1.76 E-12
^{137}Cs	2.39 E+03	6.0000 E-09	1.44 E-05	1.00 E-03	2.20 E-05	3.20 E-02	2.30 E-04	1.06 E-07	2.33 E-09
^{144}Ce	4.96 E+01	6.0000 E-09	2.98 E-07	1.00 E-03	2.20 E-05	3.50 E-01	2.30 E-04	2.40 E-08	5.27 E-10
^{152}Eu	4.96 E+00	6.0000 E-09	2.98 E-08	1.00 E-03	2.20 E-05	7.60 E-04	2.30 E-04	5.20 E-12	1.14 E-13
^{154}Eu	4.96 E+01	6.0000 E-09	2.98 E-07	1.00 E-03	2.20 E-05	2.60 E-01	2.30 E-04	1.78 E-08	3.91 E-10
^{155}Eu	4.96 E+01	6.0000 E-09	2.98 E-07	1.00 E-03	2.20 E-05	3.90 E-02	2.30 E-04	2.67 E-09	5.87 E-11
^{237}Np	5.90 E-03	6.0000 E-09	3.54 E-11	1.00 E-03	2.20 E-05	7.10 E-02	2.30 E-04	5.78 E-13	1.27 E-14
^{239}Pu	1.48 E+02	6.0000 E-09	8.91 E-07	1.00 E-03	2.20 E-05	5.10 E+02	2.30 E-04	1.04 E-04	2.30 E-06
^{240}Pu	5.51 E+01	6.0000 E-09	3.30 E-07	1.00 E-03	2.20 E-05	5.10 E+02	2.30 E-04	3.88 E-05	8.53 E-07
^{241}Am	7.11 E+02	6.0000 E-09	4.27 E-06	1.00 E-03	2.20 E-05	5.20 E+02	2.30 E-04	5.10 E-04	1.12 E-05
^{244}Cm	1.96 E+00	6.0000 E-09	1.18 E-08	1.00 E-03	2.20 E-05	2.70 E+02	2.30 E-04	7.31 E-07	1.61 E-08
							TOTAL	6.59 E-04	1.45 E-05

[a]Source: Mishima et al. 1986.
[b]Source: Peach 1990.
[c]Source: DOE 1988. Consequences were calculated for the inhalation pathway only.

Table D-4. Consequences of Explosion in Transuranic Extraction Product Storage Tank.

Radionuclide	Tank inventory (Ci)	Explosion release fraction[a]	Release quantity (Ci)	χ/Q (sec/m^3)[b]		Dose conversion factor (rem/µCi)[c]	Breathing rate[b] (m^3/sec)	Maximum individual dose (rem)	
				Onsite	Offsite			Onsite	Offsite
^{237}Np	1.37 E-01	6.0000 E-09	8.22 E-10	1.00 E-03	2.20 E-05	7.10 E-02	2.30 E-04	1.34 E-11	2.95 E-13
^{239}Pu	6.06 E+02	6.0000 E-09	3.63 E-06	1.00 E-03	2.20 E-05	5.10 E+02	2.30 E-04	4.26 E-04	9.38 E-06
^{240}Pu	2.25 E+02	6.0000 E-09	1.35 E-06	1.00 E-03	2.20 E-05	5.10 E+02	2.30 E-04	1.58 E-04	3.48 E-06
^{241}Am	2.83 E+03	6.0000 E-09	1.70 E-05	1.00 E-03	2.20 E-05	5.20 E+02	2.30 E-04	2.03 E-03	4.47 E-05
^{244}Cm	8.01 E+00	6.0000 E-09	4.81 E-08	1.00 E-03	2.20 E-05	2.70 E+02	2.30 E-04	2.98 E-06	6.57 E-08
							TOTAL	2.62 E-03	5.77 E-05

[a]Source: Mishima et al. 1986.
[b]Source: Peach 1990.
[c]Source: DOE 1988. Consequences were calculated for the inhalation pathway only.

Table D-5. Consequences of Explosion in Sludge Washing Dewatered Solids Storage Tank.

Radionuclide	Tank inventory (Ci)	Explosion release fraction[a]	Release quantity (Ci)	χ/Q (sec/m^3)[b]		Dose conversion factor (rem/μCi)[c]	Breathing rate[b] (m^3/sec)	Maximum individual dose (rem)	
				Onsite	Offsite			Onsite	Offsite
^{60}Co	7.87 E+00	6.0000 E-09	4.72 E-08	1.00 E-03	2.20 E-05	3.00 E-02	2.30 E-04	3.26 E-10	7.16 E-12
^{63}Ni	2.39 E+02	6.0000 E-09	1.44 E-06	1.00 E-03	2.20 E-05	3.00 E-03	2.30 E-04	9.91 E-10	2.18 E-11
^{90}Sr	3.93 E+03	6.0000 E-09	2.36 E-05	1.00 E-03	2.20 E-05	1.30 E+00	2.30 E-04	7.06 E-06	1.55 E-07
^{99}Tc	5.99 E-01	6.0000 E-09	3.59 E-09	1.00 E-03	2.20 E-05	3.20 E-05	2.30 E-04	2.64 E-14	5.81 E-16
^{106}Ru	7.87 E+01	6.0000 E-09	4.72 E-07	1.00 E-03	2.20 E-05	4.40 E-01	2.30 E-04	4.78 E-08	1.05 E-09
^{125}Sb	7.87 E+01	6.0000 E-09	4.72 E-07	1.00 E-03	2.20 E-05	9.80 E-03	2.30 E-04	1.06 E-09	2.34 E-11
^{129}I	7.87 E-04	6.0000 E-09	4.72 E-12	1.00 E-03	2.20 E-05	1.80 E-01	2.30 E-04	1.95 E-13	4.30 E-15
^{134}Cs	3.93 E-01	6.0000 E-09	2.36 E-09	1.00 E-03	2.20 E-05	4.70 E-02	2.30 E-04	2.55 E-11	5.61 E-13
^{137}Cs	7.87 E+02	6.0000 E-09	4.72 E-06	1.00 E-03	2.20 E-05	3.20 E-02	2.30 E-04	3.47 E-08	7.64 E-10
^{144}Ce	7.87 E+01	6.0000 E-09	4.72 E-07	1.00 E-03	2.20 E-05	3.50 E-01	2.30 E-04	3.80 E-08	8.36 E-10
^{152}Eu	7.87 E+00	6.0000 E-09	4.72 E-08	1.00 E-03	2.20 E-05	7.60 E-04	2.30 E-04	8.25 E-12	1.81 E-13
^{154}Eu	7.87 E+01	6.0000 E-09	4.72 E-07	1.00 E-03	2.20 E-05	2.60 E-01	2.30 E-04	2.82 E-08	6.21 E-10
^{155}Eu	7.87 E+01	6.0000 E-09	4.72 E-07	1.00 E-03	2.20 E-05	3.90 E-02	2.30 E-04	4.23 E-09	9.31 E-11
^{237}Np	5.43 E-02	6.0000 E-09	3.26 E-10	1.00 E-03	2.20 E-05	7.10 E-02	2.30 E-04	5.32 E-12	1.17 E-13
^{239}Pu	2.44 E+02	6.0000 E-09	1.46 E-06	1.00 E-03	2.20 E-05	5.10 E+02	2.30 E-04	1.72 E-04	3.78 E-06
^{240}Pu	9.05 E+01	6.0000 E-09	5.43 E-07	1.00 E-03	2.20 E-05	5.10 E+02	2.30 E-04	6.37 E-05	1.40 E-06
^{241}Am	1.15 E+03	6.0000 E-09	6.89 E-06	1.00 E-03	2.20 E-05	5.20 E+02	2.30 E-04	8.25 E-04	1.81 E-05
^{244}Cm	3.23 E+00	6.0000 E-09	1.94 E-08	1.00 E-03	2.20 E-05	2.70 E+02	2.30 E-04	1.20 E-06	2.64 E-08
							TOTAL	1.07 E-03	2.35 E-05

[a]Source: Mishima et al. 1986.
[b]Source: Peach 1990.
[c]Source: DOE 1988. Consequences were calculated for the inhalation pathway only.

D1.2.3 Hanford Waste Vitrification Plant Accidents

- Product Storage Tank Explosion--Pretreatment product is stored within the HWVP and transferred to the glass melter. It was assumed that the frequencies and consequences of explosions in the HWVP storage tanks are equal to those calculated previously for product storage in TRUEX or SW facilities.

- Loss of Filters--Mishima et al. (1986) evaluated the consequences of an accidental loss of filtration of exhaust air emitted from the HWVP. It was assumed that total loss of all filtration occurs and that the entire inventory of material airborne in the HWVP canyon is released without filtration. This was judged to be an unlikely event and will be assigned a frequency of 1×10^{-5}/yr. Mishima (1986) calculated the consequences of this event to be 2×10^{-3} rem to the maximum onsite individual and 4×10^{-5} rem to the maximum offsite individual.

D1.3 CALCULATION OF ACCIDENT RISK IMPACTS FOR EACH ALTERNATIVE

Accident risks were defined as the product of the accident frequencies and probabilities. As discussed previously, the radiological consequences to the public were first converted from individual radiological dose estimates to population dose estimates. This was done in two steps. The first step was to apply the GENII computer code to the SST ferrocyanide explosion accident and calculate the population doses that would result from this accident. The population doses from the other accidents were assumed to be linear with respect to the dose to the maximum exposed offsite individual. The population doses for the remaining accidents were, therefore, estimated by multiplying the population dose from the SST ferrocyanide explosion by the ratio of the individual dose for the remaining accidents to the individual dose from the ferrocyanide explosion. The resulting population doses were then converted to health effects using a conversion factor.

The conversion of individual doses to population doses for workers was not performed for the reasons discussed previously. The results of the worker risk calculations yield risk values in terms of the projected annual radiological dose to the maximum exposed individuals (i.e., measured in units of rem/yr). Because the pretreatment alternatives differ in terms of the length of time required before the processing of SSTs will begin, the length of pretreatment operations, and the length of DST waste vitrification operations at HWVP, the annual risk estimates will be integrated over their respective operating years to calculate the total radiological accident risk over these operating timeframes. This final step (i.e., multiplying by operating durations) was performed for population risks as well as for worker risks.

Total operating risk values were calculated for SSTs, pretreatment facilities, and HWVP. The annual risk calculations were performed by multiplying the accident frequencies and consequences presented in Table A-1 and then summing over the risk values for the different accident scenarios. This resulted in the annual risk values presented in Table D-6. Note that

Table D-6. Total Annual Risk Values for Each Double-Shell Tank Processing Facility.

Facility	Accident scenario	Frequency per year[d]	Consequences onsite	Rem[a] offsite	Worker risk (rem/yr)[b]	Offsite[c] consequences (person-rem)	Offsite[d] risk (person-rem/yr)
SST Storage	FeCn Explosion	1.00 E-06	6.72 E+03	1.48 E+02	6.72 E-03	8.60 E+03[e]	8.60 E-03
Pretreatment with TRUEX	Blowback	3.00 E-08	4.90 E+00	9.20 E+00	1.47 E-07	5.35 E+02	1.60 E-05
	Hydrogen explosion	1.00 E-05	0.00 E+00	3.00 E-02	0.00 E+00	1.74 E+00	1.74 E-05
	Ion exchange column explosion	1.00 E-05	2.10 E+00	3.90 E+00	2.10 E-05	2.27 E+02	2.27 E-03
	Solvent fire	1.00 E-05	2.00 E-02	9.00 E-01	2.00 E-07	5.23 E+01	5.23 E-04
	Seismic blowback	1.00 E-05	4.90 E+00	1.00 E+01	4.90 E-05	5.81 E+02	5.81 E-03
	Dissolver explosion	1.00 E-04	6.00 E-04	1.00 E-05	6.00 E-08	5.81 E-04	5.81 E-08
	Product explosion	1.00 E-05	3.00 E-03	6.00 E-05	3.00 E-08	3.49 E-03	3.49 E-08
				TOTAL	7.04 E-05	TOTAL	8.63 E-03
Pretreatment with SW	Blowback	3.00 E-08	4.90 E+00	9.20 E+00	1.47 E-07	5.35 E+02	1.60 E-05
	Hydrogen explosion	1.00 E-05	0.00 E+00	3.00 E-02	0.00 E+00	1.74 E-05	1.74 E-05
	Ion exchange column explosion	1.00 E-05	2.10 E+00	3.90 E+00	2.10 E-05	2.27 E+02	2.27 E-03
	Solvent fire	1.00 E-05	2.00 E-02	9.00 E-01	2.00 E-07	5.23 E+01	5.23 E-04
	Seismic/blowback	1.00 E-05	4.90 E+00	1.00 E+01	4.90 E-05	5.81 E+02	5.81 E-03
	Sludge tank explosion	1.00 E-05	7.00 E-04	1.00 E-05	7.00 E-09	5.81 E-04	5.81 E-09
	Product explosion	1.00 E-05	1.00 E-03	2.00 E-05	1.00 E-08	1.16 E-03	1.16 E-03
				TOTAL	7.04 E-05	TOTAL	8.63 E-03
HWVP with TRUEX	Feed tank explosion	1.00 E-05	3.00 E-03	5.00 E-05	3.00 E-08	2.91 E-03	2.91 E-08
	Filter failure	1.00 E-05	2.00 E-03	4.00 E-05	2.00 E-08	2.32 E-03	2.32 E-08
				TOTAL	5.00 E-08	TOTAL	5.23 E-08
HWVP with SW	Feed tank explosion	1.00 E-05	1.00 E-03	2.00 E-05	1.00 E-08	1.16 E-03	1.16 E-08
	Filter failure	1.00 E-05	2.00 E-03	4.00 E-05	2.00 E-08	2.32 E-03	2.32 E-08
				TOTAL	3.00 E-08	TOTAL	3.49 E-08

[a]Source: see text.
[b]Product of accident frequency and onsite dose consequences.
[c]Obtained by multiplying population dose from SST ferrocyanide accident by the ratio of the offsite individual doses from other accidents to offsite individual dose from SST accident.
[d]Product accident frequency and offsite population dose.
[e]Calculated using the GENII computer code. Used as the basis for the population from the remaining accidents.
HWVP = Hanford Waste Vitrification Plant
SST = Single-shell tank
SW = Sludge washing
TRUEX = Transuranic extraction.

there is no significant differences between the total annual risk estimates for the facilities which incorporate the TRUEX process relative to the SW process. This is because the higher frequency TRUEX accidents do not contribute significantly to the total annual facility risk. These annual risk estimates were multiplied by the appropriate operating times and then summed over the facilities to arrive at the estimated total risk impacts for each alternative. These calculations are presented in Table D-7.

D1.4 OBSERVATIONS REGARDING ACCIDENT RISKS

A number of observations regarding the risks of accidental releases of radioactive material were noted during this study. These observations are summarized below.

- Based on the magnitude of the risks of SST waste explosions, the risk reduction associated with processing of these wastes will remove them as potential hazards; this far outweighs the risks of DST waste pretreatment and vitrification operations. It should be noted that the uncertainties relative to the frequencies and consequences of SST waste explosions is very high. The consequences of such explosions ranged from 1 rem (DOE 1987) to over 6,700 rem (Peach 1990).

- Pretreatment alternatives involving the TRUEX process are likely to have somewhat higher accident risks than alternatives involving SW because of the hazardous chemicals involved.

- The product streams generated by the TRUEX process are more hazardous from a radiological standpoint than the product stream generated by SW facilities. This is because the TRUEX product sent to HWVP contains higher concentrations of TRU radionuclides than does the SW product stream. However, this difference is offset by the much higher volumes of product generated by the SW process.

- Based on the dose calculations performed in this study (i.e., consequences of explosions in the TRUEX dissolver, TRU product storage tank, DST waste sludge tank, and dewatered solids tank), the consequences of accidents appear to be dominated by releases of TRU radionuclides. Use of only ^{137}Cs releases may tend to understate the consequences of accidents.

- The risk estimates developed in this study are very preliminary and should not be used as any measure of the absolute risk presented by a facility or processing alternative. They are, however, believed to be suitable for comparisons among DST pretreatment alternatives.

Table D-7. Summary of Radiological Accident Risk Results for Each Double-Shell Tank Pretreatment Alternative.

Alternative	Onsite (rem)	Offsite fatalities
1	0.10	5.0 E-05
2	0.10	5.0 E-05
3	0.10	3.4 E-05
4	0.13	4.0 E-05
5	0.13	3.8 E-05
6	0.13	4.0 E-05
7	0.13	4.0 E-05
8	0.10	3.7 E-05
9	0.10	3.8 E-05
10	0.13	4.1 E-05
11	0.13	4.0 E-05
12	0.13	4.0 E-05
13	0.13	4.0 E-05
14	0.13	3.8 E-05
15	0.13	4.0 E-05
16	0.13	4.3 E-05

D2.0 WORKER ROUTINE RADIOLOGICAL IMPACTS

This attribute is defined as the radiation doses that will be received by workers during normal construction and operations of the DST pretreatment facilities. This attribute will be measured in units of the projected fatalities from routine external radiation exposures. The total pretreatment system impacts will be included; i.e., the radiation doses from the actual pretreatment facilities will be included as well as the doses from DST in-tank processing, HWVP, and the 244-AR Vault, where appropriate. The formulae and data that were used to calculate these impacts are described below. Transportation impacts, which are calculated in a separate section, are included in this attribute.

D2.1 BASES AND APPROACH

Radiological impacts during construction are a function of the resource requirements in radiation zones and the average dose rates. These impacts were estimated using the following formula:

$$\text{Collective Dose (person-rem)} = SAMPL + \sum_i 0.44 * (C\_LABOR)_i * (DR)_i$$

where:

SAMPL = Annual dose due to process sampling activities
i = Applicable facility
C_LABOR = Labor requirements in radiation zones (person-yr)
DR = Average annual exposure (rem/person-yr).

Each of these parameters is described below. The factor of 0.44 represents the approximate fraction of total facility workers that work in radiation zones at some time during a given year. This factor, which was derived from detailed operating staff requirements for an NPF, was applied to exclude nonradiation workers (e.g., clerical and secretarial support for administrative functions) from the dose calculations.

- C_LABOR--This parameter represents the total labor requirements in radiation zones for construction of DST pretreatment capabilities. The labor estimates used in these calculations were taken from the cost and schedule analysis. The data taken from the cost and schedule analysis were converted from millions of dollars to man-year assuming that 55% of the capital costs were direct labor and using an annual labor rate of $95,000/man-year. It was also assumed that 80% of expense costs were for direct labor. One-hundred percent of the direct labor requirements were assumed to be spent in radiation zones for the applicable facilities. Therefore, the formula used to calculate construction labor requirements in radiation zones was:

  U C_LABOR = [(Cap. Costs)*0.55]/$95,000 per person-yr

  where Cap. Costs (capital costs) were taken directly from the cost and schedule supporting information.

  Many of the facilities to be constructed for DST pretreatment are not applicable to this attribute. These are listed below:

  - B Plant operations: B Plant operations are assumed to be identical for each DST pretreatment alternative and are, therefore, not a discriminating factor.

  - PUREX Plant operations: See B Plant operations above.

- HWVP and NPF construction: None of the work on HWVP, the HWVP annex, and the NPF will be performed in radiation zones. Therefore, the radiation doses during construction will be zero.

- Retrieval operations, waste transfer lines, and tank farm upgrades: The resource requirements for these three functions are identical in all alternatives. They are not included in the total construction requirements.

The following functions are included in the construction and operating labor requirements calculations:

- B Plant facility upgrades
- B Plant pretreatment upgrades
- 244-AR Vault upgrades
- PUREX Plant upgrades
- PUREX Plant pretreatment upgrades
- DST (in-tank) pretreatment.

- DR--The parameter DR represents the annual dose rate received by radiation workers. The actual value of this parameter ranges from a few millirem/yr for some worker categories to as much as the Department of Energy (DOE) limit of 1 rem/yr. A representative average of 200 millirem/yr per radiation worker was used in these calculations. The actual value of this parameter is not important to comparisons among alternatives. This is because the annual average radiation doses to most workers should not vary significantly among alternatives. Radiation dose rate limitations are established in DOE orders based on the occupancy of the specific areas. For example, there are limitations for maximum dose rates in areas that are to be occupied 24 h/d which are different than the maximum allowable dose rate for an area that will be occupied for only short times on an intermittent basis. Therefore, existing facilities will be approximately equivalent to new facilities in terms of the design radiation dose rates. This applies except, perhaps, to workers who will sample intermediate product streams. The annual average dose due to sampling activities is developed below.

- SAMPL--This parameter was introduced because it is believed that the key difference between routine radiation doses projected for existing facilities relative to new facilities will arise from significant differences in process sampling activities. At B Plant, workers are required to enter the canyon to obtain process samples. Based on discussions with B Plant staff, it was estimated that two canyon entries per day are required. Each entry requires three staff (two operators and one health physics technologist) and takes about 45 min per entry. The average canyon deck exposure rate is 50 mrem/h. This works out to an average annual dose due to sampling activities at B Plant of about 56 person-rem/yr.

At the PUREX Plant, process samples are obtained from sample "caves" located in the operating gallery. Thus, the source of their radiation exposures is primarily the external dose rate in the operating gallery. The average dose rate in the operating gallery is about 10 mrem/h. Assuming that each sample requires three staff members approximately 45 min and samples are taken twice daily, the average annual radiation dose due to sampling activities at the PUREX Plant is estimated to be 11.25 person-rem/yr.

New facilities may be designed for remote sampling operations. In this analysis, the radiation doses due to sampling activities at new facilities are assumed to be zero.

D2.2 SUMMARY OF ROUTINE RADIOLOGICAL IMPACTS TO WORKERS

The collective routine doses to workers were calculated by adding together the doses from construction, operations, and sampling activities. The resulting doses were then converted to fatalities using a factor that converts collective doses to fatalities (or latent health effects) in the exposed population. The exposed population in this case is the DST remediation workers. The conversion factor used here is 2×10^{-4} LHEs per person-rem. Latent health effects are defined as the sum of latent cancer fatalities and first- and second-generation genetic effects that are presumed to be fatal. The results are presented in Table D-8.

D3.0 NONRADIOLOGICAL IMPACTS OF ACCIDENTS TO WORKERS

This attribute includes the fatalities from industrial-type accidents that are projected to occur during DST remediation activities. These accidents are not related to the radiological or chemical hazards associated with DST remediation activities. Rather, they are related to Occupational Safety and Health Administration (OSHA)-type hazards such as accidents involving heavy equipment during construction, crane- or heavy-lifting-related accidents, and falls from ladders or elevated structures. Transportation impacts, which are calculated in a separate section, are included in this attribute.

Table D-8. Summary of Routine Radiological Impacts to Double-Shell Tank Remediation Workers.

Alternative	Construction	Operation	Transportation[a]	Total
1	0.18	1.1	0.0004	1.3
2	0.19	1.1	0.0004	1.3
3	0.13	1.7	0.0028	1.8
4	0.04	1.2	0.0004	1.2
5	0.04	1.2	0.0006	1.2
6	0.03	1.8	0.0028	1.8
7	0.03	1.3	0.0011	1.3
8	0.16	1.2	0.0004	1.4
9	0.15	1.8	0.0028	2.0
10	0.03	1.6	0.0028	1.6
11	0.06	1.2	0.0004	1.3
12	0.06	1.9	0.0028	1.9
13	0.04	1.2	0.0004	1.2
14	0.04	1.2	0.0005	1.2
15	0.03	1.8	0.0028	1.8
16	0.03	1.1	0.0003	1.1

NOTE: Components may not add exactly to totals due to rounding errors.

[a]Transportation impact results are calculated in a separate section.

D3.1 BASES AND APPROACH

The general approach to calculating nonradiological accident impacts is to multiply the total labor requirements by an average fatality rate for similar activities. Labor requirements were broken into construction and operating labor because the fatality rates would be different for these activities (i.e., fatality rates during facility construction are significantly higher than those during facility operations). The construction and operations labor requirements that were calculated for the routine radiation dose attribute were also used here.

The fatality rate for construction of facilities was taken from DOE/RW-0074 (DOE 1986) and amounted to 0.17 fatalities per million man-hours. This was converted to 3.4×10^{-4} fatalities/man-year assuming that each worker spends 40 h/week, 50 week/yr on the job (2,000 man-hour/man-year). No data relating specifically to Hanford Site construction projects could be found.

The fatality rate for facility operations was taken from O'Donnell and Hoy (1981). Fatality rates for DST remediation facilities were not addressed in this document. However, fatality rates for other nuclear fuel cycle facilities were addressed. The fatality rate chosen for this analysis was one for gaseous diffusion or gaseous centrifuge enrichment plants, which was stated to be 2.3 x 10^{-3} fatalities per 100 worker-year (2.3 x 10^{-5} fatalities per person-year).

D3.2 NONRADIOLOGICAL IMPACT RESULTS

The results of the nonradiological impact calculations are presented in Table D-9. As shown, the impacts range from about 6 to 12 fatalities. The alternative with the lowest nonradiological impacts to workers was alternative 2 (DST/B Plant with TRUEX) and the highest nonradiological impacts were projected for Alternative 15 (DST/HWVP Limited/NPF without TRUEX). Nonradiological impacts, as expected, were dominated by fatalities resulting from construction activities. It should be noted that accident statistics were not available for Hanford Site construction projects and facility operations. It is expected that the accident rates are somewhat lower than the national averages used in this analysis. Therefore, the nonradiological accident impacts presented in Table D-9 are expected to be somewhat higher than if actual Hanford Site experience were used.

Table D-9. Summary of Routine Radiological Impacts to Double-Shell Tank Remediation Workers.

Alternative	Construction	Operation	Transportation[a]	Total
1	5.4	1.2	0.02	6.7
2	5.2	1.3	0.02	6.5
3	6.2	2.1	0.17	8.4
4	8.4	1.5	0.02	10.0
5	8.5	1.6	0.03	10.1
6	8.8	2.3	0.17	11.3
7	7.8	1.6	0.07	9.5
8	5.5	1.6	0.02	7.1
9	6.5	2.4	0.17	9.0
10	6.6	2.1	0.17	8.8
11	8.6	1.6	0.02	10.1
12	9.0	2.4	0.17	11.5
13	8.9	1.5	0.02	10.4
14	8.8	1.6	0.03	10.4
15	9.2	2.4	0.17	11.7
16	8.9	1.5	0.02	10.4

NOTE: Components may not add exactly to totals due to rounding errors.

[a]Transportation impact results are calculated in a separate section.

D4.0 TRANSPORTATION IMPACTS

This section presents the bases, approach, and results of the transportation impact calculations. Five categories of transportation impacts were calculated. These are described below:

- Public Routine Radiological Impacts--This attribute measures the routine radiological doses to the public when the shipments of radioactive materials reach their destinations without releasing the package contents.

- Worker Routine Radiological Impacts--This attribute measures the routine radiological doses to the workers (truck and rail crewmembers) when the shipments of radioactive materials reach their destinations without releasing the package contents.

- Public Radiological Accident Impacts--This attribute measures the radiological risks (accident frequency times radiological consequences) to the public.

- Public Nonradiological Accident Impacts--This attribute measures the nonradiological risks to the public from vehicular accidents. These impacts are not related to the radiological nature of the cargo.

- Worker Nonradiological Accident Impacts--This attribute measures the nonradiological risks to truck and rail crews from vehicular accidents. These impacts are not related to the radiological nature of the cargo.

These attributes measure the health impacts directly related to transport of the materials over the roadways and rail lines. The impacts associated with loading and handling of shipping containers at the various DST remediation facilities are included in other attributes.

D4.1 BASES AND APPROACH

The principal materials to be shipped by truck or rail from the DST remediation facilities include canisters of vitrified high-level waste (HLW) and solid LLW. A unit risk factor approach was used in this analysis. In this approach, unit risk factors are used to represent the risk per unit distance of travel for each transportation attribute. For example, radiological risk factors are given in units of radiological fatalities per kilometer. For a given attribute, the total risk for each waste type is the product of the unit risk factor, the shipping distance, and the total number of shipments. The total risk for a given pretreatment alternative is the sum of the risks for each waste type. The formula used is summarized below:

$$RISK_i = \sum_m (URF)_{i,m,} * DIST_m * N\_SHIP_m$$

where:

$RISK_i$ = Risk impact for transportation attribute "i"
$URF_{i,m}$ = Unit risk factor for attribute "i" and material "m"
DISTm = Shipping distance for material "m"
N_SHIPm = Number of shipments of material "m."

The data that were used to calculate each of these impacts are presented in the following sections.

D4.1.1 Shipment Data

It was assumed that HLW will be shipped by rail to an offsite disposal repository and LLW will be shipped by truck to the Hanford Site LLW burial ground. The shipping distance for HLW rail shipments was assumed to be 4,800 km, representative of the distance used in the *Final Environmental Impact Statement, Disposal of Hanford Defense High-Level, Transuranic and Tank Wastes, Hanford Site, Richland, Washington* (HDW-EIS) (DOE 1987). Also, the capacity of the rail shipping containers was assumed to be five HLW canisters. Therefore, the total number of shipments was calculated by dividing the total number of canisters developed by the costs and schedule group by five canisters/shipment.

The shipping distance for LLW shipments by truck was assumed to be 20 km one-way. All LLW were assumed to be loaded into Hanford Site general purpose burial boxes having a capacity for about 43 m^3 (1,520 ft^3) of LLW. Each truck shipment was assumed to contain one box. Therefore, the total number of LLW shipments was calculated by dividing the total LLW waste volumes developed by the costs and schedule group by 1,520 ft^3/shipment.

D4.1.2 Unit Risk Factors

Unit risk factors were derived from the HDW-EIS (DOE 1987). The basic approach was to divide the total projected impacts (fatalities) given in the HDW-EIS by the total number of shipments to arrive at the unit risk factors (fatalities/shipment) for each attribute. Some adjustments were necessary to account for different shipping distances. The unit risk factors for HLW canister shipments were derived using data for "future tank wastes" and LLW unit risk factors are based on "retrievable stored TRU waste" data. The unit risk factors for each attribute are shown in Table D-10.

D4.2 RESULTS OF TRANSPORTATION IMPACT CALCULATIONS

The results of the transportation impact calculations are presented in Table D-11. In general, it was determined that transportation impacts are dominated by shipments of HLW to an offsite disposal facility. Consequently, the alternatives that generate the most HLW canisters result in the highest transportation impacts. In general, nonradiological accidents are projected to result in higher transportation impacts than radiological routine exposures which, in turn, result in higher impacts than radiological accidents.

Table D-10. Unit Risk Factors for High-Level Waste and Low-Level Waste Transport.

Risk attribute	HLW canisters	LLW boxes
Public		
Radiological routine, LHE/shipment	1.44 E-06	2.0 E-06
Radiological accidents, LHE/shipment	2.8 E-07	3.2 E-11
Nonradiological accidents, fatalities/shipment	8.2 E-05	9.7 E-07
Worker (truck or rail crew)		
Radiological routine, LHE/shipment	1.36 E-06	1.4 E-06
Nonradiological accidents, fatalities/shipment	6.7 E-06	2.8 E-07

HLW = High-level waste
LHE = Latent health effects
LLW = Low-level waste.

Table D-11. Results of Transportation Impact Calculations for Each Double-Shell Tank Remediation Alternative (Fatalities).

Alternative	Routine radiological		Radiological accident	Nonradiological accident	
	Public	Worker	Public	Public	Worker
1	3.9 E-04	3.7 E-04	7.5 E-05	1.9 E-03	2.2 E-02
2	3.9 E-04	3.7 E-04	7.5 E-05	1.9 E-03	2.2 E-02
3	3.0 E-03	2.8 E-03	5.8 E-04	1.4 E-02	1.7 E-01
4	3.9 E-04	3.6 E-04	7.5 E-05	1.8 E-03	2.2 E-02
5	6.0 E-04	5.7 E-04	1.2 E-04	2.8 E-03	3.4 E-02
6	3.0 E-03	2.8 E-03	5.8 E-04	1.4 E-02	1.7 E-01
7	1.2 E-03	1.1 E-03	2.3 E-04	5.5 E-03	6.7 E-02
8	3.9 E-04	3.6 E-04	7.5 E-05	1.8 E-03	2.2 E-02
9	3.0 E-03	2.8 E-03	5.8 E-04	1.4 E-02	1.7 E-01
10	3.0 E-03	2.8 E-03	5.8 E-04	1.4 E-02	1.7 E-01
11	3.9 E-04	3.6 E-04	7.5 E-05	1.8 E-03	2.2 E-02
12	3.0 E-03	2.8 E-03	5.8 E-04	1.4 E-02	1.7 E-01
13	3.9 E-04	3.6 E-04	7.5 E-05	1.8 E-03	2.2 E-02
14	5.1 E-04	4.8 E-04	9.9 E-05	2.4 E-03	2.9 E-02
15	3.0 E-03	2.8 E-03	5.8 E-04	1.4 E-02	1.7 E-01
16	2.6 E-04	2.5 E-04	5.1 E-05	1.2 E-03	1.5 E-02

D5.0 CHEMICAL ACCIDENT RISKS

This attribute measures the risks associated with accidental releases of hazardous chemicals from DST remediation facilities. These risks are primarily a function of the quantities and types of hazardous chemicals that are used in the DST pretreatment facilities as well as the length of time that the facilities will be in operation (i.e., exposure duration). Therefore, an accident scenario was constructed to develop estimates of the concentrations of hazardous chemicals to which representative onsite and offsite individuals may be exposed. The main difference among DST remediation alternatives that are evaluated here is a comparison of the types and quantities of hazardous chemicals used in the TRUEX process versus sludge washing.

D5.1 BASES AND APPROACH

An accident scenario was constructed for this analysis which involves simultaneous rupture of hazardous chemical storage tanks and spill of all the hazardous chemicals into the storage area. The hazardous chemicals are then assumed to evaporate and be carried into the environment through the facility ventilation system. No filtration or removal of the hazardous vapors by the facility filtration systems was assumed. Once in the environment, the prevailing winds and weather are assumed to transport the hazardous vapors to representative onsite and offsite locations. The concentrations of hazardous chemicals at these locations were then divided by the concentrations which may result in a fatality to the exposed individual. The resulting consequence estimates were then multiplied by the estimated frequency of the accident scenario and the operating duration of the DST pretreatment facility. This produces the overall result which is a measure of the total integrated probability of an individual fatality resulting from this accident scenario.

The concentrations of hazardous chemicals at the respective onsite and offsite locations were calculated using the following procedure. First, the evaporation rate was calculated using the following formula from the *Chemical Engineering Handbook* (Perry 1950) as described by Marusich (1989).

$$w = 0.00138(P_w - P)^{1.2}$$

where:

w = Rate of evaporation, lb/h-ft^2
P_w = Partial pressure of solution vapor, mm Hg
P = Reference - used 0 mm Hg.

The next step was to calculate the release rate by multiplying the rate of evaporation by the area of the spill. A 100-ft^2 spill area was assumed in all the calculations. The concentrations at the onsite and offsite locations were then calculated by multiplying the release rate by the atmospheric dispersion parameter (E/Q) at the respective locations. The E/Q values that were used in the calculations are 0.001 s/m^3 for the onsite worker and 2.2×10^{-5} s/m^3 for the offsite individual. The resulting concentrations of each chemical were then divided by the emergency response planning guideline (ERPG) (NIOSH 1990; AIHA 1991) concentrations [or surrogates as specified in PNL *Safety Analysis Procedures* (PNL 1990)] for each chemical to result in an approximate measure of the probability that the exposed individual receives a lethal dose. This measure of the consequences of the release was then multiplied by the probability of the accident occurring, estimated to be approximately 1×10^{-3}/yr, and the duration of DST pretreatment facility operations to arrive at the final result.

No attempt was made to calculate the long-term effects of exposures to the hazardous chemicals (e.g., carcinogenic effects). This was primarily because of a lack of long-term health effects data for the hazardous chemicals used in DST waste pretreatment and the length of time required to perform the long-term exposure calculations. In any event, it was judged that incorporation of long-term health effects calculations into this attribute was not likely to change the conclusions that would be derived from the short-term exposure calculations described previously. That is, if there are significant differences in hazardous chemical risks among the alternatives, they should appear in the short-term exposure risk calculations.

The ERPG concentrations or surrogates were taken from NIOSH (1990) and AIHA (1991).

D5.2 RESULTS OF CHEMICAL ACCIDENT IMPACT CALCULATIONS

The results of this analysis are presented in Table D-12. As shown in the table, alternatives involving the TRUEX process result in higher chemical accident risks than alternatives involving sludge-washing. This is primarily due to the presence of hydrofluoric acid (HF) and hydrazine (N_2H_4) in TRUEX facilities which are not used in the sludge-washing process.

D6.0 ROUTINE AND NONROUTINE EFFLUENTS

This attribute measures the potential for effluents to affect the environment. Although routine effluents are part of normal operations and pose no environmental hazard, alternatives that minimize effluents are considered more desirable.

Table D-12. Results of Chemical Accident Risk Calculations for Double-Shell Tank Remediation Alternatives.

Alternative	Probability of fatality	
	Onsite	Offsite
1	1.99 E-01	7.39 E-03
2	1.99 E-01	7.39 E-03
3	6.13 E-04	1.35 E-05
4	1.74 E-01	6.45 E-03
5	1.45 E-01	5.37 E-03
6	1.74 E-03	3.83 E-05
7	1.74 E-03	3.83 E-05
8	1.90 E-01	7.07 E-03
9	1.79 E-03	3.95 E-05
10	1.90 E-03	4.19 E-05
11	1.74 E-01	6.45 E-03
12	1.74 E-03	3.83 E-05
13	1.74 E-01	6.45 E-03
14	1.45 E-01	5.37 E-03
15	1.74 E-03	3.83 E-05
16	2.17 E-01	8.06 E-03

D6.1 BASES AND APPROACH

In order to assess the potential for effluent discharges to the environment, a scale was constructed that measured the ability of alternatives to do the following:

1. **Provide additional engineered barriers in areas of high risk to mitigate releases**--A rating of 100 was assigned for alternatives that allow for the initial design of engineered barriers into the system. A rating of 50 was assigned for alternatives where retrofit is able to provide additional engineered barriers. Alternatives that have a fatal flaw in the ability to provide engineered barriers were assigned a rating of 0.

2. **Minimize the potential for operator error by incorporating human factors engineering**--A rating of 100 was assigned to alternatives that allow for the initial design of systems that incorporate human

factors engineering. Alternatives that involve existing systems that would require retrofit were assigned a rating of 0.

3. **Reduce the potential for nonroutine releases by minimizing the quantity of routine releases**--A rating of 100 was assigned to alternatives that involve the least amount of routine discharges (i.e., new facilities that use the TRUEX process). A rating of 0 was assigned to alternatives involving the greatest amount of routine discharges (old facilities that do not use the TRUEX process). Alternatives involving moderate discharges (old facilities using the TRUEX process or new facilities not using the TRUEX process) were assigned a rating of 50.

4. **Minimize the number of facilities, thereby reducing the number of effluent discharge sources and the need for transfers between facilities**--Alternatives involving the least number of facilities were assigned a rating of 1. Alternatives involving the most number of facilities were assigned a rating of 3. Alternatives involving a moderate number of facilities were assigned a rating of 2.

The overall rating was calculated as follows: 100 points for the preferred alternatives that best met the above criteria and involved the least number of facilities; 80 points for alternatives that met all criteria but involved more facilities; 60 points for alternatives that met criteria but had higher routine effluents than preferred; 40 points for alternatives unable to accommodate one of the criteria; 20 points for alternatives unable to accommodate one or more of the criteria and having high routine effluents; and 0 for alternatives that have a fatal flaw and cannot meet minimum standards.

D6.2 RESULTS OF ROUTINE AND NONROUTINE EFFLUENT ANALYSIS

Table D-13 shows the alternatives ratings after the impacts of routine and nonroutine effluents were studied. As shown in the table, alternatives involving new facilities that use the TRUEX process resulted in less potential for effluent releases to the environment.

D7.0 LOW-LEVEL WASTE VOLUME

This attribute measures the environmental impact from the standpoint of the quantity of solid LLW generated over the duration of the alternative, from retrieval to vitrification. The LLW totals include solid waste volumes generated during facility retrofit, as well as solid waste generated during facility operation.

Table D-13. Routine and Nonroutine Effluents Scoring.

Alternative	Provides engineered barriers	Incorporates human factors	Minimizes routine releases	Minimizes number of facilities	Overall rating
1	0	0	50	2	0
2	50	0	50	2	40
3	50	0	0	2	20
4	100	100	100	2	80
5	100	100	100	2	80
6	100	100	50	2	60
7	100	100	50	2	60
8	50	0	50	2	40
9	50	0	0	2	20
10	100	100	50	2	60
11	50	100	100	3	60
12	50	100	50	3	40
13	100	100	100	3	80
14	100	100	100	3	80
15	100	100	50	3	60
16	100	100	100	1	100

D7.1 BASES AND APPROACH

The main factors affecting LLW totals are extent of retrofit required, age of facility, and length of operation time to complete the mission. Assumptions used in calculating LLW volumes are as follows:

- **Retrofit**--The amount of facility retrofit required was based on data provided in internal memo 85250-91-067, M. E. Johnson to T. L. Waldo, "Request for B Plant Pretreatment Options Cost Estimation Support," August 23, 1991, which described the equipment that would be removed to accommodate process retrofit for alternatives involving the use of existing facilities. Alternatives involving extensive retrofit will result in the generation of approximately 1,980 m^3 (70,000 ft^3) of LLW, whereas alternatives involving partial retrofit will generate only approximately 230 m^3 (8,000 ft^3). Alternatives that don't involve the use of existing facilities were assumed to generate no LLW, as no facility retrofit would be required.

- **Age of facility**--Operation of older facilities was assumed to generate approximately 140 m^3 (5,000 ft^3) of LLW per year. New facilities were assumed to operate more efficiently and generate approximately half of that volume, or 71 m^3 (2,500 ft^3) per year.

- **Length of operation**--Alternatives that involve longer operating time will generate more LLW than similar alternatives with shorter operating time.

The number of melters required was not specifically included in the calculation of LLW volume, but is shown for information.

D7.2 RESULTS OF LOW-LEVEL WASTE VOLUME CALCULATIONS

The results of this analysis are presented in Table D-14. The total solid waste ranges from 595 m^3 to 5,100 m^3 for the various alternatives. The alternative using a new pretreatment facility and TRUEX processing resulted in the least amount of LLW.

D8.0 NUMBER OF GROUT VAULTS

This attribute measures the environmental impact associated with the number of grout vaults required to dispose of DST LLW. Minimizing the number of grout vaults required is desirable from the standpoint of least environmental impact.

D8.1 BASES AND APPROACH

The measurement of liquid LLW volume that requires grout processing was derived from the material balances flowsheet included in WHC-SD-WM-TI-492, "Preliminary Material Balances for Pretreatment of NCAW, NCRW, PFP and CC Wastes" (Lowe 1991). Each alternative was considered based on the various process steps required for that particular alternative, with LLW compositions adjusted by evaporation or blending to meet grout feed composition parameters. The resultant LLW volumes were calculated into grout vault equivalencies by the factor of: 3,800 m^3 (1 Mgal) of waste = 1 grout vault. The number of grout vaults projected from disposal of double-shell slurry and double-shell slurry feed wastes is assumed to be 20 vaults.

Table D-14. Volume (1,000 ft^3) of Low-Level Waste Generated During Retrofit and Operations.

Alter-natives	Retrofit	Pretreatment operations (volume x yr)	HWVP operation (volume x yr)	Total volume (1,000 ft^3 /m^3)	Number of melters required
1	70	(5 x 15)	(2.5 x 4)	155/4400	2
2	70	(5 x 11)	(2.5 x 4)	135/3800	2
3	70	(5 x 6)	(2.5 x 32)	180/5100	10
4		(2.5 x 3.5)	(2.5 x 6)	24/680	3
5		(2.5 x 3.5)	(2.5 x 7.25)	27/760	3
6		(2.5 x 3.5)	(2.5 x 32)	89/2500	10
7		(2.5 x 3.5)	(2.5 x 12)	39/1100	4
8	70	(5 x 4.5)	(2.5 x 4)	103/2900	2
9	70	(5 x 4.5)	(2.5 x 32)	173/4900	10
10		(2.5 x 3)	(2.5 x 32)	88/2490	10
11	8	(5 x 1) + (2.5 x 3.5)	(2.5 x 4)	32/900	2
12	8	(5 x 1) + (2.5 x 4.5)	(2.5 x 32)	104/2950	10
13		(2.5 x 3.5)	(2.5 x 5)	21/595	2
14		(2.5 x 3.5)	(2.5 x 7)	26/740	3
15		(2.5 x 1) + (2.5 x 4.5)	(2.5 x 32)	94/2660	10
16		(2.5 x 5)	(2.5 x 3.5)	21/595	2

HWVP = Hanford Waste Vitrification Plant.

D8.2 RESULTS

The final results of the number of grout vaults required are provided in Table D-15. The least number of grout vaults (38) results in alternatives using new facilities, whether or not the TRUEX process is used. Using existing facilities without TRUEX processing results in a slight increase in the number of vaults (41 total), which is due to separations inefficiencies in existing facilities. Alternatives that use existing facilities and the TRUEX process result in the largest number of vaults (50). This is primarily due to inadequate space in existing facilities for installation of equipment necessary for minimization of LLW (i.e., solid-liquid separation and nitric recovery systems).

Table D-15. Number of Grout Vaults Required.

Alternative	Facility type (new/existing)	Process (TRUEX/no TRUEX)	Number of grout vaults required
1	Existing	TRUEX	50
2	Existing	TRUEX	50
3	Existing	No TRUEX	41
4	New	TRUEX	38
5	New	TRUEX	38
6	New	No TRUEX	38
7	New	No TRUEX	38
8	Existing	TRUEX	50
9	Existing	No TRUEX	41
10	New	No TRUEX	38
11	Existing/New	TRUEX (in New)	38
12	Existing/New	No TRUEX	38
13	New	TRUEX	38
14	New	TRUEX	38
15	New	No TRUEX	38
16	New	TRUEX	38

TRUEX = Transuranic extraction.

D9.0 LAND USE

This attribute measures the environmental impact associated with the amount of land requiring restricted use at the completion of the DST mission. Restricted use is defined as an underground disposal site requiring a permanent barrier (including barrier cover) or a processing facility which, upon completion of D&D, is left abovegrade. Alternatives resulting in less land that requires restricted use upon completion of the mission are considered more favorable.

D9.1 BASES AND APPROACH

The facilities that factor-in the land use assessment include grout vaults, HWVP, new DSTs, and the new pretreatment facility. Following are the assumptions that were used in calculating total land use:

- **Grout Vaults**--Acreage required for grout vaults was based on the current vault design, which requires 19 acres for 12 vaults. This equates to 1.5 acres per vault.
- **HWVP**--Land use required for HWVP is approximately 10 acres. An incremental increase of 1 acre would be required to provide sludge washing in HWVP. Providing only cesium ion exchange capabilities at HWVP would require an additional 0.1 acre.
- **DSTs**--Land use for new DSTs was based on four tanks requiring approximately 2.1 acres.
- **NPF**--Land use for a new pretreatment facility is approximately 11 acres.

D9.2 RESULTS

The results of the assessment of land use are provided in Table D-16. The minimum land use resulted in the alternative which expands HWVP for sludge washing. The land use required to accommodate additional grout vaults for existing facilities that use the TRUEX process offsets the savings in land use by not providing a new facility.

D10.0 SINGLE-SHELL TANK LEAKAGE POTENTIAL

This attribute evaluates the potential for SST leakage, based on the timing of the various facility alternatives. The environmental impact will be reduced for those alternatives that result in more timely treatment of SST wastes.

D10.1 BASES AND APPROACH

This assessment used historical data to determine the probability, over a given period of time, that an interim stabilized SST would begin to leak. Data provided in WHC-EP-0182-38, Table H-1, "Leak Volumes Estimated and Reported Before 1989," was used as the basis for this evaluation.

Table D-16. Land Use Requirements for Facility Alternatives (Acres).

Alternative	Grout vaults	New DSTs	NPF	HWVP	Total
1	80			10	90
2	80			10	90
3	62			10	72
4	57		11	10	78
5	57	2.1	11	10	80
6	57		11	10	78
7	57	2.1	11	10	80
8	80			10	90
9	62			10	72
10	57			11	68
11	57		11	10	78
12	57		11	10	78
13	57		11	10.1	78
14	57	2.1	11	10.1	80
15	57		11	10.1	78
16	57		11	10	78

DST = Double-shell tank
NPF = New pretreatment facility
HWVP = Hanford Waste Vitrification Plant.

D10.2 RESULTS AND CONCLUSIONS

The data included in Table H-1 of WHC-EP-0182-38 was reviewed to identify those SSTs where a leak occurred after interim stabilization of the tank. This data reflected 7 SSTs, over a 13-yr period, where a leak was identified after interim stabilization. This equates to approximately 0.5 newly identified leaking tank per year. Thus, for every 2 yr of delay in SST waste pretreatment, one new leaking SST would be predicted.

D11.0 REFERENCES

AIHA, 1991, *AIHA ERPGs 1991*, American Industrial Hygiene Association, Cleveland, Ohio.

DOE, 1986, *A Multi-attribute Utility Analysis of Sites Nominated for Characterization for the First Radioactive Waste Repository - A Decision-Aiding Methodology*, DOE/RW-0074, U.S. Department of Energy, Washington, D.C.

DOE, 1987, *Final Environmental Impact Statement, Disposal of Hanford Defense High-Level, Transuranic and Tank Wastes, Hanford Site, Richland, Washington*, DOE/EIS-0113, Vol. 1 through 5, U.S. Department of Energy, Washington, D.C.

DOE, 1988, *Internal Dose Conversion Factors for Calculation of Dose to the Public*, DOE/EH-0071, U.S. Department of Energy, Washington, D.C.

Johnson, M. E., 1991, "Request for B Plant Pretreatment Options Cost Estimation Support," to T. L. Waldo, Internal Memo 85250-91-067, Westinghouse Hanford Company, Richland, Washington (August 23).

Lowe, S. S., 1991, *Preliminary Material Balances for Pretreatment of NCAW, NCRW, PFP, and CC Wastes*, WHC-SD-WM-TI-492, Westinghouse Hanford Company, Richland, Washington.

Marusich, R. M., 1989, *B-Plant Preliminary Accident Analysis*, SD-WM-TI-385, Westinghouse Hanford Company, Richland, Washington.

Mishima, J., S. L. Sutter, K. A. Hawley, C. E. Jenkins, and B. A. Napier, 1986, *Potential Radiological Impacts of Upper-Bound Operational Accidents During Proposed Disposal Alternatives for Hanford Defense Wastes*, PNL-5356, Pacific Northwest Laboratory, Richland, Washington.

Naiper, B. A., R. E. Peloguin, D. L. Strenge, and J. V. Ramsdell, 1988, *Hanford Environmental Dosimetry Upgrade Project, GENII - The Hanford Environmental Radiation Dosimetry Software System* PNL-6584, Vol. 1 through 3, Pacific Northwest Laboratory, Richland, Washington.

NIOSH, 1990, *Pocket Guide to Chemical Hazards*, National Institute for Occupational Safety and Health, Cincinnati, Ohio.

Peach, J. D., 1990, "Consequences of Explosion of Hanford's Single-Shell Tanks are Understated" (Letter B-241479 to C. M. Synar, Chairman of Environment, Energy and National Resources Subcommittee, Committee on Government Operations, House of Representatives), GAO/RCED-91-34, General Accounting Office, Washington, D.C.

Perry, J. H. (editor), 1950, *Chemical Engineers Handbook*, Third Edition, McGraw-Hill Book Co., New York, New York.

PNL, 1990, *Safety Analysis*, PNL-MA-44, Pacific Northwest Laboratory, Richland, Washington.

O'Donnell, F. R., and H. C. Hoy, 1981, *Occupational Safety Data and Casualty Rates for the Uranium Fuel Cycle*, ORNL-5797, Oak Ridge National Laboratory, Oak Ridge, Tennessee.

Thurman, J. A., 1991, *Tank Farm Surveillance and Waste Status Report for May 1991*, WHC-EP-0182-38, Westinghouse Hanford Company, Richland, Washington.

APPENDIX E

HANFORD SITE TANK WASTE DISPOSAL PROGRAM REDEFINITION PEER REVIEW FINAL DRAFT

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October 15, 1991

Mr. Mike Grygiel
Manager, Redefinition Program Strategy
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Dear Mike,

Enclosed is the Final Draft of the Hanford Tank Waste Disposal Program Redefinition Peer Review Report. The report represents the consensus view of the 12 member Peer Review Committee that visited the Hanford Site September 23-25, 1991; it is issued as a Final Draft to allow one last opportunity for review.

The committee was impressed by the quality of the presentations and supporting analyses and concurs with the proposed course of action. The report is offered in the spirit of constructive commentary.

Respectfully Yours,

Kenneth D. Kok, P.E.
Manager, Richland Area Office

cc: Peer Reviewers
WH523 File

HANFORD TANK WASTE DISPOSAL PROGRAM REDEFINITION

PEER REVIEW

FINAL DRAFT

OCTOBER 15, 1991

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1.0 INTRODUCTION AND GENERAL COMMENTS

The Peer Review Committee was made up of 12 persons (see Appendix 1) selected on the basis their experience in process engineering and waste remediation. The comments contained in this report have been reviewed by the Peer Review Committee and represent a consensus of the views of the committee. The committee listened to two days of presentations which

1) laid out the method used to determine the alternatives selected for further study,

2) described the alternatives considered, and

3) presented the selected alternative.

The Committee was asked to provide an independent review of the process and information used to develop the revised Hanford Tank Disposal Strategy as well as the content of the resultant strategy to ensure:

- Appropriate processes and facilities were considered,
- Adequate national and international experience was considered,
- Adequate consideration is given to existing and emerging technology,
- Budget and schedules are reasonable, and
- Resultant strategy is achievable and is a responsible expenditure of national resources.

The committee was also requested to specifically consider the following areas:

- Feasibility of sludge washing in one million gallon double-shell tanks,
- Development potential of TRUEX,
- Validity of three-phased approach,
- Performance potential of intermediate processing, and
- Desirability of early ion exchange capability.

The committee report begins with an examination of the response of the stake holders and then addresses the five specific areas of concern. The committee has also included some discussion of the Single-Shell Tanks, miscellaneous thoughts and a look at the vulnerability of the proposed strategy.

In general, the committee was impressed by the quality of the presentations and supporting analyses, and concurred with the proposed course of action--particularly for the near term. The following critique is offered in the spirit of constructive commentary.

2.0 INTERACTIONS WITH STAKEHOLDERS

The committee was impressed with the dispatch and enthusiasm shown in the establishment and implementation of a process for interaction with the stakeholders. The principal concerns are that use of such decision-methods must now evolve into a continuing interactive process and that only a very limited involvement of the stakeholders has been incorporated to date. Hanford has clearly arrived at a substantial degree of understanding of stakeholder concerns. What is not yet clear is the extent to which the stakeholders appreciate the impact of their principal criteria upon the program or how best to resolve differences with other stakeholders, not now represented in the process.

The committee is also concerned over the extent to which the small sample within the various stakeholder communities reflects a broad consensus among the total community of interests. This is particularly important because a determined minority can delay or even derail a proposed course of action at future key decision points.

The primary improvement needed for future interactions with the stakeholders is making the choices presented more realistic. This includes introducing the severe financial constraints which are likely to plague this program as it proceeds, and carefully posing the questions in a fashion which does mute not the strength of the stakeholder preferences or deflect stakeholder judgements from choices with marginal tradeoffs. For example, it is much better to ask the stakeholders whether they would be willing to accept an increase in the number of expected occupational injuries in exchange for a faster or more secure program schedule than to ask them whether they would be willing to accept a small increase in the size of the overall project budget in exchange for the same benefit. This also requires informing stakeholders more accurately, particularly in the area of environmental and health risks.

The EIS of 1987 estimates the expected environmental and health consequences from the potential waste treatments. However, it omits a true analysis of risks, taking into account the possible range of effects and their corresponding probabilities and uncertainities. In the absence of such information stakeholders are not adequately informed, and their choices will be susceptible to revision as the information provided by this process is challenged from other quarters. These potential sources for antagonism should be removed from the program at the earliest possible date.

In summary, the stakeholder involvement would be improved by

- more clearly identifying the realistically available options (e.g., eliminate B-Plant options),

- increased surveying of stakeholder groups to include a statistically representative sample base,
- clarifying the risks associated with each option (cost, potential schedule impacts, etc.), and
- performing a more complete risk analysis for each of the options and making the results of these analyses available to the respondents.

3.0 FEASIBILITY OF SLUDGE PROCESSING IN DST'S

The panel believes that Hanford's plans to perform sludge washing in large double-shell tanks (DST's) is technically sound. This process has been demonstrated at the Savannah River Site (SRS) on sludges that are similar to NCAW. Also, washing of neutralized PUREX sludges will soon be initiated at West Valley. Therefore, the panel supports Hanford's plans, especially for the early campaigns. However, plans should consider provision of a more optimized sludge washer, designed specifically for that purpose, as soon as possible.

With regard to sludge washing, the panel offers the following suggestions:

- Secondary Containment. Although the panel concurs with Hanford's assessment that DST's have adequate secondary containment and can be permitted as RCRA facilities, the panel recommends that Hanford quickly request the Washington Department of Ecology (W/DOE) to approve the DST's as having adequate secondary containment. The DST's were not explicitly designed to RCRA standards; therefore, Hanford may need to demonstrate equivalency. This is important because sludge washing will be needed to process the waste planned for startup of the Hanford Waste Vitrification Plant (HWVP), and failure to obtain W/DOE concurrence might delay the startup of HWVP. To assist in obtaining W/DOE concurrence, an early, abbreviated risk assessment of the process could be performed.
- Waste Characterization. Good waste characterization is important in operating the sludge washing process. The two basic questions that the characterization must answer are: 1) Can the sludge be suspended by the available mixing pumps? and 2) Will the sludge settle fast enough, as the washing process proceeds, such that adequate processing rates can be maintained? These questions are critical for sludges other than NCAW, many of which are significantly different from SRS wastes and are not well characterized. The pH and electrolyte concentration of wash liquids that prevent peptization of sludges must be determined.
- Corrosion. The sludge washing program must address corrosion of the air lift circulators, which are not stress relieved. The panel encourages Hanford's plan to perform the later campaigns of sludge washing in stainless steel tanks, which would greatly reduce the corrosion concern.

- The use of additives such as sodium titanate to retain strontium in sludge recovery and washing is encouraged to minimize the radionuclide content of grout wastes.
- Tentative flowsheets for the washing of various DST's should be prepared. These should predict activity levels and quantities of supernates and washed sludges so that the suitability of down-stream processes (e.g., grouting, vitrification, evaporation, interim storage) can be assessed.

4.0 DEVELOPMENT POTENTIAL OF TRUEX/ACTINIDE RECOVERY

The recovery of actinides from supernatent solutions that are routed to the grout waste is extremely important, and is considered to be essential for SST waste. The TRUEX process has a very good potential for meeting this goal. Because of the importance of actinide recovery in reducing the number of HLW glass canisters and the overall cost, it is recommended that development of the TRUEX process be accelerated, along with development of satisfactory TRUEX feeds from the SST's.

The underlying chemistry of the TRUEX process has reached a satisfactory state of development. However, testing of the process in continuous countercurrent equipment and with actual (not simulated) waste solutions is essential for verification of the process prior to deployment. Demonstration in relatively long, continuous tests utilizing normal recycle of all reagents (especially the solvent) will be required, and an aggressive schedule should be developed for this. This is important because, in a process like TRUEX, trace components can build up in the recycle loop that may eventually disrupt the process.

Since the projected hot pilot plant date is several years away, every effort should be directed to the acquisition of data from laboratory scale and bench scale experiments using real waste, and to develop experience using countercurrent experiments and hot feeds (even if not actual waste), at an earlier date. This might be accomplished through collaborative work with other sites that already have the appropriate equipment in their hot cell facilities. It is emphasized that experimental studies under realistic conditions are needed in the earliest practical time frame.

As a precaution against unforeseen problems, a backup process for TRUEX should be available to provide more confidence that satisfactory actinide removal will be achieved. Attention should be given to early laboratory studies using extractants other than CMPO, the normal TRUEX solvent, since some alternative might be advantageous in the context of the overall impact on the total waste treatment operation. These should include different phosphorus-based extractants and the diamides (under development in France), among other possibilities. A process which gives good concentration factors for actinides (say 20) and a low purity actinide product might be preferable to a more complex process that gives a purer and more concentrated product. Therefore, one must be certain that appropriate tradeoffs are made to achieve both operational simplicity and cost efficiency. This also applies to the TRUEX solvent extraction flowsheet.

It should not be overlooked that an intermediate stage processing, prior to TRUEX extraction, may be beneficial, particularly for some SST wastes. A head-end treatment to eliminate "bad actors," such as colloids, tramp organics or complexing agents from solvent extraction feeds may turn out to be necessary or desirable. Some of the intermediate washing processes planned by Hanford before TRUEX comes on line could have such a benefit.

The potential benefits from collaboration with other sites, both within the US and in other countries, appear to be substantial. Examples include Japan (hot demonstration of TRUEX) and France (alternative solvent systems). This approach should be pursued.

5.0 PERFORMANCE POTENTIAL OF INTERMEDIATE PROCESSING

The proposals presented to the panel indicated very substantial potential savings in the numbers of glass canisters, and are well worth pursuing. However, of all the presentations we heard, the technical details of Intermediate Processing were the least developed. We rate them as speculative at this stage and cannot support them as strongly as, for example, In-Tank Washing, early Ion-Exchange and TRUEX. We note, however, that success with Intermediate Processing is not as vital to the Hanford programs as success with In-Tank Washing, Ion-Exchange, and TRUEX (or an alternative actinide removal process). An overall plan encompassing pretreatment and vitrification should be prepared for various Intermediate Processing success scenarios.

Particular concerns were expressed by panel members on three processes in particular: chromium leaching, oxidation of organophosphate compounds with peroxide, and organics destruction. The panel would like to see speculative flowsheets showing tank components and compositions (possibly obtained from historical data or personnel interviewing prior to extensive sampling) and the process chemistry to be carried out. These data would allow the committee to comment on specific questions, for example, the likelihood of peroxide being catalytically decomposed by other constituents in the tanks before it can effectively oxidize organo-phosphates.

Blending is a proposal with good prospects of success but, as with all elements of the Tank Treatment Programs, good characterization of tank contents is needed. It appeared that many of the advantages presented by the Intermediate Processing schemes for the DST's could be instituted almost as effectively by a comprehensive waste blending plan. The availability of tanks for waste blending is an important concern for Hanford, however, and detailed planning would be needed in order to implement an effective blending program. The early provision of free tank space by grouting of DSS will be important as will the space provided by the new Tank Farm. Incorporation of Cs and Sr from capsules should be considered in the blending study. By this means it should be possible to provide consistent high heat content feeds to vitrification.

As an aside to the Intermediate Processing proposals, the panel considered that funding for TRUEX and the NPF may be difficult to obtain if intermediate processing is successful in achieving significant volume (or mass) reductions of actinide-bearing sludges. This should not mean, however, that Development Proposals and Funding submissions by WHC should be pursued any less vigorously because of the Intermediate Processing potential. If intermediate processing is completely successful it can never be as effective as a comprehensive new pretreatment flowsheet. Therefore the capital raised by not building a new plant needs to be balanced against the cost of the inevitable increase in the number of canisters of vitrified waste.

6.0 VALIDITY OF THREE-PHASED APPROACH

The application of the three-phased approach to the program strategy is commendable and valid. The initiation of work with near-term probable successes in the areas of sludge washing and cesium ion exchange allows for an early start and affords the opportunity to demonstrate a continuing record of achievement. The necessity of ion exchange operations is driven by the requirement to reduce potential Cs-137 concentration to that allowed by regulation for LLRW disposal. Whereas intermediate pretreatment processing is considered somewhat more speculative in terms of technological development, it has a large potential to reduce the number of HLW canisters produced by the vitrification of some wastes. The key element in this type of pretreatment is separation of radiologically inert as well as non-RCRA materials in the waste prior to processing through the HWVP. The third phase of the program strategy involves sludge dissolution and actinide partitioning. Scoping dissolution and lab scale TRUEX experimental results are promising. These technologies are emerging and may, in the long-term, provide maximum benefit per unit cost to the tank waste disposal program.

Commitment of resources needs to be definitive. Project scope, including both extent and term, needs to be developed and utilized to prioritize the research and development work. The most promising technologies need to be funded and become operational during the initial stages. Integration of SST remediation work into the existing DST pretreatment framework is required to maximize the potential savings to the entire Hanford waste tank disposal program. An early, relative to the proposed 1996, ROD for the SST wastes is highly recommended. TRUEX type pretreatment is considered necessary to achieve cost effective processing of many of these wastes. Funding criteria need to be reasonable and based upon a long-term commitment. A twenty year waste disposal plan which includes financial considerations might be quite appropriate to the strategy. Trade-offs between significant outlays of immediate and near-term treatment funds versus tremendous long-term costs associated with the manufacture and storage of HLW glass canisters need to be recognized as pivotal discriminators for the responsible expenditure of national resources. Program success will likely require long-term commitments by regulators, funding sources, and plan administrators to deal effectively with an integrated Hanford waste disposal strategy.

7.0 DESIRABILITY OF Cs ION EXCHANGE IN HWVP

An early cesium ion exchange capability is required. The Review Group, however, is not convinced that it should necessarily be connected with the HWVP, nor should it be used as a justification for a HWVP schedule slip. More attention should be given to integrating the ion exchange facility into the waste treatment operations so that it does not impact HWVP startup. Perhaps this could be done through a phased approach, or by developing the ion exchange capability with some other facility (i.e., new waste tank). Alternatively, Cs-IX could be added to HWVP, perhaps two years later, without impacting the HWVP schedule if appropriate partition shielding is constructed between the two plants. A method to retain the 1999 date could be phasing the project to complete the HWVP in 1999 and Ion-Exchange in 2001 with partition shielding used between the two plant sections. This would enable construction and testing of the Ion-Exchange facility to be conducted after HWVP has begun radioactive operations. There appears to be sufficient potential feed for HWVP to initiate radioactive operations which do not involve the ion-exchange stage.

The above comments are based on the assumption that the start-up date of December, 1999, can be achieved for HWVP as it is currently defined. The panel considers this schedule, though achievable, tight and dependent upon timely funding and regulatory approvals.

It is anticipated that consideration of other alternatives for the ion exchange process will result in a smaller facility with less cost and schedule impact. The assumption of CS-100 resin is overly conservative. There is considerable experimental evidence that alternative resins (e.g. the resorcinol-based resin developed at Savannah River or the zeolites in use at West Valley) are superior in terms of column capacity (and column size) by more than an order of magnitude. This high selectivity, in turn, opens the possibility of options not dependent on resin elution, regeneration, etc. (difficult operations with these resins), such as incineration or direct disposal to the vitrifier. This involves a trade off of the cost of resin replacement and disposal against the cost of the regeneration operation.

BNFL does not use organic sorbents mainly due to regulatory resistance to the encapsulation of spent organic sorbents. The inorganic zeolite clinoptilolite is used on a one-through basis. In the BNFL Ion-Exchange Plant (SIXEP) activity levels are much lower than those shown in the Hanford flowsheets but the Na/Cs ratio is approximately the same and may be the most important parameter. Inorganic sorbents are therefore judged worthy of examination by WHC.

BNFL uses [in the Enhanced Actinide Removal Plant (EARP)] ferric floc precipitation to adsorb transuranics and sodium nickel ferrocyanide to remove Cs from relatively low active streams. Similar processes are used in France and other countries for treating low level waste. An in-tank process to remove Cs with the sludge might expand the waste inventory that could be processed before Cs-IX is required.

The Review Group believes that the application of more attention and some ingenuity can decrease the impact of the ion exchange process on both schedule and cost. It also points out that the availability of a flowsheet for this process would greatly assist the evaluation and critique.

8.0 SUGGESTIONS ON SST'S

The panel expanded their review scope to include the single shell tank plans. These tanks clearly are more important to the resolution of the Hanford waste issues than the double shell tanks because they represent the major risk to the site environment. The SST's are the oldest tanks, they have already experienced several failures, with more leaks discovered annually, and they were not designed to offer significant leakage detection or remediation potential. The large volume of wastes contained in these tanks, relative to the DST's, requires that an increased emphasis be placed on their remediation activities to achieve the closure requirements included in the Tri-Party Agreement. Inclusion of the high ^{90}Sr tanks early in the HWVP waste processing strategy, as presented to the panel, represents an important step in development of an integrated Hanford waste remediation plan. Completion of this integrated, overall approach to disposal of all of the Hanford wastes should continue as a high priority task.

Recommending that DOE-RL accelerate the record of decisions (ROD) for the SST decommissioning activities is key to the HWVP and the Repository Project. Development of the technologies to minimize HLW glass production at Hanford (TRUEX, Intermediate Processes, etc.) would play an important role in maximizing the utilization of resources for the DST wastes, but is crucial to the disposal of the SST wastes. As vitrification has been selected as the Best Demonstrated Available Technology by the EPA for HLW disposal, it is clear that merely sealing the SST's as they presently exist will not be an acceptable disposal alternative. By requesting an early ROD for these tanks, the proper priority can be assigned to the waste pretreatment technology development, improving the overall efficiency of the Hanford remediation activities.

Because of the risks associated with the SST's, the panel concluded that the waste vitrification plan be revisited to move processing of this waste by HWVP as early in the schedule as possible. As the plutonium finishing plant, neutralized cladding removal, and complexant concentrate wastes are stored in the more stable DST's, the SST wastes should be assigned a higher relative priority.

Several early concepts were presented for waste removal from the single shell tanks. The panel agreed that removal or some form of in-situ processing of these wastes would be required, i.e., stabilization without further treatment of the wastes in the tanks would not be a viable remediation option. The consensus was to develop the technology for waste removal from a single or small group of tanks rather than the erection of a full tank farm enclosure facility. The initial perception of the full tank farm containment concept was that the task could probably be accomplished at greater economy with mobile, smaller scale systems.

9.0 MISCELLANEOUS THOUGHTS

A. We are very concerned that important decisions to date may have been somewhat arbitrary and based on non-technical judgements that may or may not be valid. We realize there may be certain perceived economic (or political ?) realities that drive these decisions, although they were not completely clear from the presentations. The concerns are as follows:

1. Recognition that achieving the 12/99 startup date for HWVP would be an important step toward developing Hanford environmental restoration credibility. Yet a delay of 15 months to install ion exchange (IX) capability is already planned. This may be perceived as a "stonewalling" effort to the public - therefore we discourage the delay unless better justification is provided. If, however, the delay cannot be avoided, make certain the 15 months is enough or plan for a longer delay.

2. The assumption that a temporary shutdown (say one year) of HWVP is not permissible even to allow feed pretreatment that drastically reduces the number of HLW canisters of vitrified waste lacks credibility. While such a shutdown might be perceived as poor planning or funding by US/DOE and WHC in the 1990's, it is not prudent to produce an excessive number of glass canisters with raw wastes and multiply the sins. The panel questions the assumption that a 1-year shutdown of HWVP would involve a costly and difficult restart. An intermediate plant furlough may present difficulties, but they seem resolvable. A more positive approach would be to eliminate the window between the NCAW and the other DST waste availabilities to HWVP by including the early processing of high-heat SST wastes into the present schedules. This will remove the appearance of poor planning and indicate a real commitment to the SST closure milestones in the Tri-Party Agreement.

3. Hanford staff seemed relatively confident that B-Plant and the PUREX Plant cannot be employed for waste pretreatment (or any other operations) because of the cost inefficient retrofits needed for regulatory compliance. The buildings probably cannot be shown to be RCRA compliant.

Without the above constraints, the proposed waste treatment methods and schedules could be much different from those currently proposed. It appears there may be some arbitrariness in the methods and schedules proposed for meeting these constraints, and the plans being developed are less than optimum because of the constraints.

B. This section covers a number of thoughts brought out during the panel's discussion that didn't fit into the major categories.

1. Limited analytical throughput is likely to delay any option. The panel recommends that this be given a very high priority in the program and that throughput be expanded as soon as possible. Such analytical capability might make use of the FMEF, or labs at the facilities not planned for future waste treatment activities (e.g. B-Plant). The panel also recommends that Hanford make use of the analytical methods developed at other sites and countries.

2. To develop an overall strategy that succeeds even if individual processes fail to be developed successfully, the waste processing plan needs to embrace all of the high-level wastes at Hanford, including the double-shell tanks, single-shell tanks, and spent fuel.

3. The panel recommends that consideration be given to blending Sr and Cs capsules into the sludge. This seems to be the best way to dispose of these capsules.

10.0 VULNERABILITY OF PROPOSED PROGRAM

Although it is clear that those involved appear to be aware of the extent to which their proposed course of action is constrained by and remains vulnerable to factors beyond their control, the peer review committee feels that this aspect deserves statement in this record of review.

In particular, the HWVP relies upon sustained funding at an ambitious level over several decades, whereas recent dealings with the US/DOE have shown that program budgets are negotiated and revised on a year-to-year basis, with finalization often taking place late into the fiscal year. Typically, such budget changes are not accompanied by corresponding realistic changes in milestone dates and schedules. Short-term priorities often arise which divert resources away from long-term commitments. The committee is very concerned that HWVP funding under these circumstances can lead to program stretch-out and needless programmatic risk-taking in the years ahead. Since the proposed schedule is very ambitious and intolerant to the delay of key facilities such as the new waste washing tanks, which are not yet firmly committed-to/fully-designed/ or irrevocably scheduled, loss of credibility with important stakeholders, who will not fully appreciate these circumstances, is at issue.

A second point of vulnerability is the potential for regulatory evolution, and the resulting "ratcheting" of requirements, which could invalidate the present plans. This has already resulted in the elimination of the B-plant and PUREX facilities in the proposed program. Stakeholder expectations and their spectrum of emphases may also change, particularly where the groups involved encompass many subsets of interest groups. This argues for a continuing and broader interaction with stakeholders.

A third potential impediment is the requirement for consistent and timely support and decision-making at the higher administrative levels of the US/DOE, and other federal and state agencies For example the committee considers that an early record of decision (ROD) will enable the most logical incorporation of the single shell tank wastes into the overall program. Intra-site action with respect to other wastes, e.g. N-reactor's and FFTF's spent fuel can also affect the program reviewed by the committee.

In addition to these factors, the program exhibits other vulnerabilities which should at least be recognized. These include the development of new technologies, a rapid schedule, and the ability to recruit a large, highly qualified, workforce. If these expectations should fail to be met, the program schedule, budget and public and governmental support could be undermined seriously. In this light it is important to note that program elements within the joint control of US/DOE and the program (e.g., waste characterization and initial technology development efforts) are not now being conducted at the rates needed to support the program. The committee's impression was that the technical and support staff is currently stretched thin, particularly in areas such as analytical support services, and that the inevitable responses to "fire drills" will occur at the expense of progress on the long term programs. The committee is also concerned that important elements of the program are technologically ambitious, and that reliance upon a favorable outcome is perhaps too optimistic if the current effort in such areas is a true measure of the likely level of program emphasis. We refer in particular to the development of methods for intermediate waste processing, and the concern that approaches which theoretically appear to be promising may become thwarted by unappreciated ingredients in the 'witch's brew' of the waste tank inventories. If these examples of concerns are symptomatic of the program generally, increased concern at the program management level is warranted.

11.0 CONCLUSION

The committee feels, in general, that the quality of the presentations and supporting analyses was high and supports the proposed course of action in the near term. The specific points listed in the Introduction, Section 1.0, of this report were addressed. The Hanford Tank Waste Disposal Strategy does ensure that:

- Appropriate processes and facilities were considered,
- Adequate national and international experience was considered,
- Adequate consideration is given to existing and emerging technology,
- Budget and schedules are reasonable, and
- Resultant strategy is achievable and is a responsible expenditure of national resources.

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APPENDIX F
LIFE-CYCLE COSTS FOR PRETREATMENT ALTERNATIVES

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CONTENTS

ACRONYMS

CENRTC	capital equipment not related to construction
DST	double-shell tank
FY	fiscal year
HWVP	Hanford Waste Vitrification Plant
KEH	Kaiser Engineers Hanford
PUREX	Plutonium-Uranium Extraction
SST	single-shell tank
Westinghouse Hanford	Westinghouse Hanford Company

APPENDIX F
LIFE-CYCLE COSTS FOR PRETREATMENT ALTERNATIVES

F1.0 INTRODUCTION

The assumptions and bases for estimating the disposal mission costs for the 16 double-shell tank (DST) waste pretreatment alternatives are provided in this appendix. The total costs for each alternative are also included on a year-by-year basis. The costs and schedules presented in Section 7.3 for an integrated DST and single-shell tank (SST) disposal mission are based on information in Boomer et al. (1991).

F2.0 COST ASSUMPTIONS

GENERAL

Expense-funded costs are given in respective year dollars for fiscal year (FY) 1991 and FY 1992, and in FY 1993 dollars thereafter. Capital costs are shown in FY 1991 dollars for comparison of alternatives. Actual budgetary cost numbers will be different because of escalation and further refinement of cost estimates. Total program costs are used: costs for capital construction and/or upgrade of the facility; costs for waste treatment, vitrification, and grout operations; and costs for disposal in a high-level waste repository. Costs judged to be minor were excluded from the analysis. Wherever applicable, existing construction project cost estimates were used; but for comparison purposes, these costs were de-escalated to FY 1991. Costs not related to the defense waste remediation mission are not shown (e.g., normal tank farm operations). Where portions of these costs were judged to be related to the disposal mission (e.g., waste retrieval operations and in-tank washing operations), only the additional costs over nonrelated costs are shown.

B PLANT AND PLUTONIUM-URANIUM EXTRACTION (PUREX) PLANT OPERATING COSTS

Operating costs were projected for sludge washing and transuranic extraction process approaches using historical staffing and maintenance requirements for these facilities.

B PLANT FACILITY UPGRADES

These upgrades are required for safe environmental B Plant operations, the transuranic extraction pilot plant, and Waste Encapsulation and Storage Facility operations. The costs are based on construction project data and definitive design estimates for authorized environmental and safety modifications.

B PLANT AND PUREX PLANT PRETREATMENT UPGRADES

Costs were estimated by Kaiser Engineers Hanford (KEH) and Westinghouse Hanford Company (Westinghouse Hanford) personnel, based on defined pretreatment process equipment requirements and on evaluation of the facilities against regulatory codes and standards. Costs included cell cleanout, equipment burial, cell modifications, and installation of new equipment.

NEW PRETREATMENT FACILITY CONSTRUCTION COSTS

Costs were prepared by Westinghouse Hanford and KEH by using a parametric computer model called the FAST-C[1]. This method of estimating is used by the U.S. Department of Energy in the assessment of projects being considered for validation. The model is calibrated by comparison to similar facilities--in this case, the Hanford Waste Vitrification Plant (HWVP) was the basis for the comparison. The bases for input to the model were facility layouts, described in Appendix G.

HWVP PRETREATMENT FACILITY COSTS

Construction costs were prepared by Fluor Daniel personnel and are shown as incremental costs over those for the HWVP.

HWVP VITRIFICATION OPERATIONS

The HWVP vitrification operating costs were based on estimates in DOE/RL-89-17, Rev 2 (RL 1989). Variations to normal operating costs were estimated as follows:

- Down time 1 yr to 3 yr--operating costs are the same as full operations
- Capital equipment not related to construction (CENRTC) costs decrease by $5 million/yr
- Down time greater than 3 yr--operating expense decreases 50 percent/yr.

On alternatives where more than 2,000 canisters are produced, costs for building and operating additional canister storage facilities were included. It takes approximately 15 months to build a storage facility; the current design would be used for the additional facilities. The cost is $32.5 million (split $10 million and $22.5 million over two FYs) and the additional operating costs are $7.1 million expense per year and $1 million CENRTC per year. When the second additional facility is built, the incremental operations costs are $3.5 million expense per year and $500 thousand CENRTC.

HWVP PRETREATMENT FACILITY OPERATING COSTS

The HWVP pretreatment facility operating costs are included with HWVP vitrification operating costs for alternatives 10, 13, 14, and 15. The pretreatment operating costs for alternative 10 (sludge washing integrated in HWVP canyon) were estimated to be 20 percent higher than costs for vitrification only. The pretreatment operating costs for alternatives 13, 14,

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[1] Trademark of Freiman Parametric Systems, Inc.

and 15 (cesium ion exchange in HWVP canyon) were estimated to be 10 percent higher than costs for vitrification only.

NEW PRETREATMENT FACILITY OPERATING COSTS

Operating costs for sludge washing and transuranic extraction process new pretreatment facilities are based on projected staffing and material estimates in Boomer et al. (1991).

GROUT OPERATIONS AND CONSTRUCTION

Costs are taken from DOE/RL-89-17, Rev 2 (RL 1989). Vault construction and operating costs were based on the present estimate of $22/gal of grout.

PRETREATMENT TECHNOLOGY

Estimated costs are based on DOE/RL-89-17, Rev 2, Activity Data Sheet 9150.

RETRIEVAL DEVELOPMENT COSTS

Costs are based on DOE/RL-89-17, Rev 2, Activity Data Sheets 9150, 9151, and 9152.

WASTE TRANSFER LINES

Costs are based on DOE/RL-89-17, Rev 2, Activity Data Sheet 9138.

SHIPPING AND REPOSITORY DISPOSAL

Costs are estimated at $350 thousand per canister of vitrified waste.

F3.0 COSTS FOR PRETREATMENT ALTERNATIVES

Life-cycle costs for the 16 facility and process alternatives are presented on the following pages.

F4.0 REFERENCES

Boomer, K. D., S. K. Baker, A. L. Boldt, M. D. Britton, L. E. Engelsman, J. D. Gailbraith, J. S. Garfield, K. A. Giese, C. E. Golberg, B. A. Higley, K. J. Hull, L. J. Johnson, R. P. Knight, J. S. Layman, R. S. Marusich, R. J. Parazin, M. G. Piepho, E. J. Slaathaug, T. L. Waldo, and C. E. Worcester, 1991, *Systems Engineering Study for the Closure of Single-Shell Tanks*, WHC-EP-0405, Vol. 1 and 2, Westinghouse Hanford Company, Richland, Washington.

RL, 1989, *Hanford Site Environmental Restoration and Waste Management 5 Year Plan Activity Data Sheets*, DOE/RL-89-17, Rev. 2, U.S. Department of Energy Field Office, Richland, Richland, Washington.

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OPTION 1--AR VAULT/B PLANT WITH TRUEX
ANNUAL COSTS BY FISCAL YEAR ($MILLIONS)

		FY92	FY93	FY94	FY95	FY96	FY97	FY98	FY99	FY00	FY01	FY02	FY03	FY04	FY05	FY06	FY07	FY08	FY09	FY10	FY11	FY12	FY13
B Plant Operations	Exp	37.7	55.2	65.4	70.4	70.0	73.7	73.7	73.7	70.4	72.4	71.5	68.3	68.3	68.3	68.3	68.3	68.3	68.3	68.3	68.3	68.3	68.3
	Cap	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4
B Plant Fac Upgrades	Exp	4.5	4.2	4.3	3.8	3.4	2.3	1.6	1.4	1.2	1.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	Cap	11.1	10.2	18.1	17.6	11.3	6.4	1.0	1.0	0.6	0.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
B Plant Prtmt Upgds	Exp	0.5	0.8	3.3	5.1	4.5	3.8	5.3	5.2	5.1	4.6	4.0	2.5	1.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	Cap	0.0	0.0	6.5	20.0	30.0	49.0	56.0	75.0	75.0	55.0	45.0	38.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
AR Vault Ops & Upgrades	Exp	0.3	0.8	0.5	0.5	0.5	0.6	0.4	0.4	0.2	5.0	5.0	5.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	Cap	0.0	0.0	0.0	1.5	1.5	4.5	3.0	1.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
PUREX Operations	Exp	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	Cap	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
DST Pre-treatment	Exp	0.0	0.0	0.0	0.0	0.0	3.0	3.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	Cap	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
HWVP Constructn	Exp	20.0	37.5	49.5	52.7	45.7	53.4	59.5	59.4	73.6	49.1	12.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	Cap	40.2	69.9	116.0	147.7	233.4	215.6	179.2	100.2	39.7	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
HWVP Operations	Exp	1.3	1.3	1.3	1.3	5.0	7.9	16.9	25.9	41.9	56.9	73.3	73.3	73.3	73.3	73.3	73.3	73.3	73.3	73.3	73.3	73.3	73.3
	Cap	0.0	0.0	0.0	0.0	0.0	0.1	0.3	0.9	1.9	5.0	13.9	13.9	13.9	36.4	8.9	13.9	8.9	13.9	8.9	8.9	8.9	36.4
Grout Ops & Construc	Exp	30.3	52.0	66.1	68.9	71.3	74.0	64.7	64.7	64.7	64.7	64.7	64.7	64.7	64.7	64.7	64.7	64.7	64.7	64.7	64.7	64.7	64.7
	Cap	2.3	2.1	5.9	2.6	2.3	2.3	2.3	2.3	2.3	2.3	2.3	2.3	2.3	2.3	2.3	2.3	2.3	2.3	2.3	2.3	2.3	2.3
Pretreatment Technology	Exp	9.7	21.8	23.7	18.7	15.2	12.4	9.0	3.1	6.7	5.0	4.6	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0
	Cap	0.2	0.2	3.7	9.7	5.8	4.7	0.5	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3
Retrieval Development	Exp	2.9	8.6	18.8	25.8	37.3	22.7	28.9	13.6	5.4	6.5	7.0	9.0	9.0	9.0	9.0	9.0	9.0	9.0	9.0	3.0	1.5	0.5
	Cap	5.8	3.0	7.0	0.0	0.0	0.0	0.0	0.0	0.0	5.0	9.5	17.0	25.0	45.0	45.0	45.0	45.0	45.0	35.0	20.0	13.0	0.0
Retrieval Operations	Exp	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.5	3.0	1.5	0.0	0.0	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5
	Cap	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Waste Trans Lines	Exp	0.5	0.1	0.9	1.0	0.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	Cap	6.0	0.0	3.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Tank Farms Upgrades	Exp	2.5	1.0	1.4	2.1	4.1	4.0	3.1	1.9	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	Cap	0.0	8.0	11.0	12.0	25.0	62.0	70.0	32.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Ship/Repos Disposal	Exp	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	Cap	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
SUB TOTALS	Exp	110	183	235	250	257	258	266	256	272	267	242	226	221	220	220	220	220	220	220	214	212	211
	Cap	66	94	172	212	310	345	313	214	120	69	71	72	42	84	57	62	57	62	47	32	25	39
OPT 1 TOTAL		176	277	407	462	567	603	579	469	392	335	314	298	263	304	277	282	277	282	267	246	237	251
Labor	M/Yrs	1310	2087	2976	3332	3960	4168	4051	3391	2988	2643	2455	2321	2102	2340	2180	2209	2180	2209	2122	1985	1932	2007
Labor Average															2866	1465							
Site Compersn		0.07	0.09	0.04	0.07	0.02	-0.02	-0.07	-0.05	-0.04	-0.01	-0.01	-0.02	0.03	-0.02	0.00	-0.00	0.00	-0.01	-0.01	-0.01	0.01	-0.02

OPTION 1--AR VAULT/B PLANT WITH TRUEX
ANNUAL COSTS BY FISCAL YEAR ($MILLIONS)

		FY14	FY15	FY16	FY17	FY18	FY19	FY20	FY21	FY22	FY23	FY24	FY25	TOTALS
B Plant Operations	Exp	68.3	34.2	67.7	66.3	66.8	92.6	115.1	127.1	21.0	21.0	21.0	1.3	2188
	Cap	0.4	0.2	3.2	5.5	17.0	53.5	32.4	60.1	0.0	0.0	0.0	0.1	181
B Plant Fac Upgrades	Exp	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	28
	Cap	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	78
B Plant Prtmt Upgds	Exp	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	46
	Cap	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	450
AR Vault Ops & Upgrades	Exp	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	19
	Cap	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	12
PUREX Operations	Exp	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0
	Cap	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0
DST Pre-treatment	Exp	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	6
	Cap	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0
HWVP Constructn	Exp	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	513
	Cap	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1142
HWVP Operations	Exp	73.3	36.7	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1149
	Cap	8.9	6.9	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	211
Grout Ops & Construc	Exp	64.7	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1462
	Cap	2.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	57
Pretreatment Technology	Exp	3.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	171
	Cap	0.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	30
Retrieval Development	Exp	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	254
	Cap	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	365
Retrieval Operations	Exp	1.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	23
	Cap	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0
Waste Trans Lines	Exp	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	3
	Cap	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	9
Tank Farms Upgrades	Exp	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	20
	Cap	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	220
Ship/Repos Disposal	Exp	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	469.0	469
	Cap	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0
SUB TOTALS	Exp	211	71	68	66	67	93	115	127	21	21	21	470	6351
	Cap	12	7	3	6	17	54	32	60	0	0	0	0	2755
OPT 1 TOTAL		223	78	71	72	84	146	148	187	21	21	21	470	9105
Labor	M/Yrs	1844	638	589	590	661	1090	1157	1418	177	177	177	3961	69428
Labor Average Site Comparsn		-0.10	-0.00	0.00	0.01	0.04	0.00	0.03	-0.11	0.00	0.00	0.30		

10-Oct-91
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Opt-2

OPTION 2--DST/B PLANT WITH TRUEX
ANNUAL COSTS BY FISCAL YEAR ($MILLIONS)

		FY92	FY93	FY94	FY95	FY96	FY97	FY98	FY99	FY00	FY01	FY02
B Plant Operations	Exp	37.7	55.2	65.4	76.4	70.0	73.7	73.7	73.7	70.4	72.4	71.5
	Cap	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4
B Plant Fac Upgrades	Exp	4.5	4.2	4.3	3.8	3.4	2.3	1.6	1.4	1.2	1.0	0.0
	Cap	11.1	10.2	18.1	22.6	16.3	15.4	2.0	1.0	0.6	0.6	0.0
B Plant Prtmt Upgds	Exp	0.5	0.8	3.3	5.1	4.5	3.8	5.3	5.2	5.1	4.6	4.0
	Cap	0.0	0.0	6.5	20.0	30.0	49.0	56.0	75.0	75.0	55.0	45.0
PUREX Operations	Exp	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	Cap	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
DST Pre-treatment	Exp	0.0	0.0	0.0	0.0	0.0	3.0	3.0	0.0	0.0	0.0	0.0
	Cap	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
HWVP Constructn	Exp	30.0	37.3	45.8	52.5	65.1	64.3	78.6	45.1	14.6	0.0	0.0
	Cap	89.2	186.7	193.9	201.5	187.2	107.2	40.7	0.0	0.0	0.0	0.0
HWVP Operations	Exp	1.3	5.0	7.9	16.9	25.9	41.9	56.9	73.3	73.3	73.3	73.3
	Cap	0.0	0.0	0.1	0.3	0.9	1.9	5.0	13.9	13.9	13.9	36.4
Grout Ops & Construc	Exp	30.3	52.0	66.1	68.9	71.3	74.0	64.7	64.7	64.7	64.7	64.7
	Cap	2.3	2.1	5.9	2.6	2.3	2.3	2.3	2.3	2.3	2.3	2.3
Pretreatment Technology	Exp	9.7	21.8	23.7	18.7	15.2	12.4	9.0	8.1	6.7	5.0	4.6
	Cap	0.2	0.2	3.7	9.7	5.8	4.7	0.5	0.3	0.3	0.3	0.3
Retrieval Development	Exp	2.9	8.6	18.8	25.8	37.3	22.7	28.9	13.6	5.4	6.5	7.0
	Cap	5.8	3.0	7.0	0.0	0.0	0.0	0.0	0.0	0.0	5.0	9.5
Retrieval Operations	Exp	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.5	3.0	1.5	0.0
	Cap	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Waste Trans Lines	Exp	0.5	0.1	0.9	1.0	0.3	0.0	0.0	0.0	0.0	0.0	0.0
	Cap	6.0	0.0	3.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Tank Farms Upgrades	Exp	2.5	1.0	1.4	2.1	4.1	4.0	3.1	1.9	0.0	0.0	0.0
	Cap	0.0	8.0	11.0	12.0	25.0	62.0	70.0	32.0	0.0	0.0	0.0
Ship/Repos Disposal	Exp	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	Cap	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
SUB TOTALS	Exp	120	186	238	265	297	302	325	289	244	229	225
	Cap	115	211	250	269	268	243	177	125	93	78	94
OPT 2 TOTAL		235	397	488	534	565	545	502	413	337	307	319
Labor	M/Yrs	1675	2786	3448	3791	4053	3950	3759	3153	2594	2377	2439
Labor Average												
Site Comparsn		0.11	0.06	0.03	0.02	-0.01	-0.03	-0.06	-0.05	-0.02	0.01	-0.02

		FY03	FY04	FY05	FY06	FY07	FY08	FY09	FY10	FY11	FY12	FY13
B Plant Operations	Exp	68.3	68.3	68.3	68.3	68.3	68.3	68.3	68.3	68.3	68.3	68.3
	Cap	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4
B Plant Fac Upgrades	Exp	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	Cap	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
B Plant Prtmt Upgds	Exp	2.5	1.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	Cap	38.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
PUREX Operations	Exp	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	Cap	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
DST Pre-treatment	Exp	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	Cap	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
HWVP Constructn	Exp	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	Cap	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
HWVP Operations	Exp	73.3	73.3	73.3	73.3	73.3	73.3	73.3	73.3	73.3	73.3	73.3
	Cap	8.9	8.9	8.9	8.9	11.4	8.9	13.9	8.9	8.9	36.4	13.9
Grout Ops & Construc	Exp	64.7	64.7	64.7	64.7	64.7	64.7	64.7	64.7	64.7	64.7	64.7
	Cap	2.3	2.3	2.3	2.3	2.3	2.3	2.3	2.3	2.3	2.3	2.3
Pretreatment Technology	Exp	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0
	Cap	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3
Retrieval Development	Exp	9.0	9.0	9.0	9.0	9.0	9.0	9.0	9.0	3.0	1.5	0.5
	Cap	17.0	25.0	45.0	45.0	45.0	45.0	45.0	35.0	20.0	13.0	0.0
Retrieval Operations	Exp	0.0	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5
	Cap	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	
Waste Trans Lines	Exp	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	Cap	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Tank Farms Upgrades	Exp	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	Cap	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Ship/Repos Disposal	Exp	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	Cap	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
SUB TOTALS	Exp	221	221	220	220	220	220	220	220	214	212	211
	Cap	67	37	57	57	59	57	62	47	32	52	17
OPT 2 TOTAL		288	258	277	277	279	277	282	267	246	265	228
Labor	M/Yrs	2250	2073	2180	2180	2195	2180	2209	2122	1985	2091	1877
Labor Average				2695	1481							
Site Comparsn		-0.02	0.01	0.00	0.00	-0.00	0.00	-0.01	-0.01	0.01	-0.02	-0.00

OPTION 2--DST/B PLANT WITH TRUEX
ANNUAL COSTS BY FISCAL YEAR ($MILLIONS)

		FY14	FY15	FY16	FY17	FY18	FY19	FY20	FY21	FY22	FY23	FY24	FY25	TOTALS
B Plant Operations	Exp	68.3	34.2	67.7	66.3	66.8	92.6	115.1	127.1	21.0	21.0	21.0	1.3	2188
	Cap	0.4	0.2	3.2	5.5	17.0	53.5	32.4	60.1	0.0	0.0	0.0	0.1	181
B Plant Fac Upgrades	Exp	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	28
	Cap	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	98
B Plant Prtmt Upgds	Exp	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	46
	Cap	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	450
PUREX Operations	Exp	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0
	Cap	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0
DST Pre-treatment	Exp	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	6
	Cap	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0
HWVP Constructn	Exp	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	433
	Cap	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1006
HWVP Operations	Exp	73.3	36.7	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1365
	Cap	8.9	6.9	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	240
Grout Ops & Construc	Exp	64.7	34.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1497
	Cap	2.3	1.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	58
Pretreatment Technology	Exp	3.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	171
	Cap	0.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	30
Retrieval Development	Exp	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	254
	Cap	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	365
Retrieval Operations	Exp	1.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	23
	Cap	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0
Waste Trans Lines	Exp	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	3
	Cap	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	9
Tank Farms Upgrades	Exp	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	20
	Cap	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	220
Ship/Repos Disposal	Exp	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	469.0	469
	Cap	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0
SUB TOTALS	Exp	211	105	68	66	67	93	115	127	21	21	21	470	6502
	Cap	12	8	3	6	17	54	32	60	0	0	0	0	2657
OPT 2 TOTAL		223	113	71	72	84	146	148	187	21	21	21	470	9160
Labor	M/Yrs	1844	932	589	590	661	1090	1157	1418	177	177	177	3961	70141
Labor Average Site Comparsn		-0.07	-0.03	0.00	0.01	0.04	0.00	0.03	-0.11	0.00	0.00	0.30		

11-Oct-91
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Opt-3

OPTION 3--DST/B PLANT WITHOUT TRUEX
ANNUAL COSTS BY FISCAL YEAR ($MILLIONS)

		FY92	FY93	FY94	FY95	FY96	FY97	FY98	FY99	FY00	FY01	FY02	FY03	FY04	FY05	FY06	FY07	FY08	FY09	FY10	FY11	FY12	FY13
B Plant Operations	Exp	37.7	55.2	65.4	70.4	70.0	72.5	72.5	73.0	71.6	72.4	69.8	68.3	68.3	68.3	68.3	68.3	68.3	68.3	68.3	44.9	44.9	44.9
	Cap	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.3	0.3	0.3
B Plant Fac Upgrades	Exp	4.5	4.2	4.3	3.8	3.4	2.3	1.6	1.4	1.2	1.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	Cap	11.1	10.2	18.1	17.6	11.3	6.4	1.0	1.0	0.6	0.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
B Plant Prtmt Upgds	Exp	1.5	2.8	3.4	4.0	4.0	4.2	4.2	3.1	2.0	1.0	0.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	Cap	0.0	5.5	12.0	23.0	38.0	51.0	51.0	48.0	40.0	31.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
PUREX Operations	Exp	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	Cap	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
DST Pre-treatment	Exp	0.0	0.0	0.0	0.0	0.0	3.0	3.0	0.0	3.0	0.0	3.0	3.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	Cap	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
HWVP Constructn	Exp	30.0	37.3	45.8	52.5	65.1	64.3	78.6	45.1	14.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	Cap	89.2	186.7	193.9	201.5	187.2	107.2	40.7	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
HWVP Operations	Exp	1.3	5.0	7.9	16.9	25.9	41.9	56.9	73.3	73.3	73.3	73.3	73.3	73.3	73.3	73.3	80.4	80.4	80.4	80.4	80.4	80.4	80.4
	Cap	0.0	0.0	0.1	0.3	0.9	1.9	5.0	13.9	13.9	13.9	36.4	13.9	13.9	46.4	36.4	14.9	37.4	14.9	14.9	39.9	14.9	24.9
Grout Ops & Construc	Exp	30.3	52.0	66.1	68.9	71.3	74.0	55.7	55.7	55.7	55.7	55.7	55.7	55.7	55.7	55.7	55.7	55.7	55.7	55.7	55.7	55.7	0.0
	Cap	2.3	2.1	5.9	2.6	2.3	2.3	2.3	2.3	2.3	2.3	2.3	2.3	2.3	2.3	2.3	2.3	2.3	2.3	2.3	2.3	2.3	0.0
Pretreatment Technology	Exp	9.7	21.8	23.7	18.7	15.2	12.4	9.0	8.1	6.7	5.0	4.6	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0
	Cap	0.2	0.2	3.7	9.7	5.8	4.7	0.5	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3
Retrieval Development	Exp	2.9	8.6	18.8	25.8	37.3	22.7	28.9	25.5	7.0	9.0	9.0	9.0	9.0	9.0	9.0	9.0	9.0	3.0	1.5	0.5	0.0	0.0
	Cap	5.8	3.0	7.0	0.0	0.0	0.0	0.0	5.0	9.5	17.0	25.0	45.0	45.0	45.0	45.0	45.0	35.0	20.0	13.0	0.0	0.0	0.0
Retrieval Operations	Exp	0.0	0.0	0.0	0.0	0.0	1.5	1.5	3.0	0.0	0.0	0.0	0.0	1.5	3.0	3.0	3.0	3.0	1.5	1.5	0.0	0.0	0.0
	Cap	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Waste Trans Lines	Exp	0.5	0.1	0.9	1.0	0.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	Cap	6.0	0.0	3.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Tank Farms Upgrades	Exp	2.5	1.0	1.4	2.1	4.1	4.0	3.1	1.9	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	Cap	0.0	8.0	11.0	12.0	25.0	62.0	70.0	32.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Ship/Repos Disposal	Exp	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	Cap	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
SUB TOTALS	Exp	121	188	238	264	297	303	315	290	235	217	216	212	211	212	212	219	219	212	210	185	184	128
	Cap	115	216	255	267	271	236	171	103	67	66	64	62	62	94	84	63	75	38	31	43	18	25
OPT 3 TOTAL		236	404	493	531	568	539	486	393	302	283	280	274	273	307	297	282	295	250	241	227	202	154
Labor	M/Yrs	1684	2834	3481	3770	4066	3916	3642	3039	2368	2210	2191	2146	2134	2334	2276	2212	2284	2004	1951	1801	1653	1228
Labor Average															2844	1651							

OPTION 3--DST/B PLANT WITHOUT TRUEX
ANNUAL COSTS BY FISCAL YEAR ($MILLIONS)

		FY14	FY15	FY16	FY17	FY18	FY19	FY20	FY21	FY22	FY23	FY24	FY25	FY26	FY27	FY28	FY29	FY30	FY31	FY32	FY33	FY34	TOTALS
B Plant Operations	Exp	44.9	44.9	67.7	66.3	66.8	92.6	115.1	127.1	21.0	21.0	21.0	1.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	2101
	Cap	0.3	0.3	3.2	5.5	17.0	53.5	32.4	60.1	0.0	0.0	0.0	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	181
B Plant Fac Upgrades	Exp	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	28
	Cap	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	78
B Plant Prtmt Upgds	Exp	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	31
	Cap	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	300
PUREX Operations	Exp	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0
	Cap	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0
DST Pre-treatment	Exp	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	15
	Cap	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0
HWVP Constructn	Exp	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	433
	Cap	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1006
HWVP Operations	Exp	80.4	83.9	83.9	83.9	83.9	83.9	87.4	87.4	87.4	87.4	87.4	87.4	90.9	90.9	90.9	90.9	90.9	90.9	30.4	0.0	0.0	2905
	Cap	58.9	15.4	15.4	40.4	25.4	37.9	40.9	15.9	15.9	40.4	25.9	38.4	41.4	16.4	16.4	41.4	16.4	16.4	5.6	0.0	0.0	884
Grout Ops & Construc	Exp	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1198
	Cap	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	52
Pretreatment Technology	Exp	3.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	171
	Cap	0.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	30
Retrieval Development	Exp	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	254
	Cap	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	365
Retrieval Operations	Exp	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	23
	Cap	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0
Waste Trans Lines	Exp	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	3
	Cap	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	9
Tank Farms Upgrades	Exp	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	20
	Cap	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	220
Ship/Repos Disposal	Exp	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	3633.0	3633
	Cap	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0
SUB TOTALS	Exp	128	129	152	150	151	177	203	215	108	108	108	89	91	91	91	91	91	91	30	0	3633	10815
	Cap	60	16	19	46	42	91	73	76	16	40	26	39	41	16	16	41	16	16	6	0	0	3125
OPT 3 TOTAL		188	145	170	196	193	268	276	291	124	149	134	127	132	107	107	132	107	107	36	0	3633	13940
		1425	1176	1384	1531	1515	2015	2130	2246	1005	1147	1063	970	1005	860	860	1005	860	860	288	0	30594	109163

10-Oct-91
05:26 PM
Opt-4

OPTION 4--DST/NPF WITH TRUEX
ANNUAL COSTS BY FISCAL YEAR ($MILLIONS)

		FY92	FY93	FY94	FY95	FY96	FY97	FY98	FY99	FY00	FY01	FY02	FY03	FY04	FY05	FY06	FY07	FY08	FY09	FY10	FY11	FY12	FY13
B Plant Operations	Exp	37.7	40.0	43.7	46.0	45.5	45.5	45.5	45.5	45.5	44.9	44.9	44.9	44.9	44.9	44.9	44.9	44.9	44.9	44.9	44.9	44.9	44.9
	Cap	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4
B Plant Fac Upgrades	Exp	4.5	4.2	4.3	3.8	3.4	2.3	1.6	1.4	1.2	1.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	Cap	11.1	10.2	18.1	22.6	16.3	15.4	2.0	1.0	0.6	0.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
PUREX Operations	Exp	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	Cap	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
NPF Construction	Exp	0.2	3.5	10.8	17.6	26.5	35.3	35.3	35.3	52.9	61.7	79.4	88.2	93.3	93.3	107.3	79.4	26.5	0.0	0.0	0.0	0.0	0.0
	Cap	0.0	0.0	0.0	0.0	0.0	42.0	51.0	88.1	155.7	281.2	322.2	334.4	300.4	180.0	81.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
NPF Operations	Exp	0.0	0.0	0.0	0.0	0.0	1.2	2.4	3.7	8.7	13.7	28.6	43.5	70.9	97.0	124.4	124.4	124.4	124.4	72.8	67.7	66.3	66.8
	Cap	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.3	0.9	1.9	5.0	12.0	23.6	23.6	23.6	23.6	2.0	3.2	5.5	17.0
DST Pre-treatment	Exp	0.0	0.0	0.0	0.0	0.0	3.0	3.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	Cap	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
HWVP Constructn	Exp	30.0	37.3	45.8	52.5	65.1	64.3	78.6	45.1	14.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	Cap	89.2	186.7	193.9	201.5	187.2	107.2	40.7	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
HWVP Operations	Exp	1.3	5.0	7.9	16.9	25.9	41.9	56.9	73.3	73.3	73.3	73.3	65.3	49.4	36.6	49.4	65.3	73.3	73.3	73.3	73.3	30.5	0.0
	Cap	0.0	0.0	0.1	0.3	0.9	1.9	5.0	13.9	13.9	13.9	36.4	9.7	5.6	4.0	5.6	9.7	13.9	13.9	36.4	13.9	6.0	0.0
Grout Ops & Construc	Exp	30.3	52.0	66.1	68.9	71.3	74.0	78.6	78.6	78.6	78.6	78.6	78.6	78.6	78.6	78.6	78.6	78.6	78.6	78.6	78.6	0.0	0.0
	Cap	2.3	2.1	5.9	2.6	2.3	2.3	2.3	2.3	2.3	2.3	2.3	2.3	2.3	2.3	2.3	2.3	2.3	2.3	2.3	2.3	0.0	0.0
Pretreatment Technology	Exp	9.7	21.8	23.7	18.7	15.2	12.4	9.0	8.1	6.7	5.0	4.6	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	0.0
	Cap	0.2	0.2	3.7	9.7	5.8	4.7	0.5	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.0
Retrieval Development	Exp	2.9	8.6	18.8	25.8	37.3	22.7	28.9	19.0	6.5	7.0	9.0	9.0	9.0	9.0	9.0	9.0	9.0	9.0	3.0	1.5	0.5	0.0
	Cap	5.8	3.0	7.0	0.0	0.0	0.0	0.0	0.0	5.0	9.5	17.0	25.0	45.0	45.0	45.0	45.0	45.0	35.0	20.0	13.0	0.0	0.0
Retrieval Operations	Exp	0.0	0.0	0.0	0.0	0.0	1.5	3.0	3.0	0.0	0.0	0.0	0.0	0.0	0.0	3.0	3.0	3.0	3.0	3.0	0.0	0.0	0.0
	Cap	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Waste Trans Lines	Exp	0.5	0.1	0.9	1.0	0.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	Cap	6.0	0.0	3.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Tank Farms Upgrades	Exp	2.5	1.0	1.4	2.1	4.1	4.0	3.1	1.9	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	Cap	0.0	8.0	11.0	12.0	25.0	62.0	70.0	32.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Ship/Repos Disposal	Exp	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	Cap	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
SUB TOTALS	Exp	120	174	223	253	295	308	346	315	288	285	318	333	349	362	420	408	363	336	279	269	145	112
	Cap	115	211	243	249	238	236	172	138	178	308	379	374	359	244	158	81	86	76	61	33	12	17
OPT 4 TOTAL		235	384	467	502	533	544	518	453	466	594	698	707	708	606	578	489	448	412	340	302	157	129
Labor	M/Yrs	1673	2680	3291	3575	3858	3960	3908	3451	3457	4188	4878	4965	5018	4464	4449	3903	3549	3268	2702	2457	1293	1041
Labor Average															3812	1884							
Site Comparsn		0.10	0.06	0.02	0.02	0.01	-0.02	-0.04	0.01	0.08	0.07	0.01	0.00	-0.07	-0.02	-0.06	-0.03	-0.02	-0.05	0.03	-0.10	-0.02	0.04

OPTION 4--DST/NPF WITH TRUEX
ANNUAL COSTS BY FISCAL YEAR ($MILLIONS)

		FY14	FY15	FY16	FY17	FY18	FY19	FY20	FY21	FY22	FY23	FY24	FY25	TOTALS
B Plant Operations	Exp	44.9	44.9	67.7	66.3	66.8	92.6	115.1	127.1	21.0	21.0	21.0	1.3	1668
	Cap	0.4	0.4	3.2	5.5	17.0	53.5	32.4	60.1	0.0	0.0	0.0	0.1	181
B Plant Fac Upgrades	Exp	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	28
	Cap	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	98
PUREX Operations	Exp	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0
	Cap	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0
NPF Construc- tion	Exp	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	847
	Cap	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1836
NPF Operations	Exp	92.6	115.1	127.1	21.0	21.0	21.0	1.3	1.3	1.3	1.3	1.3	1.3	1447
	Cap	53.5	32.4	60.1	0.0	0.0	0.0	0.1	0.1	0.1	0.1	0.1	0.1	289
DST Pre- treatment	Exp	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	6
	Cap	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0
HWVP Constructn	Exp	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	433
	Cap	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1006
HWVP Operations	Exp	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1039
	Cap	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	205
Grout Ops & Construc	Exp	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1463
	Cap	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	50
Pretreatment Technology	Exp	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	165
	Cap	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	29
Retrieval Development	Exp	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	254
	Cap	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	365
Retrieval Operations	Exp	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	23
	Cap	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0
Waste Trans Lines	Exp	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	3
	Cap	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	9
Tank Farms Upgrades	Exp	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	20
	Cap	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	220
Ship/Repos Disposal	Exp	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	469.0	469
	Cap	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0
SUB TOTALS	Exp	138	160	195	87	88	114	116	128	22	22	22	472	7864
	Cap	54	33	63	6	17	54	33	60	0	0	0	0	4289
OPT 4 TOTAL		191	193	258	93	105	167	149	189	22	22	22	472	12153
Labor	M/Yrs	1470	1537	2007	767	838	1266	1168	1430	188	188	188	3973	91052
Labor Average Site Comparsn		0.00	0.04	-0.11	0.01	0.04	-0.01	0.03	-0.11	0.00	0.00	0.30		

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OPTION 5--DST/INTERMEDIATE PROCESSING/NPF WITH TRUEX
ANNUAL COSTS BY FISCAL YEAR ($MILLIONS)

		FY92	FY93	FY94	FY95	FY96	FY97	FY98	FY99	FY00	FY01	FY02	FY03	FY04	FY05	FY06	FY07	FY08	FY09	FY10	FY11	FY12	FY13
B Plant Operations	Exp	37.7	40.0	43.7	46.0	45.5	45.5	45.5	45.5	45.5	44.9	44.9	44.9	44.9	44.9	44.9	44.9	44.9	44.9	44.9	44.9	44.9	44.9
	Cap	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4
B Plant Fac Upgrades	Exp	4.5	4.2	4.3	3.8	3.4	2.3	1.6	1.4	1.2	1.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	Cap	11.1	10.2	18.1	22.6	16.3	15.4	2.0	1.0	0.6	0.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
PUREX Operations	Exp	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	Cap	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
NPF Construction	Exp	0.2	3.5	10.8	17.6	26.5	35.3	35.3	35.3	52.9	61.7	79.4	88.2	93.3	93.3	107.3	79.4	26.5	0.0	0.0	0.0	0.0	0.0
	Cap	0.0	0.0	0.0	0.0	0.0	42.0	51.0	88.1	155.7	281.2	322.2	334.4	300.4	180.0	81.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
NPF Operations	Exp	0.0	0.0	0.0	0.0	0.0	1.2	2.4	3.7	8.7	13.7	28.6	43.5	70.9	97.0	124.4	124.4	124.4	124.4	52.0	67.7	66.3	66.8
	Cap	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.3	0.9	1.9	5.0	12.0	23.6	23.6	23.6	23.6	2.0	3.2	5.5	17.0
DST Pre-treatment	Exp	0.0	0.0	0.0	0.0	0.0	3.0	3.0	0.0	0.0	0.0	0.0	3.0	3.0	3.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	Cap	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
HWVP Constructn	Exp	30.0	37.3	45.8	52.5	65.1	64.3	78.6	45.1	14.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	Cap	89.2	186.7	193.9	201.5	187.2	107.2	40.7	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
HWVP Operations	Exp	1.3	5.0	7.9	16.9	25.9	41.9	56.9	73.3	73.3	73.3	73.3	65.3	65.3	73.3	73.3	73.3	73.3	73.3	73.3	42.7	0.0	0.0
	Cap	0.0	0.0	0.1	0.3	0.9	1.9	5.0	13.9	13.9	13.9	36.4	9.7	5.6	13.9	13.9	36.4	13.9	13.9	36.4	8.9	0.0	0.0
Grout Ops & Construc	Exp	30.3	52.0	66.1	68.9	71.3	74.0	78.6	78.6	78.6	78.6	78.6	78.6	78.6	78.6	78.6	78.6	78.6	78.6	78.6	78.6	0.0	0.0
	Cap	2.3	2.1	5.9	2.6	2.3	2.3	2.3	2.3	2.3	2.3	2.3	2.3	2.3	2.3	2.3	2.3	2.3	2.3	2.3	2.3	0.0	0.0
Pretreatment Technology	Exp	9.7	21.8	23.7	18.7	15.2	12.4	9.0	8.1	6.7	5.0	4.6	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.3	0.0
	Cap	0.2	0.2	3.7	9.7	5.8	4.7	0.5	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.0
Retrieval Development	Exp	2.9	8.6	18.8	25.8	37.3	22.7	28.9	13.6	5.4	6.5	7.0	9.0	9.0	9.0	9.0	9.0	9.0	9.0	9.0	3.0	1.5	0.5
	Cap	5.8	3.0	7.0	0.0	0.0	0.0	0.0	0.0	0.0	5.0	9.5	17.0	25.0	45.0	45.0	45.0	45.0	45.0	35.0	20.0	13.0	0.0
Retrieval Operations	Exp	0.0	0.0	0.0	0.0	0.0	1.5	3.0	3.0	0.0	0.0	0.0	0.0	0.0	0.0	3.0	3.0	3.0	3.0	3.0	0.0	0.0	0.0
	Cap	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Waste Trans Lines	Exp	0.5	0.1	0.9	1.0	0.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	Cap	6.0	0.0	3.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Tank Farms Upgrades	Exp	2.5	1.0	1.4	2.1	4.1	4.0	3.1	1.9	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	Cap	0.0	8.0	11.0	12.0	25.0	62.0	70.0	32.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Ship/Repos Disposal	Exp	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	Cap	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
SUB TOTALS	Exp	120	174	223	253	295	308	346	310	287	285	316	336	368	402	444	416	363	336	264	240	116	112
	Cap	115	211	243	249	238	236	172	138	173	304	372	366	339	254	167	108	86	86	76	35	19	17
OPT 5 TOTAL		235	384	467	502	533	544	518	448	460	589	688	702	707	656	610	524	448	422	340	275	135	130
Labor	M/Yrs	1673	2680	3291	3575	3858	3960	3908	3405	3419	4157	4818	4944	5062	4856	4699	4125	3549	3326	2664	2223	1085	1046
Labor Average															3829	1997							
Site Comparsn		0.10	0.06	0.02	0.02	0.01	-0.02	-0.05	0.01	0.09	0.07	0.01	0.00	-0.03	-0.03	-0.06	-0.05	-0.02	-0.05	-0.04	-0.09	-0.00	0.04

OPTION 5--DST/INTERMEDIATE PROCESSING/NPF WITH T
ANNUAL COSTS BY FISCAL YEAR ($MILLIONS)

		FY14	FY15	FY16	FY17	FY18	FY19	FY20	FY21	FY22	FY23	FY24	FY25	TOTALS
B Plant Operations	Exp	44.9	44.9	67.7	66.3	66.8	92.6	115.1	127.1	21.0	21.0	21.0	1.3	1668
	Cap	0.4	0.4	3.2	5.5	17.0	53.5	32.4	60.1	0.0	0.0	0.0	0.1	181
B Plant Fac Upgrades	Exp	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	28
	Cap	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	98
PUREX Operations	Exp	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0
	Cap	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0
NPF Construc-tion	Exp	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	847
	Cap	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1836
NPF Operations	Exp	92.6	115.1	127.1	21.0	21.0	21.0	1.3	1.3	1.3	1.3	1.3	1.3	1426
	Cap	53.5	32.4	60.1	0.0	0.0	0.0	0.1	0.1	0.1	0.1	0.1	0.1	289
DST Pre-treatment	Exp	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	15
	Cap	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0
HWVP Constructn	Exp	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	433
	Cap	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1006
HWVP Operations	Exp	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1062
	Cap	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	239
Grout Ops & Construc	Exp	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1463
	Cap	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	50
Pretreatment Technology	Exp	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	165
	Cap	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	2.
Retrieval Development	Exp	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	254
	Cap	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	365
Retrieval Operations	Exp	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	23
	Cap	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	[illegible]	0.0	0.0	0.0	0
Waste Trans Lines	Exp	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	3
	Cap	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	9
Tank Farms Upgrades	Exp	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	20
	Cap	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	220
Ship/Repos Disposal	Exp	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	731.5	732
	Cap	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0
SUB TOTALS	Exp	138	160	195	87	88	114	116	128	22	22	22	734	8138
	Cap	54	33	63	6	17	54	33	60	0	0	0	0	4323
OPT 5 TOTAL		191	193	258	93	105	167	149	189	22	22	22	734	12461
Labor	M/Yrs	1470	1537	2007	767	838	1266	1168	1430	188	188	188	6183	93556
Labor Average Site Comparsn		0.00	0.04	-0.11	0.01	0.04	-0.01	0.03	-0.11	0.00	0.00	0.47		

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OPTION 6--DST/NPF WITHOUT TRUEX
ANNUAL COSTS BY FISCAL YEAR ($MILLIONS)

		FY92	FY93	FY94	FY95	FY96	FY97	FY98	FY99	FY00	FY01	FY02	FY03	FY04	FY05	FY06	FY07	FY08	FY09	FY10	FY11	FY12	FY13
B Plant Operations	Exp	37.7	40.0	43.7	46.0	45.5	45.5	45.5	45.5	45.5	44.9	44.9	44.9	44.9	44.9	44.9	44.9	44.9	44.9	44.9	44.9	44.9	44.9
	Cap	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4
B Plant Fac Upgrades	Exp	4.5	4.2	4.3	3.8	3.4	2.3	1.6	1.4	1.2	1.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	Cap	11.1	10.2	18.1	17.6	11.3	6.4	1.0	1.0	0.6	0.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
PUREX Operations	Exp	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	Cap	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
NPF Construction	Exp	2.6	8.1	12.7	19.1	25.5	25.5	25.5	38.2	44.6	57.3	63.7	76.4	76.4	95.6	57.3	19.1	0.0	0.0	0.0	0.0	0.0	0.0
	Cap	0.0	0.0	0.0	13.0	26.0	32.5	59.3	113.9	222.6	252.2	261.0	235.0	130.0	58.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
NPF Operations	Exp	0.0	0.0	0.0	0.0	0.6	1.3	1.9	4.4	6.9	14.4	22.0	35.8	49.0	62.8	62.8	62.8	62.8	62.8	31.2	67.7	66.3	66.8
	Cap	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.3	0.8	1.5	4.3	11.9	11.9	11.9	11.9	6.0	3.2	5.5	17.0
DST Pre-treatment	Exp	0.0	0.0	0.0	0.0	0.0	3.0	3.0	0.0	3.0	3.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	Cap	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
HWVP Constructn	Exp	30.0	37.3	45.8	52.5	65.1	64.3	78.6	45.1	14.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	Cap	89.2	186.7	193.9	201.5	187.2	107.2	40.7	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
HWVP Operations	Exp	1.3	5.0	7.9	16.9	25.9	41.9	56.9	73.3	73.3	73.3	73.3	73.3	73.3	73.3	73.3	80.4	80.4	80.4	80.4	80.4	80.4	80.4
	Cap	0.0	0.0	0.1	0.3	0.9	1.9	5.0	13.9	13.9	13.9	36.4	13.9	13.9	46.4	36.4	14.9	37.4	14.9	14.9	39.9	14.9	24.9
Grout Ops & Construc	Exp	30.3	52.0	66.1	68.9	71.3	74.0	55.7	55.7	55.7	55.7	55.7	55.7	55.7	55.7	55.7	55.7	55.7	55.7	55.7	55.7	55.7	0.0
	Cap	2.3	2.1	5.9	2.6	2.3	2.3	2.3	2.3	2.3	2.3	2.3	2.3	2.3	2.3	2.3	2.3	2.3	2.3	2.3	2.3	2.3	0.0
Pretreatment Technology	Exp	9.7	21.8	23.7	18.7	15.2	12.4	9.0	8.1	6.7	5.0	4.6	3.0	3.0	3.0	3.0	3.0	3.0	3.0	0.0	0.0	0.0	0.0
	Cap	0.2	0.2	3.7	9.7	5.8	4.7	0.5	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.0	0.0	0.0	0.0
Retrieval Development	Exp	2.9	8.6	18.8	25.8	37.3	22.7	28.9	25.5	7.0	9.0	9.0	9.0	9.0	9.0	9.0	9.0	9.0	3.0	1.5	0.5	0.0	0.0
	Cap	5.8	3.0	7.0	0.0	0.0	0.0	0.0	5.0	9.5	17.0	25.0	45.0	45.0	45.0	45.0	45.0	35.0	20.0	13.0	0.0	0.0	0.0
Retrieval Operations	Exp	0.0	0.0	0.0	0.0	0.0	1.5	1.5	1.5	1.5	0.0	0.0	0.0	0.0	3.0	3.0	3.0	3.0	3.0	1.5	0.0	0.0	0.0
	Cap	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Waste Trans Lines	Exp	0.5	0.1	0.9	1.0	0.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	Cap	6.0	0.0	3.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Tank Farms Upgrades	Exp	2.5	1.0	1.4	2.1	4.1	4.0	3.1	1.9	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	Cap	0.0	8.0	11.0	12.0	25.0	62.0	70.0	32.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Ship/Repos Disposal	Exp	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	Cap	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
SUB TOTALS	Exp	122	178	225	255	294	298	311	301	260	264	273	298	311	347	309	278	259	253	215	249	247	192
	Cap	115	211	243	257	259	217	179	169	250	287	326	298	193	157	96	75	87	50	37	46	23	42
OPT 6 TOTAL		237	389	469	512	553	516	490	469	510	550	599	596	505	505	405	353	346	303	252	295	270	234
Labor	M/Yrs	1693	2719	3307	3634	3976	3771	3658	3509	3635	3880	4186	4234	3741	3835	3160	2773	2685	2417	2024	2364	2216	1863
Labor Average															3556	2067							

OPTION 6--DST/NPF WITHOUT TRUEX
ANNUAL COSTS BY FISCAL YEAR ($MILLIONS)

		FY14	FY15	FY16	FY17	FY18	FY19	FY20	FY21	FY22	FY23	FY24	FY25	FY26	FY27	FY28	FY29	FY30	FY31	FY32	FY33	FY34	TOTALS
B Plant Operations	Exp	44.9	44.9	67.7	66.3	66.8	92.6	115.1	127.1	21.0	21.0	21.0	1.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1668
	Cap	0.4	0.3	3.2	5.5	17.0	53.5	32.4	60.1	0.0	0.0	0.0	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	181
B Plant Fac Upgrades	Exp	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	28
	Cap	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	78
PUREX Operations	Exp	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0
	Cap	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0
NPF Construc-tion	Exp	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	648
	Cap	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1404
NPF Operations	Exp	92.6	115.1	127.1	21.0	21.0	21.0	1.3	1.3	1.3	1.3	1.3	1.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1088
	Cap	53.5	32.4	60.1	0.0	0.0	0.0	0.1	0.1	0.1	0.1	0.1	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	233
DST Pre-treatment	Exp	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	12
	Cap	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0
HWVP Constructn	Exp	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	433
	Cap	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1006
HWVP Operations	Exp	80.4	83.9	83.9	83.9	83.9	83.9	87.4	87.4	87.4	87.4	87.4	87.4	90.9	90.9	90.9	90.9	90.9	90.9	30.4	0.0	0.0	2905
	Cap	58.9	15.4	15.4	40.4	25.4	37.9	40.9	15.9	15.9	40.4	25.9	38.4	41.4	16.4	16.4	41.4	16.4	16.4	5.6	0.0	0.0	884
Grout Ops & Construc	Exp	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1198
	Cap	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	52
Pretreatment Technology	Exp	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	156
	Cap	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	28
Retrieval Development	Exp	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	254
	Cap	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	365
Retrieval Operations	Exp	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	23
	Cap	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0
Waste Trans Lines	Exp	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	3
	Cap	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	9
Tank Farms Upgrades	Exp	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	20
	Cap	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	220
Ship/Repos Disposal	Exp	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	3633.0	3633
	Cap	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0
SUB TOTALS	Exp	218	244	279	171	172	198	204	216	110	110	110	90	91	91	91	91	91	91	30	0	3633	12069
	Cap	113	48	79	46	42	91	73	76	16	41	26	39	41	16	16	41	16	16	6	0	0	4461
OPT 6 TOTAL		331	292	357	217	214	289	277	292	126	150	136	129	132	107	107	132	107	107	36	0	3633	16530
Labor Labor Average	M/Yrs	2488	2332	2803	1707	1691	2192	2141	2258	1016	1158	1074	981	1005	860	860	1005	860	860	288	0	30594	127458

11-Oct-91
07:28 AM
Opt-7

OPTION 7--DST/INT PROC/NPF WITHOUT TRUEX
ANNUAL COSTS BY FISCAL YEAR ($MILLIONS)

		FY92	FY93	FY94	FY95	FY96	FY97	FY98	FY99	FY00	FY01	FY02	FY03	FY04	FY05	FY06	FY07	FY08	FY09	FY10	FY11	FY12	FY13
B Plant Operations	Exp	37.7	40.0	43.7	46.0	45.5	45.5	45.5	45.5	45.5	44.9	44.9	44.9	44.9	44.9	44.9	44.9	44.9	44.9	44.9	44.9	44.9	44.9
	Cap	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4
B Plant Fac Upgrades	Exp	4.5	4.2	4.3	3.8	3.4	2.3	1.6	1.4	1.2	1.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	Cap	11.1	10.2	18.1	17.6	11.3	6.4	1.0	1.0	0.6	0.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
PUREX Operations	Exp	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	Cap	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
NPF Construction	Exp	2.6	8.1	12.7	19.1	25.5	25.5	25.5	38.2	44.6	57.3	63.7	76.4	76.4	95.6	57.3	19.1	0.0	0.0	0.0	0.0	0.0	0.0
	Cap	0.0	0.0	0.0	13.0	26.0	32.5	59.3	113.9	222.6	252.2	261.0	235.0	130.0	58.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
NPF Operations	Exp	0.0	0.0	0.0	0.0	0.6	1.3	1.9	4.4	6.9	14.4	22.0	35.8	49.0	62.8	62.8	62.8	62.8	62.8	31.2	67.7	66.3	66.8
	Cap	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.3	0.8	1.5	4.3	11.9	11.9	11.9	11.9	6.0	3.2	5.5	17.0
DST Pretreatment	Exp	0.0	0.0	0.0	0.0	0.0	3.0	3.0	0.0	3.0	3.0	0.0	3.0	3.0	3.0	3.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	Cap	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
HWVP Constructn	Exp	30.0	37.3	45.8	52.5	65.1	64.3	78.6	45.1	14.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	Cap	89.2	186.7	193.9	201.5	187.2	107.2	40.7	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
HWVP Operations	Exp	1.3	5.0	7.9	16.9	25.9	41.9	56.9	73.3	73.3	73.3	73.3	65.3	65.3	65.3	73.3	73.3	73.3	73.3	73.3	73.3	80.4	80.4
	Cap	0.0	0.0	0.1	0.3	0.9	1.9	5.0	13.9	13.9	13.9	36.4	5.6	5.6	5.6	13.9	13.9	36.4	13.9	23.9	58.9	14.9	14.9
Grout Ops & Construc	Exp	30.3	52.0	66.1	68.9	71.3	74.0	55.7	55.7	55.7	55.7	55.7	55.7	55.7	55.7	55.7	55.7	55.7	55.7	55.7	55.7	55.7	0.0
	Cap	2.3	2.1	5.9	2.6	2.3	2.3	2.3	2.3	2.3	2.3	2.3	2.3	2.3	2.3	2.3	2.3	2.3	2.3	2.3	2.3	2.3	0.0
Pretreatment Technology	Exp	9.7	21.8	23.7	18.7	15.2	12.4	9.0	8.1	6.7	5.0	4.6	3.0	3.0	3.0	3.0	3.0	3.0	3.0	0.0	0.0	0.0	0.0
	Cap	0.2	0.2	3.7	9.7	5.8	4.7	0.5	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.0	0.0	0.0	0.0
Retrieval Development	Exp	2.9	8.6	18.8	25.8	37.3	22.7	28.9	25.5	7.0	9.0	9.0	9.0	9.0	9.0	9.0	9.0	9.0	3.0	1.5	0.5	0.0	0.0
	Cap	5.8	3.0	7.0	0.0	0.0	0.0	0.0	5.0	9.5	17.0	25.0	45.0	45.0	45.0	45.0	45.0	35.0	20.0	13.0	0.0	0.0	0.0
Retrieval Operations	Exp	0.0	0.0	0.0	0.0	0.0	1.5	1.5	1.5	1.5	0.0	0.0	0.0	0.0	3.0	3.0	3.0	3.0	3.0	1.5	0.0	0.0	0.0
	Cap	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Waste Trans Lines	Exp	0.5	0.1	0.9	1.0	0.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	Cap	6.0	0.0	3.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Tank Farms Upgrades	Exp	2.5	1.0	1.4	2.1	4.1	4.0	3.1	1.9	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	Cap	0.0	8.0	11.0	12.0	25.0	62.0	70.0	32.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Ship/Repos Disposal	Exp	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	Cap	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
SUB TOTALS	Exp	122	178	225	255	294	298	311	301	260	264	273	293	306	342	312	271	252	246	208	242	247	192
	Cap	115	211	243	257	259	217	179	169	250	287	326	289	195	116	74	74	86	49	46	65	23	32
OPT 7 TOTAL		237	389	469	512	553	516	490	469	510	550	599	583	491	459	386	345	338	295	254	307	270	224
Labor	M/Yrs	1693	2719	3307	3634	3976	3771	3658	3509	3635	3880	4186	4144	3651	3556	3055	2708	2619	2352	2016	2414	2216	1805
Labor Average															3523	1635							

OPTION 7--DST/INT PROC/NPF WITHOUT TRUEX
ANNUAL COSTS BY FISCAL YEAR ($MILLIONS)

		FY14	FY15	FY16	FY17	FY18	FY19	FY20	FY21	FY22	FY23	FY24	FY25	FY26	FY27	FY28	FY29	FY30	FY31	FY32	FY33	FY34	TOTALS
B Plant Operations	Exp	44.9	44.9	67.7	66.3	66.8	92.6	115.1	127.1	21.0	21.0	21.0	1.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1668
	Cap	0.4	0.3	3.2	5.5	17.0	53.5	32.4	60.1	0.0	0.0	0.0	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	181
B Plant Fac Upgrades	Exp	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	28
	Cap	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	78
PUREX Operations	Exp	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0
	Cap	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0
NPF Construction	Exp	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	648
	Cap	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1404
NPF Operations	Exp	92.6	115.1	127.1	21.0	21.0	21.0	1.3	1.3	1.3	1.3	1.3	1.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1088
	Cap	53.5	32.4	60.1	0.0	0.0	0.0	0.1	0.1	0.1	0.1	0.1	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	233
DST Pre-treatment	Exp	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	24
	Cap	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0
HWVP Constructn	Exp	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	433
	Cap	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1006
HWVP Operations	Exp	80.4	80.4	80.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1487
	Cap	39.9	14.9	14.9	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	363
Grout Ops & Construc	Exp	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1198
	Cap	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	52
Pretreatment Technology	Exp	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	156
	Cap	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	28
Retrieval Development	Exp	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	254
	Cap	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	365
Retrieval Operations	Exp	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	23
	Cap	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0
Waste Trans Lines	Exp	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	3
	Cap	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	9
Tank Farms Upgrades	Exp	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	20
	Cap	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	220
Ship/Repos Disposal	Exp	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1428.0	1428
	Cap	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0
SUB TOTALS	Exp	218	240	275	87	88	114	116	128	22	22	22	3	0	0	0	0	0	0	0	0	1428	8457
	Cap	94	48	78	6	17	54	33	60	0	0	0	0	0	0	0	0	0	0	0	0	0	3941
OPT 7 TOTAL		312	288	353	93	105	167	149	189	22	22	22	3	0	0	0	0	0	0	0	0	1428	12398
Labor Labor Average	M/Yrs	2378	2300	2770	767	838	1266	1168	1430	188	188	188	23	0	0	0	0	0	0	0	0	12025	94035

10-Oct-91
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Opt-8

OPTION 8--DST/PUREX WITH TRUEX
ANNUAL COSTS BY FISCAL YEAR ($MILLIONS)

		FY92	FY93	FY94	FY95	FY96	FY97	FY98	FY99	FY00	FY01	FY02	FY03	FY04	FY05	FY06	FY07	FY08	FY09	FY10	FY11	FY12	FY13
B Plant Operations	Exp	37.7	40.0	43.7	46.0	45.5	45.5	45.5	45.5	45.5	44.9	44.9	44.9	44.9	44.9	44.9	44.9	44.9	44.9	44.9	44.9	44.9	44.9
	Cap	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4
B Plant Fac Upgrades	Exp	4.5	4.2	4.3	3.8	3.4	2.3	1.6	1.4	1.2	1.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	Cap	11.1	10.2	18.1	22.6	16.3	15.4	2.0	1.0	0.6	0.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
PUREX Operations	Exp	67.7	64.0	65.0	90.0	100.0	115.0	120.0	120.0	120.0	120.0	120.0	120.0	120.0	120.0	120.0	120.0	120.0	10.0	67.7	66.3	66.8	92.6
	Cap	3.2	6.0	2.0	8.0	7.0	14.0	7.0	11.0	7.0	11.0	7.0	16.0	14.0	9.0	5.0	7.0	5.0	1.0	3.2	5.5	17.0	53.5
PUREX Fac Upgds	Exp	0.0	0.0	4.2	14.0	7.0	14.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	Cap	0.0	0.0	10.8	36.0	18.0	36.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
PUREX Pre-trmnt Upgds	Exp	0.0	0.0	0.0	0.0	1.0	3.0	7.0	9.0	5.0	5.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	Cap	0.0	0.0	0.0	0.0	9.0	27.0	63.0	81.0	45.0	45.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
DST Pre-treatment	Exp	0.0	0.0	0.0	0.0	0.0	1.5	3.0	1.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	Cap	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
HWVP Constructn	Exp	30.0	37.3	45.8	52.5	65.1	64.3	78.6	45.1	14.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	Cap	89.2	186.7	193.9	201.5	187.2	107.2	40.7	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
HWVP Operations	Exp	1.3	5.0	7.9	16.9	25.9	41.9	56.9	73.3	73.3	73.3	73.3	73.3	73.3	73.3	73.3	73.3	73.3	73.3	30.5	0.0	0.0	0.0
	Cap	0.0	0.0	0.1	0.3	0.9	1.9	5.0	13.9	13.9	13.9	36.4	8.9	8.9	11.4	11.4	13.9	8.9	13.9	6.0	0.0	0.0	0.0
Grout Ops & Construc	Exp	30.3	52.0	66.1	68.9	71.3	74.0	91.7	91.7	91.7	91.7	91.7	91.7	91.7	91.7	91.7	91.7	91.7	91.7	0.0	0.0	0.0	0.0
	Cap	2.3	2.1	5.9	2.6	2.3	2.3	2.3	2.3	2.3	2.3	2.3	2.3	2.3	2.3	2.3	2.3	2.3	2.3	0.0	0.0	0.0	0.0
Pretreatment Technology	Exp	9.7	21.8	23.7	18.7	15.2	12.4	9.0	8.1	6.7	5.0	4.6	3.0	3.0	3.0	3.0	3.0	3.0	3.0	0.0	0.0	0.0	0.0
	Cap	0.2	0.2	3.7	9.7	5.8	4.7	0.5	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.0	0.0	0.0	0.0
Retrieval Development	Exp	2.9	8.6	18.8	25.8	37.3	22.7	28.9	20.1	12.4	9.0	9.0	9.0	9.0	9.0	9.0	9.0	9.0	3.0	1.5	0.5	0.0	0.0
	Cap	5.8	3.0	7.0	0.0	0.0	0.0	0.0	5.0	9.5	17.0	25.0	45.0	45.0	45.0	45.0	45.0	35.0	20.0	13.0	0.0	0.0	0.0
Retrieval Operations	Exp	0.0	0.0	0.0	0.0	0.0	1.5	3.0	3.0	1.5	0.0	0.0	0.0	3.0	3.0	3.0	3.0	1.5	0.0	0.0	0.0	0.0	0.0
	Cap	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Waste Trans Lines	Exp	0.5	0.1	0.9	1.0	0.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	Cap	6.0	0.0	3.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Tank Farms Upgrades	Exp	2.5	1.0	1.4	2.1	4.1	4.0	3.1	1.9	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	Cap	0.0	8.0	11.0	12.0	25.0	62.0	70.0	32.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Ship/Repos Disposal	Exp	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	Cap	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
SUB TOTALS	Exp	187	234	282	340	376	402	448	421	372	350	344	342	345	345	345	345	343	226	145	112	112	138
	Cap	118	217	256	293	272	271	191	147	79	91	71	73	71	68	64	69	52	38	23	6	17	54
OPT 8 TOTAL		305	451	538	633	648	673	639	568	451	440	415	415	416	413	409	414	395	264	167	118	129	191
Labor	M/Yrs	2260	3225	3857	4558	4741	4954	4880	4392	3589	3470	3306	3301	3315	3300	3277	3303	3192	2122	1349	975	1041	1470
Labor Average															3796	1534							
Site Comparsn		0.10	0.06	0.06	0.01	0.02	-0.02	-0.05	-0.08	-0.01	-0.02	-0.00	0.00	-0.00	-0.00	0.00	-0.01	-0.09	-0.06	-0.03	0.01	0.04	0.00

OPTION 8--DST/PUREX WITH TRUEX
ANNUAL COSTS BY FISCAL YEAR ($MILLIONS)

		FY14	FY15	FY16	FY17	FY18	FY19	FY20	FY21	FY22	FY23	FY24	FY25	TOTALS
B Plant Operations	Exp	44.9	44.9	67.7	66.3	66.8	92.6	115.1	127.1	21.0	21.0	21.0	1.3	1668
	Cap	0.4	0.4	3.2	5.5	17.0	53.5	32.4	60.1	0.0	0.0	0.0	0.1	181
B Plant Fac Upgrades	Exp	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	28
	Cap	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	98
PUREX Operations	Exp	115.1	127.1	21.0	21.0	21.0	1.3	1.3	1.3	1.3	1.3	1.3	1.3	2439
	Cap	32.4	60.1	0.0	0.0	0.0	0.1	0.1	0.1	0.1	0.1	0.1	0.1	313
PUREX Fac Upgds	Exp	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	39
	Cap	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	101
PUREX Pre-trmnt Upgds	Exp	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	30
	Cap	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	270
DST Pre-treatment	Exp	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	6
	Cap	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0
HWVP Constructn	Exp	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	433
	Cap	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1006
HWVP Operations	Exp	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	993
	Cap	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	170
Grout Ops & Construc	Exp	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1463
	Cap	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	45
Pretreatment Technology	Exp	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	156
	Cap	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	28
Retrieval Development	Exp	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	254
	Cap	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	365
Retrieval Operations	Exp	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	23
	Cap	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0
Waste Trans Lines	Exp	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	3
	Cap	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	9
Tank Farms Upgrades	Exp	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	20
	Cap	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	220
Ship/Repos Disposal	Exp	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	469.0	469
	Cap	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0
SUB TOTALS	Exp	160	172	89	87	88	94	116	128	22	22	22	472	8024
	Cap	33	61	3	6	17	54	33	60	0	0	0	0	2807
OPT 8 TOTAL		193	233	92	93	105	148	149	189	22	22	22	472	10831
Labor	M/Yrs	1537	1799	765	767	838	1101	1168	1430	188	188	188	3973	83822
Labor Average Site Comparsn		0.03	-0.09	0.00	0.01	0.03	0.00	0.03	-0.11	0.00	0.00	0.30		

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Opt-9

OPTION 9--DST/PUREX WITHOUT TRUEX
ANNUAL COSTS BY FISCAL YEAR ($MILLIONS)

		FY92	FY93	FY94	FY95	FY96	FY97	FY98	FY99	FY00	FY01	FY02	FY03	FY04	FY05	FY06	FY07	FY08	FY09	FY10	FY11	FY12	FY13
B Plant Operations	Exp	37.7	40.0	43.7	46.0	45.5	45.5	45.5	45.5	45.5	44.9	44.9	44.9	44.9	44.9	44.9	44.9	44.9	44.9	44.9	44.9	44.9	44.9
	Cap	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4
B Plant Fac Upgrades	Exp	4.5	4.2	4.3	3.8	3.4	2.3	1.6	1.4	1.2	1.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	Cap	11.1	10.2	18.1	17.6	11.3	6.4	1.0	1.0	0.6	0.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
PUREX Operations	Exp	43.7	40.0	41.0	66.0	76.0	91.0	91.0	91.0	91.0	91.0	91.0	91.0	91.0	91.0	91.0	91.0	91.0	52.8	67.7	66.3	66.8	92.6
	Cap	2.0	6.0	2.0	8.0	7.0	14.0	7.0	11.0	7.0	7.0	7.0	7.0	7.0	11.0	7.0	11.0	7.0	7.0	3.2	5.5	17.0	53.5
PUREX Fac Upgds	Exp	0.0	0.0	4.2	14.0	7.0	14.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	Cap	0.0	0.0	10.8	36.0	18.0	36.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
PUREX Pre-trmnt Upgds	Exp	0.0	0.0	0.0	0.0	1.0	3.0	7.0	8.0	5.0	2.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	Cap	0.0	0.0	0.0	0.0	9.0	27.0	63.0	72.0	45.0	18.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
DST Pre-treatment	Exp	0.0	0.0	0.0	0.0	0.0	3.0	3.0	0.0	3.0	3.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	Cap	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
HWVP Constructn	Exp	30.0	37.3	45.8	52.5	65.1	64.3	78.6	45.1	14.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	Cap	89.2	186.7	193.9	201.5	187.2	107.2	40.7	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
HWVP Operations	Exp	1.3	5.0	7.9	16.9	25.9	41.9	56.9	73.3	73.3	73.3	73.3	73.3	73.3	73.3	73.3	80.4	80.4	80.4	80.4	80.4	80.4	80.4
	Cap	0.0	0.0	0.1	0.3	0.9	1.9	5.0	13.9	13.9	13.9	36.4	13.9	13.9	46.4	36.4	14.9	37.4	14.9	14.9	39.9	14.9	24.9
Grout Ops & Construc	Exp	30.3	52.0	66.1	68.9	71.3	74.0	55.7	55.7	55.7	55.7	55.7	55.7	55.7	55.7	55.7	55.7	55.7	55.7	55.7	55.7	55.7	0.0
	Cap	2.3	2.1	5.9	2.6	2.3	2.3	2.3	2.3	2.3	2.3	2.3	2.3	2.3	2.3	2.3	2.3	2.3	2.3	2.3	2.3	2.3	0.0
Pretreatment Technology	Exp	9.7	21.8	23.7	18.7	15.2	12.4	9.0	8.1	6.7	5.0	4.6	3.0	3.0	3.0	3.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	Cap	0.2	0.2	3.7	9.7	5.8	4.7	0.5	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Retrieval Development	Exp	2.9	8.6	18.8	25.8	37.3	22.7	28.9	25.5	7.0	9.0	9.0	9.0	9.0	9.0	9.0	9.0	9.0	3.0	1.5	0.5	0.0	0.0
	Cap	5.8	3.0	7.0	0.0	0.0	0.0	0.0	5.0	9.5	17.0	25.0	45.0	45.0	45.0	45.0	45.0	35.0	20.0	13.0	0.0	0.0	0.0
Retrieval Operations	Exp	0.0	0.0	0.0	0.0	0.0	1.5	1.5	1.5	3.0	0.0	0.0	0.0	0.0	3.0	3.0	3.0	3.0	3.0	0.0	0.0	0.0	0.0
	Cap	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Waste Trans Lines	Exp	0.5	0.1	0.9	1.0	0.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	Cap	6.0	0.0	3.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Tank Farms Upgrades	Exp	2.5	1.0	1.4	2.1	4.1	4.0	3.1	1.9	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	Cap	0.0	8.0	11.0	12.0	25.0	62.0	70.0	32.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Ship/Repos Disposal	Exp	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	Cap	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
SUB TOTALS	Exp	163	210	258	316	352	380	382	357	306	285	279	277	277	280	280	284	284	240	250	248	248	218
	Cap	117	217	256	288	267	262	190	138	79	60	71	69	69	105	91	74	82	45	34	48	35	79
OPT 9 TOTAL		280	427	514	604	619	642	572	495	385	344	350	346	346	385	371	358	366	284	284	296	282	297
Labor	M/Yrs	2051	3022	3655	4326	4510	4713	4315	3805	3034	2744	2759	2731	2731	2967	2886	2818	2867	2278	2303	2365	2287	2291
Labor Average															3383	2043							

OPTION 9--DST/PUREX WITHOUT TRUEX ANNUAL COSTS BY FISCAL YEAR ($MILLIONS)

		FY14	FY15	FY16	FY17	FY18	FY19	FY20	FY21	FY22	FY23	FY24	FY25	FY26	FY27	FY28	FY29	FY30	FY31	FY32	FY33	FY34	TOTALS
B Plant Operations	Exp	44.9	44.9	67.7	66.3	66.8	92.6	115.1	127.1	21.0	21.0	21.0	1.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1668
	Cap	0.4	0.3	3.2	5.5	17.0	53.5	32.4	60.1	0.0	0.0	0.0	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	181
B Plant Fac Upgrades	Exp	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	28
	Cap	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	78
PUREX Operations	Exp	115.1	127.1	21.0	21.0	21.0	1.3	1.3	1.3	1.3	1.3	1.3	1.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	2019
	Cap	32.4	60.1	0.0	0.0	0.0	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	307
PUREX Fac Upgds	Exp	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	39
	Cap	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	101
PUREX Pre-trmnt Upgds	Exp	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	26
	Cap	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	234
DST Pre-treatment	Exp	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	12
	Cap	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0
HWVP Constructn	Exp	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	433
	Cap	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1006
HWVP Operations	Exp	80.4	83.9	83.9	83.9	83.9	83.9	87.4	87.4	87.4	87.4	87.4	87.4	90.9	90.9	90.9	90.9	90.9	90.9	30.4	0.0	0.0	2905
	Cap	58.9	15.4	15.4	40.4	25.4	37.9	40.9	15.9	15.9	40.4	25.9	38.4	41.4	16.4	16.4	41.4	16.4	16.4	5.6	0.0	0.0	884
Grout Ops & Construc	Exp	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1198
	Cap	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	52
Pretreatment Technology	Exp	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	147
	Cap	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	27
Retrieval Development	Exp	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	254
	Cap	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	365
Retrieval Operations	Exp	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	23
	Cap	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0
Waste Trans Lines	Exp	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	3
	Cap	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	9
Tank Farms Upgrades	Exp	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	20
	Cap	0 0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	220
Ship/Repos Disposal	Exp	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	3633.0	3633
	Cap	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0
SUB TOTALS	Exp	240	256	173	171	172	178	204	216	110	110	110	90	91	91	91	91	91	91	30	0	3633	12409
	Cap	92	76	19	46	42	92	73	76	16	41	26	39	41	16	16	41	16	16	6	0	0	3465
OPT 9 TOTAL		332	332	191	217	214	269	277	292	126	150	136	129	132	107	107	132	107	107	36	0	3633	15874
Labor Labor Average	M/Yrs	2555	2594	1561	1707	1691	2027	2141	2258	1016	1158	1074	981	1005	860	860	1005	860	860	288	0	30594	124556

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OPTION 10--DST/HWVP WITHOUT TRUEX
ANNUAL COSTS BY FISCAL YEAR ($MILLIONS)

		FY92	FY93	FY94	FY95	FY96	FY97	FY98	FY99	FY00	FY01	FY02	FY03	FY04	FY05	FY06	FY07	FY08	FY09	FY10	FY11	FY12	FY13
B Plant Operations	Exp	37.7	40.0	43.7	46.0	45.5	45.5	45.5	45.5	45.5	44.9	44.9	44.9	44.9	44.9	44.9	44.9	44.9	44.9	44.9	44.9	44.9	44.9
	Cap	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4
B Plant Fac Upgrades	Exp	4.5	4.2	4.3	3.8	3.4	2.3	1.6	1.4	1.2	1.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	Cap	11.1	10.2	18.1	17.6	11.3	6.4	1.0	1.0	0.6	0.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
PUREX Operations	Exp	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	Cap	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
DST Pre-treatment	Exp	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.5	3.0	1.5	3.0	3.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	Cap	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
HWVP Constructn	Exp	30.0	30.0	30.0	37.3	45.8	52.5	65.1	64.3	78.6	45.1	14.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	Cap	35.0	35.0	89.2	186.7	193.9	201.5	187.2	170.2	40.7	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
HWVP Operations	Exp	1.3	1.3	1.3	5.0	7.9	16.9	25.9	41.9	56.9	73.3	88.0	88.0	73.3	73.3	73.3	73.3	88.0	95.1	95.1	87.7	80.4	80.4
	Cap	0.0	0.0	0.0	0.0	0.1	0.3	0.9	1.9	5.0	13.9	15.9	15.9	36.4	13.9	13.9	46.4	38.4	16.9	16.9	39.9	14.9	24.9
HWVP Annex	Exp	8.0	10.0	15.0	18.0	27.0	34.0	25.0	9.0	3.0	1.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	Cap	8.0	18.0	33.0	55.0	75.0	88.0	68.0	51.0	20.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Grout Ops & Construc	Exp	30.3	52.0	66.1	68.9	71.3	74.0	55.7	55.7	55.7	55.7	55.7	55.7	55.7	55.7	55.7	55.7	55.7	55.7	55.7	55.7	55.7	0.0
	Cap	2.3	2.1	5.9	2.6	2.3	2.3	2.3	2.3	2.3	2.3	2.3	2.3	2.3	2.3	2.3	2.3	2.3	2.3	2.3	2.3	2.3	0.0
Pretreatment Technology	Exp	9.7	21.8	23.7	18.7	15.2	12.4	9.0	8.1	6.7	5.0	4.6	3.0	3.0	3.0	3.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	Cap	0.2	0.2	3.7	9.7	5.8	4.7	0.5	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Retrieval Development	Exp	2.9	8.6	18.8	25.8	37.3	22.7	28.9	25.5	7.0	9.0	9.0	9.0	9.0	9.0	9.0	9.0	9.0	3.0	1.5	0.5	0.0	0.0
	Cap	5.8	3.0	7.0	0.0	0.0	0.0	0.0	5.0	9.5	17.0	25.0	45.0	45.0	45.0	45.0	45.0	35.0	20.0	13.0	0.0	0.0	0.0
Retrieval Operations	Exp	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.5	1.5	1.5	3.0	1.5	0.0	0.0	1.5	3.0	3.0	3.0	3.0	0.0	0.0	0.0
	Cap	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Waste Trans Lines	Exp	0.5	0.1	0.9	1.0	0.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	Cap	6.0	0.0	3.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Tank Farms Upgrades	Exp	2.5	1.0	1.4	2.1	4.1	4.0	3.1	1.9	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	Cap	0.0	8.0	11.0	12.0	25.0	62.0	70.0	32.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Ship/Repos Disposal	Exp	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	Cap	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
SUB TOTALS	Exp	127	169	205	227	258	264	260	256	259	238	223	205	186	186	187	186	201	202	200	189	181	125
	Cap	69	77	172	284	314	366	330	264	79	35	44	64	84	62	62	94	76	40	33	43	18	25
OPT 10 TOTAL		196	246	377	511	572	630	590	520	338	273	267	269	270	248	249	280	277	241	233	231	199	151
Labor	M/Yrs	1471	1868	2722	3552	3988	4342	4100	3687	2638	2204	2130	2097	2054	1924	1936	2110	2130	1928	1875	1837	1626	1202
Labor Average															2770	1611							

OPTION 10--DST/HWVP WITHOUT TRUEX
ANNUAL COSTS BY FISCAL YEAR ($MILLIONS)

		FY14	FY15	FY16	FY17	FY18	FY19	FY20	FY21	FY22	FY23	FY24	FY25	FY26	FY27	FY28	FY29	FY30	FY31	FY32	FY33	FY34	TOTALS
B Plant Operations	Exp	44.9	44.9	67.7	66.3	66.8	92.6	115.1	127.1	21.0	21.0	21.0	1.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1668
	Cap	0.4	0.3	3.2	5.5	17.0	53.5	32.4	60.1	0.0	0.0	0.0	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	181
B Plant Fac Upgrades	Exp	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	28
	Cap	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	78
PUREX Operations	Exp	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0
	Cap	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0
DST Pre-treatment	Exp	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	12
	Cap	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0
HWVP Constructn	Exp	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	495
	Cap	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1139
HWVP Operations	Exp	80.4	83.9	83.9	83.9	83.9	83.9	87.4	87.4	87.4	87.4	87.4	87.4	90.9	90.9	90.9	90.9	90.9	90.9	90.9	90.9	30.4	3009
	Cap	58.9	15.4	15.4	40.4	25.4	37.9	40.9	15.9	15.9	40.4	25.9	38.4	41.4	16.4	16.4	41.4	16.4	16.4	41.4	16.4	5.6	899
HWVP Annex	Exp	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	150
	Cap	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	416
Grout Ops & Construc	Exp	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1198
	Cap	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	52
Pretreatment Technology	Exp	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	147
	Cap	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	27
Retrieval Development	Exp	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	254
	Cap	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	365
Retrieval Operations	Exp	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	25
	Cap	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0
Waste Trans Lines	Exp	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	3
	Cap	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	9
Tank Farms Upgrades	Exp	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	20
	Cap	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	220
Ship/Repos Disposal	Exp	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	3633.0	3633
	Cap	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0
SUB TOTALS	Exp	125	129	152	150	151	177	203	215	108	108	108	89	91	91	91	91	91	91	91	91	3663	10639
	Cap	59	16	19	46	42	91	73	76	16	40	26	39	41	16	16	41	16	16	41	16	6	3388
OPT 10 TOTAL		185	145	170	196	193	268	276	291	124	149	134	127	132	107	107	132	107	107	132	107	3669	14026
Labor Labor Average	M/Yrs	1398	1176	1384	1531	1515	2015	2130	2246	1005	1147	1063	970	1005	860	860	1005	860	860	1005	860	30882	109201

10-Oct-91
05:26 PM
Opt-11

OPTION 11--DST/B PLANT (LIMITED)/NPF WITH TRUEX
ANNUAL COSTS BY FISCAL YEAR ($MILLIONS)

		FY92	FY93	FY94	FY95	FY96	FY97	FY98	FY99	FY00	FY01	FY02	FY03	FY04	FY05	FY06	FY07	FY08	FY09	FY10	FY11	FY12	FY13
B Plant Operations	Exp	37.7	55.2	65.4	70.4	70.0	72.5	71.5	71.5	67.7	57.7	46.7	43.8	43.8	43.8	43.8	43.8	43.4	43.4	43.7	43.7	43.7	43.7
	Cap	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4
B Plant Fac Upgds	Exp	4.5	4.2	4.3	3.8	3.4	2.3	1.6	1.4	1.2	1.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	Cap	11.1	10.2	18.1	22.6	16.3	15.4	2.0	1.0	0.6	0.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
B Plant Pre-trmnt Upgds	Exp	0.0	0.0	0.5	1.0	1.5	2.0	1.5	1.0	0.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	Cap	0.0	0.0	0.0	6.0	15.0	25.0	15.0	6.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
PUREX Operations	Exp	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	Cap	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
NPF Construction	Exp	0.2	3.5	10.8	17.6	26.5	35.3	35.3	35.3	52.9	61.7	79.4	88.2	93.3	93.3	107.3	79.4	26.5	0.0	0.0	0.0	0.0	0.0
	Cap	0.0	0.0	0.0	0.0	0.0	42.0	51.0	88.1	155.7	281.2	322.2	334.4	300.4	180.0	81.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
NPF Operations	Exp	0.0	0.0	0.0	0.0	0.0	1.2	2.4	3.7	8.7	13.7	28.6	43.5	70.9	97.0	124.4	124.4	124.4	124.4	72.8	67.7	66.3	66.8
	Cap	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.3	0.9	1.9	5.0	12.0	23.6	23.6	23.6	23.6	2.0	3.2	5.5	17.0
DST Pre-treatment	Exp	0.0	0.0	0.0	0.0	0.0	1.5	3.0	1.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	Cap	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
HWVP Constructn	Exp	30.0	37.3	45.8	52.5	65.1	64.3	78.6	45.1	14.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	Cap	89.2	186.7	193.9	201.5	187.2	107.2	40.7	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
HWVP Operations	Exp	1.3	5.0	7.9	16.9	25.9	41.9	56.9	73.3	73.3	73.3	73.3	65.3	49.4	36.6	49.4	65.3	73.3	73.3	73.3	73.3	30.5	0.0
	Cap	0.0	0.0	0.1	0.3	0.9	1.9	5.0	13.9	13.9	13.9	36.4	9.7	5.6	4.0	5.6	9.7	11.4	11.4	13.9	36.4	6.0	0.0
Grout Ops & Construc	Exp	30.3	52.0	66.1	68.9	71.3	74.0	78.6	78.6	78.6	78.6	78.6	78.6	78.6	78.6	78.6	78.6	78.6	78.6	78.6	78.6	0.0	0.0
	Cap	2.3	2.1	5.9	2.6	2.3	2.3	2.3	2.3	2.3	2.3	2.3	2.3	2.3	2.3	2.3	2.3	2.3	2.3	2.3	2.3	0.0	0.0
Pretreatment Technology	Exp	9.7	21.8	23.7	16.7	15.2	12.4	9.0	8.1	6.7	5.0	4.6	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	0.0	0.0
	Cap	0.2	0.2	3.7	9.7	5.8	4.7	0.5	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.0	0.0
Retrieval Development	Exp	2.9	8.6	18.8	25.8	37.3	22.7	28.9	19.0	6.5	7.0	9.0	9.0	9.0	9.0	9.0	9.0	9.0	9.0	3.0	1.5	0.5	0.0
	Cap	5.8	3.0	7.0	0.0	0.0	0.0	0.0	0.0	5.0	9.5	17.0	25.0	45.0	45.0	45.0	45.0	45.0	35.0	20.0	13.0	0.0	0.0
Retrieval Operations	Exp	0.0	0.0	0.0	0.0	0.0	1.5	3.0	3.0	1.5	0.0	0.0	0.0	0.0	0.0	3.0	3.0	3.0	3.0	1.5	0.0	0.0	0.0
	Cap	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Waste Trans Lines	Exp	0.5	0.1	0.9	1.0	0.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	Cap	6.0	0.0	3.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Tank Farms Upgrades	Exp	2.5	1.0	1.4	2.1	4.1	4.0	3.1	1.9	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	Cap	0.0	8.0	11.0	12.0	25.0	62.0	70.0	32.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Ship/Repos Disposal	Exp	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	Cap	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
SUB TOTALS	Exp	120	189	246	279	321	336	373	343	312	298	320	331	348	361	419	407	361	335	276	268	141	111
	Cap	115	211	243	255	253	261	187	144	178	308	379	374	359	244	158	81	83	73	39	56	12	17
OPT 11 TOTAL		235	399	489	534	574	597	560	487	490	607	700	705	707	605	577	488	444	408	315	323	153	128
Labor	M/Yrs	1673	2808	3478	3824	4164	4337	4226	3725	3661	4296	4894	4956	5009	4455	4440	3894	3522	3241	2549	2577	1256	1031
Labor Average															3965	1876							

OPTION 11--DST/B PLANT (LIMITED)/NPF WITH TRUEX
ANNUAL COSTS BY FISCAL YEAR ($MILLIONS)

		FY14	FY15	FY16	FY17	FY18	FY19	FY20	FY21	FY22	FY23	FY24	FY25	TOTALS
B Plant Operations	Exp	43.7	43.7	67.7	66.3	66.8	92.6	115.1	127.1	21.0	21.0	21.0	1.3	1854
	Cap	0.4	0.4	3.2	5.5	17.0	53.5	32.4	60.1	0.0	0.0	0.0	0.1	181
B Plant Fac Upgds	Exp	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	28
	Cap	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	98
B Plant Pre-trmnt Upgds	Exp	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	8
	Cap	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	67
PUREX Operations	Exp	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0
	Cap	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0
NPF Construc-tion	Exp	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	847
	Cap	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1836
NPF Operations	Exp	92.6	115.1	127.1	21.0	21.0	21.0	1.3	1.3	1.3	1.3	1.3	1.3	1447
	Cap	53.5	32.4	60.1	0.0	0.0	0.0	0.1	0.1	0.1	0.1	0.1	0.1	289
DST Pre-treatment	Exp	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	6
	Cap	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0
HWVP Constructn	Exp	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	433
	Cap	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1006
HWVP Operations	Exp	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1039
	Cap	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	200
Grout Ops & Construc	Exp	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1463
	Cap	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	50
Pretreatment Technology	Exp	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	162
	Cap	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	29
Retrieval Development	Exp	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	254
	Cap	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	365
Retrieval Operations	Exp	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	23
	Cap	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0
Waste Trans Lines	Exp	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	3
	Cap	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	9
Tank Farms Upgrades	Exp	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	20
	Cap	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	220
Ship/Repos Disposal	Exp	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	469.0	469
	Cap	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0
SUB TOTALS	Exp	136	159	195	87	88	114	116	128	22	22	22	472	8055
	Cap	54	33	63	6	17	54	33	60	0	0	0	0	4351
OPT 11 TOTAL		190	192	258	93	105	167	149	189	22	22	22	472	12405
Labor Labor Average	M/Yrs	1460	1527	2007	767	838	1266	1168	1430	188	188	188	3973	93017

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OPTION 12--DST/B PLANT (LIMITED)/NPF WITHOUT TRUEX
ANNUAL COSTS BY FISCAL YEAR ($MILLIONS)

		FY92	FY93	FY94	FY95	FY96	FY97	FY98	FY99	FY00	FY01	FY02	FY03	FY04	FY05	FY06	FY07	FY08	FY09	FY10	FY11	FY12	FY13
B Plant Operations	Exp	37.7	55.2	65.4	70.4	70.0	72.5	71.5	71.5	67.7	57.7	46.7	43.8	43.8	43.8	43.8	43.8	43.4	43.4	43.7	43.7	43.7	43.7
	Cap	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4
B Plant Fac Upgds	Exp	4.5	4.2	4.3	3.8	3.4	2.3	1.6	1.4	1.2	1.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	Cap	11.1	10.2	18.1	17.6	11.3	6.4	1.0	1.0	0.6	0.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
B Plant Pre-trmnt Upgds	Exp	0.0	0.0	0.5	1.0	1.5	2.0	1.5	1.0	0.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	Cap	0.0	0.0	0.0	6.0	15.0	25.0	15.0	6.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
PUREX Operations	Exp	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	Cap	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
NPF Construc-tion	Exp	2.6	8.1	12.7	19.1	25.5	25.5	25.5	38.2	44.6	57.3	63.7	76.4	76.4	95.6	57.3	19.1	0.0	0.0	0.0	0.0	0.0	0.0
	Cap	0.0	0.0	0.0	13.0	26.0	32.5	59.3	113.9	222.6	252.2	261.0	235.0	130.0	58.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
NPF Operations	Exp	0.0	0.0	0.0	0.0	0.6	1.3	1.9	4.4	6.9	14.4	22.0	35.8	49.0	62.8	62.8	62.8	62.8	62.8	31.2	26.5	26.5	26.5
	Cap	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.3	0.8	1.5	4.3	11.9	11.9	11.9	11.9	6.0	5.0	5.0	5.0
DST Pre-treatment	Exp	0.0	0.0	0.0	0.0	0.0	3.0	3.0	0.0	3.0	3.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	Cap	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
HWVP Constructn	Exp	30.0	37.3	45.3	52.5	65.1	64.3	78.6	45.1	14.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	Cap	89.2	186.7	193.9	201.5	187.2	107.2	40.7	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
HWVP Operations	Exp	1.3	5.0	7.9	16.9	25.9	41.9	56.9	73.3	73.3	73.3	73.3	73.3	73.3	73.3	73.3	80.4	80.4	80.4	80.4	80.4	80.4	80.4
	Cap	0.0	0.0	0.1	0.3	0.9	1.9	5.0	13.9	13.9	13.9	36.4	13.9	13.9	46.4	36.4	14.9	37.4	14.9	14.9	39.9	14.9	24.9
Grout Ops & Construc	Exp	30.3	52.0	66.1	68.9	71.3	74.0	55.7	55.7	55.7	55.7	55.7	55.7	55.7	55.7	55.7	55.7	55.7	55.7	55.7	55.7	55.7	0.0
	Cap	2.3	2.1	5.9	2.6	2.3	2.3	2.3	2.3	2.3	2.3	2.3	2.3	2.3	2.3	2.3	2.3	2.3	2.3	2.3	2.3	2.3	0.0
Pretreatment Technology	Exp	9.7	21.8	23.7	18.7	15.2	12.4	9.0	8.1	6.7	5.0	4.6	3.0	3.0	3.0	3.0	3.0	3.0	3.0	0.0	0.0	0.0	0.0
	Cap	0.2	0.2	3.7	9.7	5.8	4.7	0.5	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.0	0.0	0.0	0.0
Retrieval Development	Exp	2.9	8.6	18.8	25.8	37.3	22.7	28.9	25.5	7.0	9.0	9.0	9.0	9.0	9.0	9.0	9.0	9.0	3.0	1.5	0.5	0.0	0.0
	Cap	5.8	3.0	7.0	0.0	0.0	0.0	0.0	5.0	9.5	17.0	25.0	45.0	45.0	45.0	45.0	45.0	35.0	20.0	13.0	0.0	0.0	0.0
Retrieval Operations	Exp	0.0	0.0	0.0	0.0	0.0	1.5	1.5	1.5	3.0	0.0	0.0	0.0	0.0	1.5	3.0	3.0	3.0	3.0	1.5	0.0	0.0	0.0
	Cap	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Waste Trans Lines	Exp	0.5	0.1	0.9	1.0	0.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	Cap	6.0	0.0	3.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Tank Farms Upgrades	Exp	2.5	1.0	1.4	2.1	4.1	4.0	3.1	1.9	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	Cap	0.0	8.0	11.0	12.0	25.0	62.0	70.0	32.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Ship/Repos Disposal	Exp	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	Cap	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
SUB TOTALS	Exp	122	193	247	280	320	327	339	328	284	276	275	297	310	345	308	277	257	251	214	207	206	151
	Cap	115	211	243	263	274	242	194	175	250	287	326	298	193	157	96	75	87	50	37	48	23	30
OPT 12 TOTAL		237	404	491	543	594	570	533	502	534	563	601	595	504	502	404	352	345	301	251	254	229	181
Labor	M/Yrs	1693	2847	3494	3883	4282	4160	3977	3771	3838	3988	4201	4225	3732	3813	3150	2764	2672	2405	2014	2017	1868	1444
Labor Average															3707	2122							

OPTION 12--DST/B PLANT (LIMITED)/NPF WITHOUT TRUEX
ANNUAL COSTS BY FISCAL YEAR ($MILLIONS)

		FY14	FY15	FY16	FY17	FY18	FY19	FY20	FY21	FY22	FY23	FY24	FY25	FY26	FY27	FY28	FY29	FY30	FY31	FY32	FY33	FY34+	TOTALS
B Plant Operations	Exp	43.7	43.7	67.7	66.3	66.8	92.6	115.1	127.1	21.0	21.0	21.0	1.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1854
	Cap	0.4	0.4	3.2	5.5	17.0	53.5	32.4	60.1	0.0	0.0	0.0	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	181
B Plant Fac Upgds	Exp	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	28
	Cap	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	78
B Plant Pre-trmnt Upgds	Exp	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	8
	Cap	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	67
PUREX Operations	Exp	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0
	Cap	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0
NPF Construction	Exp	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	648
	Cap	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1404
NPF Operations	Exp	26.5	26.5	67.7	66.3	66.8	92.6	115.1	127.1	21.0	21.0	21.0	1.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1214
	Cap	5.0	5.0	3.2	5.5	17.0	53.5	32.4	60.1	0.0	0.0	0.0	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	257
DST Pre-treatment	Exp	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	12
	Cap	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0
HWVP Constructn	Exp	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	433
	Cap	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1006
HWVP Operations	Exp	80.4	83.9	83.9	83.9	83.9	83.9	87.4	87.4	87.4	87.4	87.4	87.4	90.9	90.9	90.9	90.9	90.9	90.9	30.4	0.0	0.0	2905
	Cap	58.9	15.4	15.4	40.4	25.4	37.9	40.9	15.9	15.9	40.4	25.9	38.4	41.4	16.4	16.4	41.4	16.4	16.4	5.6	0.0	0.0	884
Grout Ops & Construc	Exp	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1198
	Cap	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	52
Pretreatment Technology	Exp	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	156
	Cap	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	28
Retrieval Development	Exp	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	254
	Cap	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	365
Retrieval Operations	Exp	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	23
	Cap	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0
Waste Trans Lines	Exp	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	3
	Cap	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	9
Tank Farms Upgrades	Exp	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	20
	Cap	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	220
Ship/Repos Disposal	Exp	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	3633.0	3633
	Cap	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0
SUB TOTALS	Exp	151	154	219	217	218	269	318	342	129	129	129	90	91	91	91	91	91	91	30	0	3633	12389
	Cap	64	21	22	51	59	145	106	136	16	40	26	39	41	16	16	41	16	16	6	0	0	4552
OPT 12 TOTAL		215	175	241	268	277	414	423	478	145	170	155	129	132	107	107	132	107	107	36	0	3633	16941
Labor Labor Average	M/Yrs	1640	1418	1973	2121	2175	3105	3286	3665	1182	1324	1240	981	1005	860	860	1005	860	860	288	0	30594	130682

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OPTION 13--DST/HWVP (LIMITED)/NPF WITH TRUEX
ANNUAL COSTS BY FISCAL YEAR ($MILLIONS)

		FY92	FY93	FY94	FY95	FY96	FY97	FY98	FY99	FY00	FY01	FY02	FY03	FY04	FY05	FY06	FY07	FY08	FY09	FY10	FY11	FY12	FY13
B Plant Operations	Exp	37.7	40.0	43.7	46.0	45.5	45.5	45.5	45.5	45.5	44.9	44.9	44.9	44.9	44.9	44.9	44.9	44.9	44.9	44.9	44.9	44.9	44.9
	Cap	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4
B Plant Fac Upgrades	Exp	4.5	4.2	4.3	3.8	3.4	2.3	1.6	1.4	1.2	1.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	Cap	11.1	10.2	18.1	22.6	16.3	15.4	2.0	1.0	0.6	0.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
PUREX Operations	Exp	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	Cap	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
NPF Construction	Exp	0.2	3.5	10.8	17.6	26.5	35.3	35.3	35.3	52.9	61.7	79.4	88.2	93.3	93.3	107.3	79.4	26.5	0.0	0.0	0.0	0.0	0.0
	Cap	0.0	0.0	0.0	0.0	0.0	42.0	51.0	88.1	155.7	281.2	322.2	334.4	300.4	180.0	81.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
NPF Operations	Exp	0.0	0.0	0.0	0.0	0.0	1.2	2.4	3.7	8.7	13.7	28.6	43.5	70.9	97.0	124.4	124.4	124.4	124.4	72.8	67.7	66.3	66.8
	Cap	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.3	0.9	1.9	5.0	12.0	23.6	23.6	23.6	23.6	2.0	3.2	5.5	17.0
DST Pre-treatment	Exp	0.0	0.0	0.0	0.0	0.0	0.0	0.0	3.0	3.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	Cap	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
HWVP Constructn	Exp	30.0	37.3	45.8	52.5	65.1	64.3	78.6	45.1	14.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	Cap	89.2	186.7	193.9	201.5	187.2	107.2	40.7	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
HWVP Operations	Exp	1.3	1.3	5.0	7.9	16.9	25.9	41.9	56.9	73.3	80.7	80.7	73.3	65.3	52.9	65.3	73.3	73.3	73.3	73.3	73.3	30.5	0.0
	Cap	0.0	0.0	0.0	0.1	0.3	0.9	1.9	5.0	8.9	13.9	13.9	36.4	5.6	4.0	5.6	8.9	13.9	36.4	13.9	13.9	6.0	0.0
HWVP Annex	Exp	5.0	7.0	8.0	10.0	12.5	15.0	9.5	5.0	3.0	1.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	Cap	0.0	10.0	16.0	24.0	41.0	51.0	36.0	21.0	8.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Grout Ops & Construc	Exp	30.3	52.0	66.1	68.9	71.3	74.0	78.6	78.6	78.6	78.6	78.6	78.6	78.6	78.6	78.6	78.6	78.6	78.6	78.6	78.6	0.0	0.0
	Cap	2.3	2.1	5.9	2.6	2.3	2.3	2.3	2.3	2.3	2.3	2.3	2.3	2.3	2.3	2.3	2.3	2.3	2.3	2.3	2.3	0.0	0.0
Pretreatment Technology	Exp	9.7	21.8	23.7	18.7	15.2	12.4	9.0	8.1	6.7	5.0	4.6	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	0.0	0.0
	Cap	0.2	0.2	3.7	9.7	5.8	4.7	0.5	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.0	0.0
Retrieval Development	Exp	2.9	8.6	18.8	25.8	37.3	22.7	28.9	19.0	6.5	7.0	9.0	9.0	9.0	9.0	9.0	9.0	9.0	9.0	3.0	1.5	0.5	0.0
	Cap	5.8	3.0	7.0	0.0	0.0	0.0	0.0	0.0	5.0	9.5	17.0	25.0	45.0	45.0	45.0	45.0	45.0	35.0	20.0	13.0	0.0	0.0
Retrieval Operations	Exp	0.0	0.0	0.0	0.0	0.0	0.0	1.5	3.0	3.0	1.5	0.0	0.0	0.0	0.0	3.0	3.0	3.0	3.0	1.5	0.0	0.0	0.0
	Cap	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Waste Trans Lines	Exp	0.5	0.1	0.9	1.0	0.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	Cap	6.0	0.0	3.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Tank Farms Upgrades	Exp	2.5	1.0	1.4	2.1	4.1	4.0	3.1	1.9	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	Cap	0.0	8.0	11.0	12.0	25.0	62.0	70.0	32.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Ship/Repos Disposal	Exp	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	Cap	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
SUB TOTALS	Exp	125	177	228	254	298	303	336	307	297	295	326	341	365	379	436	416	363	336	277	269	142	112
	Cap	115	221	259	273	278	286	205	150	181	308	357	401	359	244	158	81	86	98	39	33	12	17
OPT 13 TOTAL		240	397	488	527	576	589	541	457	478	604	683	741	724	623	594	496	448	434	316	302	154	129
Labor	M/Yrs	1715	2766	3426	3721	4122	4203	4014	3450	3550	4271	4810	5187	5152	4602	4583	3966	3549	3399	2559	2457	1266	1041
Labor Average															3928	1892							

OPTION 13--DST/HWVP (LIMITED)/NPF WITH TRUEX
ANNUAL COSTS BY FISCAL YEAR ($MILLIONS)

		FY14	FY15	FY16	FY17	FY18	FY19	FY20	FY21	FY22	FY23	FY24	FY25	TOTALS
B Plant Operations	Exp	44.9	44.9	67.7	66.3	66.8	92.6	115.1	127.1	21.0	21.0	21.0	1.3	1668
	Cap	0.4	0.4	3.2	5.5	17.0	53.5	32.4	60.1	0.0	0.0	0.0	0.1	181
B Plant Fac Upgrades	Exp	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	28
	Cap	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	98
PUREX Operations	Exp	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0
	Cap	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0
NPF Construction	Exp	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	847
	Cap	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1836
NPF Operations	Exp	92.6	115.1	127.1	21.0	21.0	21.0	1.3	1.3	1.3	1.3	1.3	1.3	1447
	Cap	53.5	32.4	60.1	0.0	0.0	0.0	0.1	0.1	0.1	0.1	0.1	0.1	289
DST Pre-treatment	Exp	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	6
	Cap	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0
HWVP Constructn	Exp	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	433
	Cap	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1006
HWVP Operations	Exp	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1046
	Cap	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	190
HWVP Annex	Exp	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	76
	Cap	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	207
Grout Ops & Construc	Exp	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1463
	Cap	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	50
Pretreatment Technology	Exp	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	162
	Cap	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	29
Retrieval Development	Exp	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	254
	Cap	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	365
Retrieval Operations	Exp	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	23
	Cap	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0
Waste Trans Lines	Exp	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	3
	Cap	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	9
Tank Farms Upgrades	Exp	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	20
	Cap	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	220
Ship/Repos Disposal	Exp	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	469.0	469
	Cap	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0
SUB TOTALS	Exp	138	160	195	87	88	114	116	128	22	22	22	472	7944
	Cap	54	33	63	6	17	54	33	60	0	0	0	0	4480
OPT 13 TOTAL		191	193	258	93	105	167	149	189	22	22	22	472	12424
Labor	M/Yrs	1470	1537	2007	767	838	1266	1168	1430	188	188	188	3973	92832
Labor Average														

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OPTION 14--DST/INT PROC/HWVP (LIMITED)/NPF WITH TRUEX
ANNUAL COSTS BY FISCAL YEAR ($MILLIONS)

		FY92	FY93	FY94	FY95	FY96	FY97	FY98	FY99	FY00	FY01	FY02	FY03	FY04	FY05	FY06	FY07	FY08	FY09	FY10	FY11	FY12	FY13
B Plant Operations	Exp	37.7	40.0	43.7	46.0	45.5	45.5	45.5	45.5	45.5	44.9	44.9	44.9	44.9	44.9	44.9	44.9	44.9	44.9	44.9	44.9	44.9	44.9
	Cap	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4
B Plant Fac Upgrades	Exp	4.5	4.2	4.3	3.8	3.4	2.3	1.6	1.4	1.2	1.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	Cap	11.1	10.2	18.1	22.6	16.3	15.4	2.0	1.0	0.6	0.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
PUREX Operations	Exp	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	Cap	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
NPF Construction	Exp	0.2	3.5	10.8	17.6	26.5	35.3	35.3	35.3	52.9	61.7	79.4	88.2	93.3	93.3	107.3	79.4	26.5	0.0	0.0	0.0	0.0	0.0
	Cap	0.0	0.0	0.0	0.0	0.0	42.0	51.0	88.1	155.7	281.2	322.2	334.4	300.4	180.0	81.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
NPF Operations	Exp	0.0	0.0	0.0	0.0	0.0	1.2	2.4	3.7	8.7	13.7	28.6	43.5	70.9	97.0	124.4	124.4	124.4	124.4	52.0	67.7	66.3	66.8
	Cap	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.3	0.9	1.9	5.0	12.0	23.6	23.6	23.6	23.6	2.0	3.2	5.5	17.0
DST Pre-treatment	Exp	0.0	0.0	0.0	0.0	0.0	0.0	0.0	3.0	3.0	0.0	0.0	0.0	3.0	3.0	3.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	Cap	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
HWVP Constructn	Exp	30.0	37.3	45.8	52.5	65.1	64.3	78.6	45.1	14.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	Cap	89.2	186.7	193.9	201.5	187.2	107.2	40.7	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
HWVP Operations	Exp	1.3	1.3	5.0	7.9	16.9	25.9	41.9	56.9	73.3	80.7	80.7	73.3	65.3	65.3	65.3	73.3	73.3	73.3	73.3	48.0	0.0	0.0
	Cap	0.0	0.0	0.0	0.1	0.3	0.9	1.9	5.0	8.9	13.4	13.9	36.4	5.6	5.6	5.6	8.9	13.9	36.4	13.9	8.9	0.0	0.0
HWVP Annex	Exp	5.0	7.0	8.0	10.0	12.5	15.0	9.5	5.0	3.0	1.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	Cap	0.0	10.0	16.0	24.0	41.0	51.0	36.0	21.0	8.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Grout Ops & Construc	Exp	30.3	52.0	66.1	68.9	71.3	74.0	78.6	78.6	78.6	78.6	78.6	78.6	78.6	78.6	78.6	78.6	78.6	78.6	78.6	78.6	0.0	0.0
	Cap	2.3	2.1	5.9	2.6	2.3	2.3	2.3	2.3	2.3	2.3	2.3	2.3	2.3	2.3	2.3	2.3	2.3	2.3	2.3	2.3	0.0	0.0
Pretreatment Technology	Exp	9.7	21.8	23.7	18.7	15.2	12.4	9.0	8.1	6.7	5.0	4.6	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	0.0	0.0
	Cap	0.2	0.2	3.7	9.7	5.8	4.7	0.5	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.0	0.0
Retrieval Development	Exp	2.9	8.6	18.8	25.8	37.3	22.7	28.9	13.6	5.4	6.5	7.0	9.0	9.0	9.0	9.0	9.0	9.0	9.0	9.0	3.0	1.5	0.5
	Cap	5.8	3.0	7.0	0.0	0.0	0.0	0.0	0.0	0.0	5.0	9.5	17.0	25.0	45.0	45.0	45.0	45.0	45.0	35.0	20.0	13.0	0.0
Retrieval Operations	Exp	0.0	0.0	0.0	0.0	0.0	0.0	1.5	3.0	3.0	1.5	0.0	0.0	0.0	0.0	3.0	3.0	3.0	3.0	1.5	0.0	0.0	0.0
	Cap	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Waste Trans Lines	Exp	0.5	0.1	0.9	1.0	0.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	Cap	6.0	0.0	3.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Tank Farms Upgrades	Exp	2.5	1.0	1.4	2.1	4.1	4.0	3.1	1.9	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	[illegible]	0.0	0.0	0.0
	Cap	0.0	8.0	11.0	12.0	25.0	62.0	70.0	32.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Ship/Repos Disposal	Exp	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	Cap	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
SUB TOTALS	Exp	125	177	228	254	298	303	336	301	296	295	324	341	368	394	439	416	363	336	262	245	113	112
	Cap	115	221	259	273	278	286	205	150	176	303	349	393	339	246	158	81	86	108	54	35	19	17
OPT 14 TOTAL		240	397	488	527	576	589	541	451	472	598	673	733	707	640	597	496	448	444	316	280	132	130
Labor	M/Yrs	1715	2766	3426	3721	4122	4203	4014	3405	3512	4238	4750	5141	5062	4741	4609	3966	3549	3456	2521	2268	1058	1046
Labor Average															3915	1938							

OPTION 14--DST/INT PROC/HWVP (LIMITED)/NPF WITH
ANNUAL COSTS BY FISCAL YEAR ($MILLIONS)

		FY14	FY15	FY16	FY17	FY18	FY19	FY20	FY21	FY22	FY23	FY24	FY25	TOTALS
B Plant Operations	Exp	44.9	44.9	67.7	66.3	66.8	92.6	115.1	127.1	21.0	21.0	21.0	1.3	1668
	Cap	0.4	0.4	3.2	5.5	17.0	53.5	32.4	60.1	0.0	0.0	0.0	0.1	181
B Plant Fac Upgrades	Exp	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	28
	Cap	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	98
PUREX Operations	Exp	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0
	Cap	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0
NPF Construc-tion	Exp	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	847
	Cap	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1836
NPF Operations	Exp	92.6	115.1	127.1	21.0	21.0	21.0	1.3	1.3	1.3	1.3	1.3	1.3	1426
	Cap	53.5	32.4	60.1	0.0	0.0	0.0	0.1	0.1	0.1	0.1	0.1	0.1	289
DST Pre-treatment	Exp	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	15
	Cap	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0
HWVP Constructn	Exp	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	433
	Cap	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1006
HWVP Operations	Exp	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1002
	Cap	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	180
HWVP Annex	Exp	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	76
	Cap	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	207
Grout Ops & Construc	Exp	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1463
	Cap	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	50
Pretreatment Technology	Exp	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	162
	Cap	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	29
Retrieval Development	Exp	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	254
	Cap	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	365
Retrieval Operations	Exp	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	23
	Cap	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0
Waste Trans Lines	Exp	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	3
	Cap	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	9
Tank Farms Upgrades	Exp	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	20
	Cap	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	220
Ship/Repos Disposal	Exp	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	619.5	620
	Cap	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0
SUB TOTALS	Exp	138	160	195	87	88	114	116	128	22	22	22	622	8039
	Cap	54	33	63	6	17	54	33	60	0	0	0	0	4470
OPT 14 TOTAL		191	193	258	93	105	167	149	189	22	22	22	622	12509
Labor Labor Average	M/Yrs	1470	1537	2007	767	838	1266	1168	1430	188	188	188	5240	93577

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OPTION 15--DST/HWVP (LIMITED)/NPF WITHOUT TRUEX
ANNUAL COSTS BY FISCAL YEAR ($MILLIONS)

		FY92	FY93	FY94	FY95	FY96	FY97	FY98	FY99	FY00	FY01	FY02	FY03	FY04	FY05	FY06	FY07	FY08	FY09	FY10	FY11	FY12	FY13
B Plant Operations	Exp	37.7	40.0	43.7	46.0	45.5	45.5	45.5	45.5	45.5	44.9	44.9	44.9	44.9	44.9	44.9	44.9	44.9	44.9	44.9	44.9	44.9	44.9
	Cap	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4
B Plant Fac Upgrades	Exp	4.5	4.2	4.3	3.8	3.4	2.3	1.6	1.4	1.2	1.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	Cap	11.1	10.2	18.1	17.6	11.3	6.4	1.0	1.0	0.6	0.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
PUREX Operations	Exp	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	Cap	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
NPF Construction	Exp	2.6	8.1	12.7	19.1	25.5	25.5	25.5	38.2	44.6	57.3	63.7	76.4	76.4	95.6	57.3	19.1	0.0	0.0	0.0	0.0	0.0	0.0
	Cap	0.0	0.0	0.0	13.0	26.0	32.5	59.3	113.9	222.6	252.2	261.0	235.0	130.0	58.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
NPF Operations	Exp	0.0	0.0	0.0	0.0	0.6	1.3	1.9	4.4	6.9	14.4	22.0	35.8	49.0	62.8	62.8	62.8	62.8	62.8	31.2	67.7	66.3	66.8
	Cap	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.3	0.8	1.5	4.3	11.9	11.9	11.9	11.9	6.0	3.2	5.5	17.0
DST Pre-treatment	Exp	0.0	0.0	0.0	0.0	0.0	0.0	0.0	3.0	3.0	1.5	4.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	Cap	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
HWVP Constructn	Exp	30.0	37.3	45.8	52.5	65.1	64.3	78.6	45.1	14.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	Cap	89.2	186.7	193.9	201.5	187.2	107.2	40.7	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
HWVP Operations	Exp	1.3	1.3	5.0	7.9	16.9	25.9	41.9	56.9	73.3	80.7	80.7	73.3	73.3	73.3	73.3	73.3	73.3	80.4	80.4	80.4	80.4	80.4
	Cap	0.0	0.0	0.0	0.1	0.3	0.9	1.9	5.0	13.9	13.9	36.4	8.9	11.4	13.9	13.9	46.4	33.9	14.9	14.9	37.4	14.9	14.9
HWVP Annex	Exp	5.0	7.0	8.0	10.0	12.5	15.0	9.5	5.0	3.0	1.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	Cap	0.0	10.0	16.0	24.0	41.0	51.0	36.0	21.0	8.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Grout Ops & Construc	Exp	30.3	52.0	66.1	68.9	71.3	74.0	55.7	55.7	55.7	55.7	55.7	55.7	55.7	55.7	55.7	55.7	55.7	55.7	55.7	55.7	55.7	0.0
	Cap	2.3	2.1	5.9	2.6	2.3	2.3	2.3	2.3	2.3	2.3	2.3	2.3	2.3	2.3	2.3	2.3	2.3	2.3	2.3	2.3	2.3	0.0
Pretreatment Technology	Exp	9.7	21.8	23.7	18.7	15.2	12.4	9.0	8.1	6.7	5.0	4.6	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	0.0	0.0	0.0
	Cap	0.2	0.2	3.7	9.7	5.8	4.7	0.5	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.0	0.0	0.0
Retrieval Development	Exp	2.9	8.6	18.8	25.8	37.3	22.7	28.9	25.5	7.0	9.0	9.0	9.0	9.0	9.0	9.0	9.0	9.0	3.0	1.5	0.5	0.0	0.0
	Cap	5.8	3.0	7.0	0.0	0.0	0.0	0.0	5.0	9.5	17.0	25.0	45.0	45.0	45.0	45.0	45.0	35.0	20.0	13.0	0.0	0.0	0.0
Retrieval Operations	Exp	0.0	0.0	0.0	0.0	0.0	0.0	1.5	1.5	1.5	3.0	1.5	0.0	0.0	3.0	3.0	3.0	1.5	1.5	1.5	0.0	0.0	0.0
	Cap	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Waste Trans Lines	Exp	0.5	0.1	0.9	1.0	0.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	Cap	6.0	0.0	3.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Tank Farms Upgrades	Exp	2.5	1.0	1.4	2.1	4.1	4.0	3.1	1.9	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	Cap	0.0	8.0	11.0	12.0	25.0	62.0	70.0	32.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Ship/Repos Disposal	Exp	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	Cap	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
SUB TOTALS	Exp	127	181	230	256	298	293	303	292	263	274	287	298	311	347	309	271	250	251	218	249	247	192
	Cap	115	221	259	281	299	267	212	181	258	287	326	293	191	125	74	106	84	50	37	43	23	32
OPT 15 TOTAL		242	402	490	537	597	560	515	473	521	560	612	591	502	472	383	377	334	301	255	293	270	224
Labor	M/Yrs	1735	2805	3442	3780	4240	4015	3777	3508	3706	3964	4299	4205	3727	3647	3029	2896	2592	2405	2051	2349	2216	1805

OPTION 15--DST/HWVP (LIMITED)/NPF WITHOUT TRUEX
ANNUAL COSTS BY FISCAL YEAR ($MILLIONS)

		FY14	FY15	FY16	FY17	FY18	FY19	FY20	FY21	FY22	FY23	FY24	FY25	FY26	FY27	FY28	FY29	FY30	FY31	FY32	FY33	FY34	TOTALS
B Plant Operations	Exp	44.9	44.9	67.7	66.3	66.8	92.6	115.1	127.1	21.0	21.0	21.0	1.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1668
	Cap	0.4	0.4	3.2	5.5	17.0	53.5	32.4	60.1	0.0	0.0	0.0	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	181
B Plant Fac Upgrades	Exp	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	28
	Cap	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	78
PUREX Operations	Exp	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0
	Cap	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0
NPF Construc-tion	Exp	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	648
	Cap	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1404
NPF Operations	Exp	92.6	115.1	127.1	21.0	21.0	21.0	1.3	1.3	1.3	1.3	1.3	1.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1088
	Cap	53.5	32.4	60.1	0.0	0.0	0.0	0.1	0.1	0.1	0.1	0.1	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	233
DST Pre-treatment	Exp	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	12
	Cap	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0
HWVP Constructn	Exp	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	433
	Cap	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1006
HWVP Operations	Exp	80.4	80.4	83.9	83.9	83.9	83.9	83.9	83.9	87.4	87.4	87.4	87.4	87.4	87.4	87.4	90.9	90.9	90.9	90.9	53.2	0.0	2926
	Cap	24.9	59.9	15.4	15.4	37.9	15.4	25.4	60.9	15.9	15.9	40.9	15.9	15.9	50.9	38.4	16.4	41.4	16.4	16.4	9.8	0.0	847
HWVP Annex	Exp	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	76
	Cap	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	207
Grout Ops & Construc	Exp	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1198
	Cap	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	52
Pretreatment Technology	Exp	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	159
	Cap	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	28
Retrieval Development	Exp	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	254
	Cap	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	365
Retrieval Operations	Exp	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	23
	Cap	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0
Waste Trans Lines	Exp	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	3
	Cap	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	9
Tank Farms Upgrades	Exp	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	20
	Cap	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	220
Ship/Repos Disposal	Exp	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	3633.0	3633
	Cap	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0
SUB TOTALS	Exp	218	240	279	171	172	198	200	212	110	110	110	90	87	87	87	91	91	91	91	53	3633	12169
	Cap	79	93	79	21	55	69	58	121	16	16	41	16	16	51	38	16	41	16	16	10	0	4632
OPT 15 TOTAL		297	333	357	192	227	266	258	333	126	126	151	106	103	138	126	107	132	107	107	63	3633	16801
Labor	M/Yrs	2291	2561	2803	1563	1764	2062	2022	2489	1016	1016	1161	851	828	1031	958	860	1005	860	860	505	30594	129293

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OPTION 16--NPF WITH TRUEX
ANNUAL COSTS BY FISCAL YEAR ($MILLIONS)

		FY92	FY93	FY94	FY95	FY96	FY97	FY98	FY99	FY00	FY01	FY02	FY03	FY04	FY05	FY06	FY07	FY08	FY09	FY10	FY11	FY12	FY13
B Plant Operations	Exp	37.7	40.0	43.7	46.0	45.5	45.5	45.5	45.5	45.5	44.9	44.9	44.9	44.9	44.9	44.9	44.9	44.9	44.9	44.9	44.9	44.9	44.9
	Cap	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4
B Plant Fac Upgrades	Exp	4.5	4.2	4.3	3.8	3.4	2.3	1.6	1.4	1.2	1.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	Cap	11.1	10.2	18.1	22.6	16.3	15.4	2.0	1.0	0.6	0.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
PUREX Operations	Exp	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	Cap	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
NPF Construction	Exp	0.2	3.5	10.8	17.6	26.5	35.3	35.3	35.3	52.9	61.7	79.4	88.2	93.3	93.3	107.3	79.4	26.5	0.0	0.0	0.0	0.0	0.0
	Cap	0.0	0.0	0.0	0.0	0.0	42.0	51.0	88.1	155.7	281.2	322.2	334.4	300.4	180.0	81.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
NPF Operations	Exp	0.0	0.0	0.0	0.0	0.0	1.2	2.4	3.7	8.7	13.7	28.6	43.5	70.9	97.0	124.4	124.4	124.4	124.4	124.4	72.8	67.7	66.3
	Cap	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.3	0.9	1.9	5.0	12.0	23.6	23.6	23.6	23.6	23.6	2.0	3.2	5.5
HWVP Constructn	Exp	14.5	14.5	14.5	14.5	14.5	14.5	14.5	20.0	25.0	30.0	37.3	45.8	52.5	65.1	64.3	78.6	45.1	14.6	0.0	0.0	0.0	0.0
	Cap	28.0	15.0	5.0	5.0	5.0	5.0	15.0	28.0	43.0	89.2	186.7	193.9	201.5	187.2	107.2	40.7	0.0	0.0	0.0	0.0	0.0	0.0
HWVP Operations	Exp	1.3	1.3	1.3	1.3	1.3	1.3	1.3	1.3	1.3	1.3	5.0	7.9	16.9	25.9	41.9	56.9	73.3	73.3	73.3	73.3	73.3	30.5
	Cap	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.3	0.9	1.9	5.6	8.9	13.9	36.4	13.9	11.4	6.0
Grout Ops & Construc	Exp	30.3	52.0	66.1	68.9	71.3	74.0	68.8	68.8	68.8	68.8	68.8	68.8	68.8	68.8	73.3	73.3	73.3	73.3	73.3	73.3	73.3	73.3
	Cap	2.3	2.1	5.9	2.6	2.3	2.3	2.3	2.3	2.3	2.3	2.3	2.3	2.3	2.3	2.3	2.3	2.3	2.3	2.3	2.3	2.3	2.3
Pretreatment Technology	Exp	9.7	21.8	23.7	18.7	15.2	12.4	9.0	8.1	6.7	5.0	4.6	3.0	3.0	3.0	3.0	3.0	3.0	0.0	0.0	0.0	0.0	0.0
	Cap	0.2	0.2	3.7	9.7	5.8	4.7	0.5	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.0	0.0	0.0	0.0	0.0
Retrieval Development	Exp	2.9	8.6	18.8	25.8	37.3	22.7	28.9	13.6	5.4	6.5	7.0	9.0	9.0	9.0	9.0	9.0	9.0	9.0	9.0	3.0	1.5	0.5
	Cap	5.8	3.0	7.0	0.0	0.0	0.0	0.0	0.0	0.0	5.0	9.5	17.0	25.0	45.0	45.0	45.0	45.0	45.0	35.0	20.0	13.0	0.0
Retrieval Operations	Exp	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	3.0	3.0	3.0	3.0	4.5	3.0	3.0	0.0	0.0
	Cap	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Waste Trans Lines	Exp	0.5	0.1	0.9	1.0	0.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	Cap	6.0	0.0	3.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Tank Farms Upgrades	Exp	2.5	1.0	1.4	2.1	4.1	4.0	3.1	1.9	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	Cap	0.0	8.0	11.0	12.0	25.0	62.0	70.0	32.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Ship/Repos Disposal	Exp	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	Cap	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
SUB TOTALS	Exp	104	147	186	200	219	213	210	200	216	233	276	311	359	410	471	473	403	344	328	270	261	216
	Cap	54	39	55	52	55	132	141	152	202	379	522	550	535	428	262	118	81	85	98	39	30	14
OPT 16 TOTAL		158	186	240	252	274	345	352	352	418	612	798	861	894	838	733	590	483	429	426	309	291	230
Labor	M/Yrs	1188	1463	1878	1984	2165	2558	2589	2561	2986	4157	5345	5806	6124	5931	5482	4662	3856	3390	3327	2500	2371	1897
Labor Average															3338	2094							

OPTION 16--NPF WITH TRUEX
ANNUAL COSTS BY FISCAL YEAR ($MILLIONS)

		FY14	FY15	FY16	FY17	FY18	FY19	FY20	FY21	FY22	FY23	FY24	FY25	TOTALS
B Plant Operations	Exp	44.9	44.9	67.7	66.3	66.8	92.6	115.1	127.1	21.0	21.0	21.0	1.3	1668
	Cap	0.4	0.4	3.2	5.5	17.0	53.5	32.4	60.1	0.0	0.0	0.0	0.1	181
B Plant Fac Upgrades	Exp	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	28
	Cap	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	98
PUREX Operations	Exp	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0
	Cap	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0
NPF Construction	Exp	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	847
	Cap	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1836
NPF Operations	Exp	66.8	92.6	115.1	127.1	21.0	21.0	21.0	1.3	1.3	1.3	1.3	1.3	1570
	Cap	17.0	53.5	32.4	60.1	0.0	0.0	0.0	0.1	0.1	0.1	0.1	0.1	312
HWVP Constructn	Exp	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	580
	Cap	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1155
HWVP Operations	Exp	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	565
	Cap	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	99
Grout Ops & Construc	Exp	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1499
	Cap	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	54
Pretreatment Technology	Exp	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	153
	Cap	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	28
Retrievel Development	Exp	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	254
	Cap	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	365
Retrieval Operations	Exp	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	23
	Cap	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0
Waste Trans Lines	Exp	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	3
	Cap	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	9
Tank Farms Upgrades	Exp	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	20
	Cap	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	220
Ship/Repos Disposal	Exp	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	316.8	317
	Cap	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0
SUB TOTALS	Exp	112	138	183	193	88	114	136	128	22	22	22	319	7525
	Cap	17	54	36	66	17	54	32	60	0	0	0	0	4359
OPT 16 TOTAL		129	191	218	259	105	167	169	189	22	22	22	320	11885
Labor Labor Average	M/Yrs	1041	1470	1745	2008	838	1266	1334	1430	188	188	188	2691	88609

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APPENDIX G

DESCRIPTION OF CANDIDATE NEW PRETREATMENT FACILITIES

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CONTENTS

LIST OF FIGURES

LIST OF TABLES

ACRONYMS

AMU	aqueous makeup unit
DSS	double-shell slurry
DSSF	double-shell slurry feed
DST	double-shell tanks
EIS	environmental impact statement
HVAC	heating, ventilating, and air conditioning
HLW	high-level waste
HWVP	Hanford Waste Vitrification Plant
LLW	low-level waste
NCAW	neutralized current acid waste
NCRW	neutralized cladding removal waste
OSR	operating safety requirements
PFP	Plutonium Finishing Plant
ROM	rough order of magnitude
SCWO	supercritical water oxidation
SST	single-shell tanks
SW	Sludge Wash
TRU	transuranic
TRUEX	transuranic extraction

CONVERSION FACTORS

1 ft = 0.3048 m
1 gal = 3.785 L or 3.785 x 10^{-3} m^3

APPENDIX G
DESCRIPTION OF CANDIDATE NEW PRETREATMENT FACILITIES

G1.0 INTRODUCTION

Construction of a new shielded remotely operated facility with support structures in the 200 East or 200 West Areas would provide maximum flexibility in selection and operation of waste pretreatment processes. Suitably sized, such a facility would permit pretreatment of waste retrieved from all or a selected number of double-shell tanks (DST) and single-shell tanks (SST) (see Section 6.5.2.7).

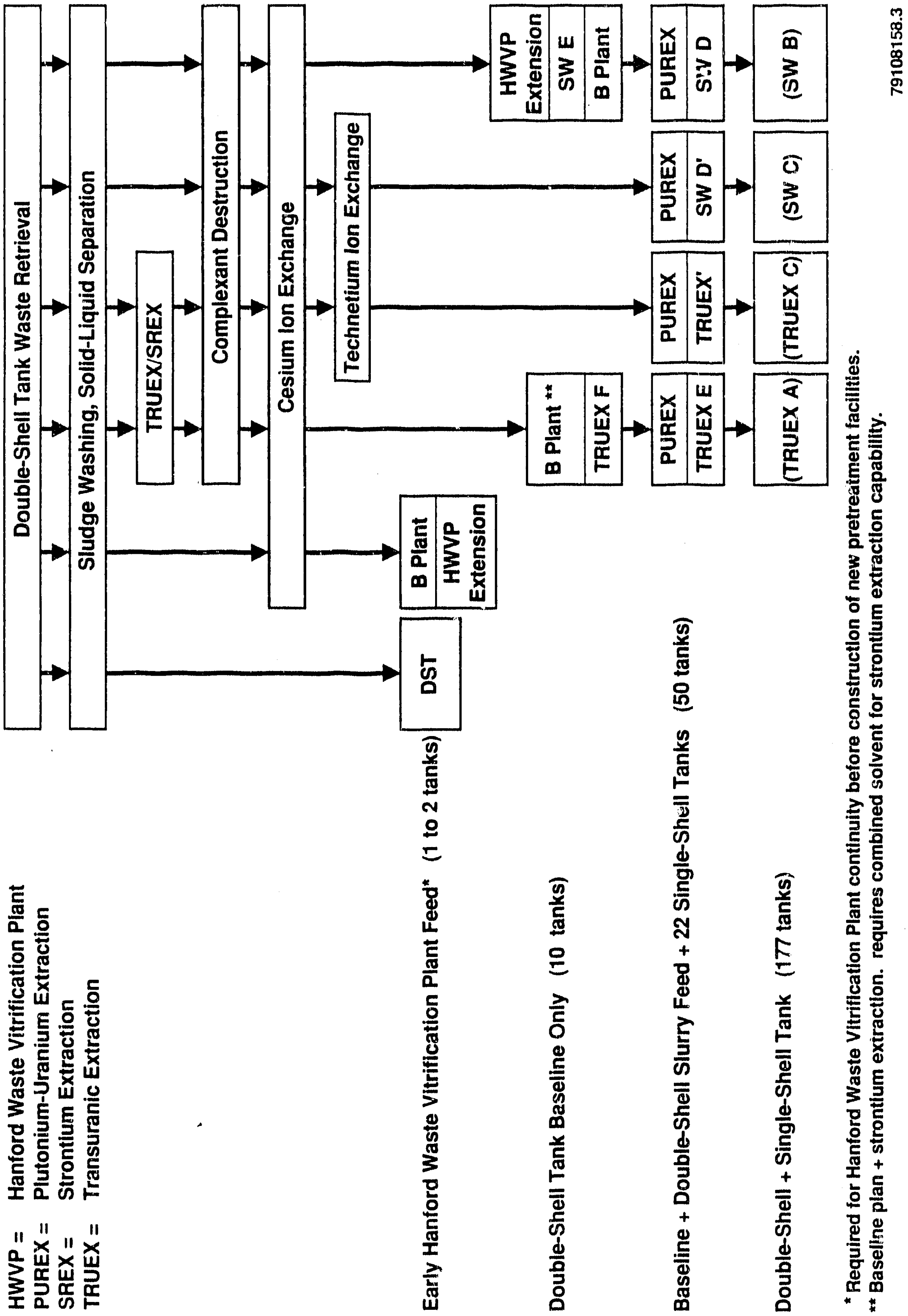
Ten facilities were evaluated for partitioning the DST waste. These are shown in Figure G-1. The two base case facilities [Transuranic Extraction (TRUEX) F, Sludge Wash (SW) E] are sized to process only the existing DST transuranic (TRU) waste (10 tanks). The three expanded case facilities (TRUEX E and E', SW D) are sized to process all the DST wastes including double-shell slurry (DSS) and double-shell slurry feed (DSSF), plus the 22 SSTs deemed most likely to warrant retrieval. The four "full size" cases (TRUEX A and C, SW C and B) are sized to process the wastes in all 149 SSTs. It is assumed that these plants could also handle the DST wastes with small changes, although some vessels may not be optimally sized for complexant destruction.

The TRUEX F and SW E plants will be described in detail. Other facility descriptions will be limited largely to the differences between these plants and the TRUEX F or SW E facilities.

The new facilities shown in Figure G-1 which are similar in design but differ only in capacity (TRUEX F, E, and A; TRUEX E' and C; SW D' and C; SW D and B) were assumed to have a similar layout and width. (Since Figure G-1 was made, it was decided to delete SW D' from the work scope). Only the building lengths were assumed to change with capacity. This was done to provide a common basis for cost comparison. More efficient layouts for the smaller plants could give narrower cell widths and/or different interior arrangements. The SW E facility design is slightly different than the others, being laid out with a single cell row canyon. This facility is assumed to have minimum sludge washing and cesium removal capability, with complexant destruction equipment added several years later. A double cell row canyon design could not be easily justified for this smaller facility. Because of the method used to calculate the cost estimates, the SW E cost estimate is somewhat high when compared to the costs for the double cell canyon plants.

A nominal 10 yr was selected as the processing period for each facility, except for SW E, which is about 7 yr. The volumetric flowrates will vary with waste type, solids content, amount of flushwater, and similar issues. They should average 10,000 to 13,000 gal/day for the base cases (TRUEX F and SW E), and 29,000 to 39,000 gal/day for the expanded cases (TRUEX E and E', SW D and D'). The full-scale plants should process 50,000 to 60,000 gal/day to process all the SST waste.

Figure G-1. Tank Waste Pretreatment Process-Facility Alternatives.



The processing durations are somewhat arbitrary. A 10 yr processing duration was selected as the basis for the full-scale plants sized to partition all the SST waste. This same duration was assumed for most of the other plants in an effort to provide a common basis for comparison. Equipment sizing and flowsheet values have been ratioed to the full-scale SST designs, with suitable down sizing for some of the equipment. Not all the equipment sizes were ratioed directly to the full-scale SST design based on flowrates. The main evaporator is the same size in all plants except SW E, where it is about half size. Cesium removal equipment in TRUEX F and SW E is about half the size of that in the full-scale plants.

The limiting factor for some of the equipment is the complexant destruction reaction vessels. These need to be fairly large because of the excessive foaming that may occur, and the large liquid volumes involved. The full-scale plants assume a supercritical water oxidation (SCWO) process for complexant destruction. The SCWO process, although it provides greater assurance of complexant destruction than the H_2O_2 method, was not selected for the new DST waste partitioning facilities. The SCWO process involves high temperatures and pressures, which were felt to be unsuitable for a remote radiochemical environment unless no other alternative existed.

Site location has not been considered for these facilities. A logical location would be in the 200 East Area near the Hanford Waste Vitrification Plant (HWVP) or grout facilities, but available building sites within 200 East Area with required rail access and construction space are limited. Site selection should have little impact on choice of facility as siting problems should be similar for any partitioning plant.

Table G-1 summarizes the estimated rough order of magnitude (ROM) costs for the new facilities. These costs are very preliminary and do not include costs for condensate recycle systems, many auxiliary equipment items, external buildings, and systems, which would be identified in conceptual design.

All cost estimates should be taken as rough values only. They are based on very rough equipment list summaries and sizing estimates. All facility designs need more work to be reliable enough to use for planning purposes. The estimates can be used for comparison, however. The cost estimates were developed using the FAST-C[1] parametric estimating program developed for the U.S. Department of Energy. The parametric values are based on the equivalent of the preliminary HWVP estimate of $1.06 billion. The costs include a 50 percent contingency based on RL Order 5700.3 (RL 1985).

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[1]Trademark of Freiman Parametric Systems, Inc.

Table G-1. Estimated Partitioning Facility Costs.

Facility	Estimated cost in billions (1991$)
SW B[a]	$1.3
SW C[a]	$1.7
SW D	$1.4
SW E[b]	$1.3
TRUEX A	$1.8
TRUEX C	$2.5
TRUEX E	$1.7
TRUEX E'	$2.0
TRUEX F	$1.5

[a]SW B and C costs are biased slightly low due to different complexant destruction equipment and the omission of several minor equipment items.

[b]SW E cost is biased slightly high due to canyon cells being in a single row. The cost for SW E without cesium ion exchange capabilities is $1.1 mm.

G2.0 NON-TRUEX FACILITIES

The non-TRUEX facilities, referred to as sludge wash plants, pass the washed solids in the waste on to high-level waste (HLW) treatment, while processing the supernatant phase to make it acceptable for low-level waste (LLW) treatment. Constituents removed from the supernatant are sent to HLW treatment. Many of the proposed flowsheets assume in-tank washing of DST solids followed by a settle-decant separation. All the new facilities include tanks, centrifuges, and polishing filters to provide washing and separation to augment any separation gained by in-tank washing.

G2.1 SLUDGE WASH E

Facility Description

The SW E facility will provide a minimum DST pretreatment capability. The facility will include equipment to centrifuge, wash, and filter the DST wastes. Ion exchange equipment will be included to remove cesium from the supernatant. Space will be provided in the canyon to add complexant destruction equipment at a later date. Washed solids and cesium will be removed from the supernatant streams and be sent to HLW treatment and the remaining waste sent to LLW solidification. After acidification, complexant destruction, and reneutralization, the TRU elements and other ions precipitated from the complexed waste will be sent to HLW treatment.

Figure G-2 shows scope drawings of what the facility may look like. The layout is based on experience at operating radiochemical processing facilities and includes some of the features and/or arrangements necessary to allow efficient operation. The main plant dimensions would be roughly 1,206-ft long by 135-ft wide by 95-ft high (37 ft of which is belowgrade), with a single row of 20-ft wide cells in the canyon. One side of the facility will have a nominal 105-ft by 305-ft office annex, and the other side will have a 135-ft by 365-ft addition for heating, ventilating, and air conditioning (HVAC) equipment.

Equipment would be segregated into several cells. About 295 ft of the canyon space would be left vacant for the future complexant destruction equipment. An overhead process crane running the length of the canyon would span the cells. At one end of the canyon would be an empty cell for dismantling failed equipment. Railroad access is provided to the canyon.

The canyon would be surrounded by three gallery levels. The bottom level would contain storage areas and hot shops for equipment and manipulator repair. The middle gallery would contain sample caves and some service piping to the canyon. The upper gallery would contain the majority of the cold side piping to the canyon, as well as closed loop process heating and cooling systems. Above the upper service gallery would be the aqueous makeup unit (AMU) area. A gravity drain system will be used to add process chemicals to the canyon.

Control rooms, office areas, change rooms, switchgear rooms, and cold maintenance shops will be located on one side of the plant next to the galleries and the AMU area. On the opposite side of the facility will be the exhaust filters, blowers, and stack.

The exterior to the building will be a set of four nominal 100,000-gal lag storage tanks for receipt of incoming solutions or lag storage of processed wastes. An exhaust system and separate stack is shown for these tanks. The facility site will also include an electrical substation, cooling tower, bulk chemical storage area, and parking lot.

Solids washing and separation equipment consists of parallel feed tanks, centrifuges, catch tanks, and polishing filters. Waste slurry will be brought into the facility from one of the lag storage tanks to one of the feed tanks. From there, it will be passed through a centrifuge to remove the solids. The solids that will be caught in the centrifuge will be washed with water to remove the majority of the residual supernatant. The washed solids will be slurried out of the centrifuge with water to a catch tank. If required to meet tank farm specifications, the slurry will be adjusted to 0.01$\underline{M}$ OH^- and 0.011$\underline{M}$ NO_2^- before being transferred to HLW storage in one of the lag storage tanks or direct to a DST. The supernatant from the centrifuge will pass to a receipt tank and then to a feed tank for a polishing filter. The polishing filter will trap residual solids not removed by the centrifuge.

Clarified supernatant and wash water from the centrifuge-filter steps will be passed through two stages of ion exchange to remove 99 percent of the cesium. The cesium "product" stream will be concentrated, neutralized, and sent to HLW feed storage. The cesium depleted supernatant and ion exchange wastestreams will be concentrated and sent to LLW storage.

The supernatant and/or ion exchange waste evaporator will also be used as required to concentrate dilute incoming wastestreams that may occur during in-tank sludge washing or tank flushing activities.

Complexed wastes would be passed through the solids washing and separation equipment and the solids sent to HLW storage. The clarified supernatant would be sent to one of two parallel reaction vessels. The supernatant would be acidified with HNO_3, and H_2O_2 would be added to reduce the complexants. The resulting solution will then be neutralized and the precipitated actinides (and other formerly complexed ions) will be removed by centrifuging and filtration. The solids slurry will be sent to HLW and the supernatant will be sent to LLW.

It is currently planned to process complexed waste through the SW E facility after the other DST wastes have been processed. This delay means the facility cost could be spread over a number of years by erecting a separate complexant destruction add-on to the SW E facility at a later date, or by providing space for the equipment when the facility is built, with equipment installation several years later. The former would cost more in the long term and be more difficult to integrate into the pretreatment process, but would be preferable if a complexant destruction process is not settled on by the time detailed design started for the SW E facility. For this study, it was assumed that reaction with H_2O_2 was the complexant destruction process. The cost section assumes costs for complexant destruction equipment located in the main SW E facility.

In-tank washing and settle-decant separation is planned for most of the DST wastes. The centrifuges are included in the SW E design because they provide an active, more reliable, and more controllable process for washing and separating the solids. By having an active, controllable process for solid washing and separation, reliance will not have to be placed on the in-tank process that could be prone to extended settling times, excess solids in the supernatant, excess supernatant in the solids, or excess wash water usage. The benefits accrued from in-tank washing and settling can lessen the load on the centrifuges and increase the performance of the new facility.

For neutralized current acid waste (NCAW), there is a current operating safety requirements (OSR) limit that restricts the amount of time tank air lift circulators can be off to 15 hour, plus 5 hour restart time. Based on NCAW processing tests done at B Plant several years ago, a 240 hour settling time is recommended for the NCAW. At this time, changing or eliminating the current OSR limit has not been approved. To effectively in-tank wash and separate NCAW, the current OSR limit will have to be extended significantly or eliminated. If it is extended to 20 days, reliance will have to be placed on the solids effectively settling in the 10-day period and that no process or procedural problems occur that extend the decant cycle beyond 20 days. The centrifuges will allow adequate solid-liquid separation regardless of what happens in the DSTs.

Tests with neutralized cladding removal waste (NCRW) solids indicate settling rates are low, so an active washing and separation process is required. Adequately suspending the large quantity of NCRW solids in a waste tank may also be difficult.

In-tank washing is planned for Plutonium Finishing Plant (PFP) solids. It is assumed that the quantity of solids (one eighth to one quarter of tank 241-SY-102 available volume) can be adequately suspended and washed in tank 241-SY-102. Because cesium levels in this waste are low, it has been assumed that PFP supernatant will not have to be processed through a pretreatment facility. Thus, a pretreatment facility should not be required for PFP wastes if only a minimum level of pretreatment was provided. If in-tank washing and solids separation do not perform as planned in tank 241-SY-102, the washing and settling equipment in the SW E facility would be available.

One of the alternatives for a SW E facility is to delete the cesium ion exchange equipment and perform cesium removal in HWVP. The building length would be reduced to about 729 ft, 295 ft of which would still be open for future complexant destruction equipment. Costs for SW E facilities with and without cesium ion exchange equipment are included in the cost section.

Cost and Schedule

The estimated cost for the base case, the SW E facility, is $1.32 billion in 1991 dollars. This includes the complexant destruction equipment that would be installed several years after the facility was operating. If cesium removal equipment was eliminated from the facility, the cost would be reduced to $1.08 billion.

A base cost for a SW E facility with a separate annex for complexant destruction was not estimated. This annex may be able to be constructed with thinner walls and to less rigid design requirements than the base case, SW E facility, because of the relatively low radiation level of the complexed waste after the cesium is removed.

The schedule for the base case, SW E facility, estimates a startup date of late 2005. This is a rough estimate. The startup date is affected by estimates in funding availability, work scope approval, environmental impact statement (EIS) record of decision, design time, construction, and political decisions.

Regulatory Compliance Issues

It is planned to construct and operate any new facility in compliance with all applicable regulations in effect at the time the facility is designed. At this time, there does not appear to be any major regulatory concerns with a SW E concept, except potentially for the technetium level in the LLW stream from NCAW processing. If detailed design identified any concerns, the process would be redesigned or a waiver requested depending on which action was the safest and most economical.

G2.2 SLUDGE WASH D

This facility is similar in concept to the SW E but is sized to accommodate the base case 10 DST tanks plus the DSS and DSSF in other DSTs and the 22 SSTs assumed to most justify retrieval. The facility includes equipment to wash and separate the sludge from the supernatant, remove cesium from the supernatant, and destroy complexants. There are no alternates where cesium removal and/or complexant destruction are not included.

Figure G-3 shows scope drawings for a SW D facility. The main building would be about 547-ft long by 340-ft wide with a canyon area about 70-ft wide. The SW D building arrangement differs from the SW E design in that a double wide row of cells is assumed for the canyon area. This was done to try and minimize the building length. An engineering study may indicate that the SW E facility should have a double row of cells also or that the SW D facility should have a single cell arrangement.

Most SW D process equipment will be about two to three times that in the SW E facility. Peroxide will be used for complexant destruction, and the complexant destruction equipment will be installed at the same time as the rest of the plant equipment. There will be six 100,000-gal exterior lag storage tanks.

The estimated ROM cost for the SW D facility is $1.40 billion in 1991 dollars. This is about 12 percent more than the SW E baseline DST plant with a capacity more than double the baseline.

A SW D' facility is similar to SW D but includes technetium removal equipment as indicated in Figure G-1. This was originally planned for evaluation but it was later decided that such a design would not be necessary, and the plan was discarded.

G2.3 SLUDGE WASH B

The full-scale SW B facility is sized to process all the SST waste through sludge washing, cesium removal, and complexant destruction in 10 yr. It is described in Boomer et al. (1991). Processing all the DST and SST waste should likely take about 15 to 18 yr. The SW B facility is based on the SCWO process for complexed waste destruction. This was done because SCWO was the only process available that could confidently be assumed could destroy the complexants.

Estimated ROM cost for a SW B facility is $1.25 billion in 1991 dollars. This is less than for the SW E and D facilities because of the different complexant destruction equipment and the omission of several minor equipment items from the SW B estimate.

G2.4 SLUDGE WASH C

The full-scale SW C facility sized to process all the SST waste through sludge washing, cesium removal, complexant destruction, and technetium removal is described in Boomer et al. (1991). The design will be similar to the SW B layout, with the addition of technetium removal. Estimated ROM cost is $1.73 billion in 1991 dollars.

G3.0 TRUEX FACILITIES

The five TRUEX facilities will contain most of the same equipment as the sludge wash plants, with the addition of dissolution and solvent extraction equipment to remove strontium and actinides from the waste solids. Uranium will be separated from the actinides and the strontium and TRU streams are sent to HLW. Technetium originally present in the solids is separated from the uranium stream and also sent to HLW. The uranium stream is assumed to be sent to LLW as its purification and recovery appears uneconomical at the present time. Cesium will be separated from the supernatant and dissolved solids and will be sent to the HLW. Remaining supernatant, dissolved solids, and chemical wastestreams are sent to LLW. Technetium is removed from the supernatant stream in the TRUEX E' and TRUEX C facilities. The TRUEX F facility is described below. Descriptions of other facilities are limited to the differences between them and TRUEX F.

G3.1 TRUEX F

Facility Description

The TRUEX F facility will be sized to process the existing DST TRU wastes to reduce the volume of HLW requiring solidification compared to a SW E facility. Dissolution and solvent extraction have been added to remove strontium and TRUs. The HLW stream from TRUEX F will contain TRUs, cesium, strontium, technetium initially present in the solids, and undissolved solids from dissolution. The LLW stream will contain uranium, technetium present in the supernatant, depleted supernatant, and chemical wastestreams.

Figure G-4 shows scope drawings of what a TRUEX F facility may look like. The building dimensions will be about 582-ft long by 195-ft wide, with a 305-ft long by 105-ft wide addition on one side for office space, and a 335-ft long by 135-ft wide addition on the other for ventilation system equipment. The building will be about 95-ft tall, with 37 ft of that underground. The canyon will be about 70-ft wide and contain a double row of 20-ft wide cells.

Canyon equipment would be segregated into a number of cells. Spanning the cells would be an overhead process crane running the length of the canyon. At least two canyon cranes will be required. At one end of the canyon would be an empty cell for dismantling failed equipment. Railroad access would be provided to the canyon.

Three gallery levels would surround the canyon. The bottom level would contain storage areas and hot shops for equipment and manipulator repair. The middle gallery would contain sample caves and some service piping to the canyon. The upper gallery would contain the majority of the cold side piping to the canyon, as well as closed-loop process heating and cooling systems. Above the upper service gallery would be the AMU area. A gravity drain system will be used to add process chemicals to the canyon.

Control rooms, office areas, change rooms, switchgear rooms, and cold maintenance shops will all be located on one side of the facility next to the galleries and the AMU area. On the opposite side of the facility will be the exhaust filters, blowers, and stack.

The exterior to the building will be a set of six nominal 100,000-gal lag storage tanks for receipt of incoming solutions or lag storage of processed wastes. An exhaust system and separate stack is shown for these tanks. The facility site also will include an electrical substation, cooling tower, bulk chemical storage area, and parking lot.

The equipment will include that described for a SW E facility, plus dissolution and solvent extraction equipment to remove the TRU elements and strontium. Equipment sizes for TRUEX F will be about one-fourth to one-half that for the TRUEX A facility. The supernatant evaporator will be full sized and the cesium removal equipment will be about half size. The solid dissolvers will be one-half the size of those in the TRUEX A facility to accommodate the complexant destruction process.

Retrieved DST wastes will be pumped to one of the six lag storage tanks located outside the building. From there, wastes will be transferred into the building where they will be centrifuged and washed to remove as much supernatant as practical from the solids. Supernatant and wash water from the centrifuge step will be processed through two stages of ion exchange to remove a target 99 percent of the cesium. The cesium eluted from the ion exchange resin will be concentrated and sent out as HLW. Spent supernatant is concentrated and sent out as LLW. Solids from the sludge washing steps will be dissolved in acid and passed through the TRUEX and strontium extraction process equipment to remove the strontium and actinides. The strontium and TRUs will be stripped from the TRUEX and strontium extraction organic, concentrated, and sent to HLW. Undissolved solids from the dissolution step will also be sent to HLW.

Any technetium in the dissolved solids will follow the uranium through the process. Technetium will be removed from the uranium stream by a small ion exchange system and sent to the HLW. The impure uranium stream will be concentrated and sent to LLW. The aqueous raffinate from the TRUEX process will be neutralized and centrifuged. Waste solids from this centrifuge will be sent to LLW while the supernatant is returned for cesium recovery with the supernatant from the retrieved waste. The LLW will also contain miscellaneous chemical wastes and wash solutions.

Wastes with complexed organics would probably be processed in a slightly different manner. The complexed waste supernatant will likely be decanted from solids in the DST and processed separately from them. The complexed waste cesium depleted supernatant stream would be (1) acidified, (2) have H_2O_2 added to reduce the complexants, (3) neutralized, and (4) centrifuged to remove the "uncomplexed TRU" solids, which have precipitated. The TRU-depleted supernatant would be sent to LLW and the solids to HLW. Once the complexed waste supernatant had been processed, the solids would be retrieved from the DST and sent through dissolution and partitioning.

Retrieval of wastes from DSTs may be a little different for a TRUEX F facility when compared to the SW E facility. With the latter, in-tank washing of the solids is planned for some of the wastes, with the solids left behind being sent direct to HLW storage. With a TRUEX facility, less wash water may be needed because the existing supernatant would be used to slurry the solids out as much as possible.

Cost and Schedule

Estimated cost of the TRUEX F facility is $1.52 billion in 1991 dollars.

The schedule for the base case, TRUEX F facility, estimates a startup date of 2006. This is a rough estimate. The startup date is affected by estimates in funding availability, work scope approval, EIS record of decision, design time, construction, and political decisions.

Regulatory Compliance

It is planned to construct and operate any new facility in compliance with all applicable regulations in effect at the time the facility is designed. At this time, there does not appear to be any major regulatory concerns with a TRUEX F concept, although means of processing and disposing of organic wastes could result in cost increases. If detailed design identified any concerns, the process would be redesigned or a waiver requested depending on which action was the safest and most economical.

- TRUEX E--This facility will be similar in design to the TRUEX F facility but with about two to three times the throughput capacity to accommodate all DST wastes as well as the 22 SSTs. It is similar to a SW D facility with TRUEX-strontium extraction added.

  Figure G-5 shows sketches of a TRUEX E facility. The building would be about 655-ft long, with the same height, width, and general layout as the TRUEX F facility.

  The estimated ROM cost for the TRUEX E facility is $1.70 billion in 1991 dollars. This is about 12 percent more than TRUEX F, with over double the throughput rate in most process areas. The estimated startup date is late 2006, the same as for TRUEX F.

- **TRUEX A**--This would be the full-scale TRUEX processing facility to treat all 149 SSTs. The throughput rate would be about 50 percent more than TRUEX E. The main difference other than capacity is that the complexant destruction process is based upon a SCWO process. The estimated cost is $1.8 billion in 1991 dollars.

- **TRUEX E'**--This facility would be similar to the TRUEX E facility, with the addition of technetium removal ion exchange equipment. Equipment size will be about the same size as for TRUEX E.

Technetium removal from the supernatant is assumed to be accomplished using one stage of ion exchange equipment. Removed technetium will be sent to out as HLW while the spent supernatant and ion exchange chemicals go to LLW.

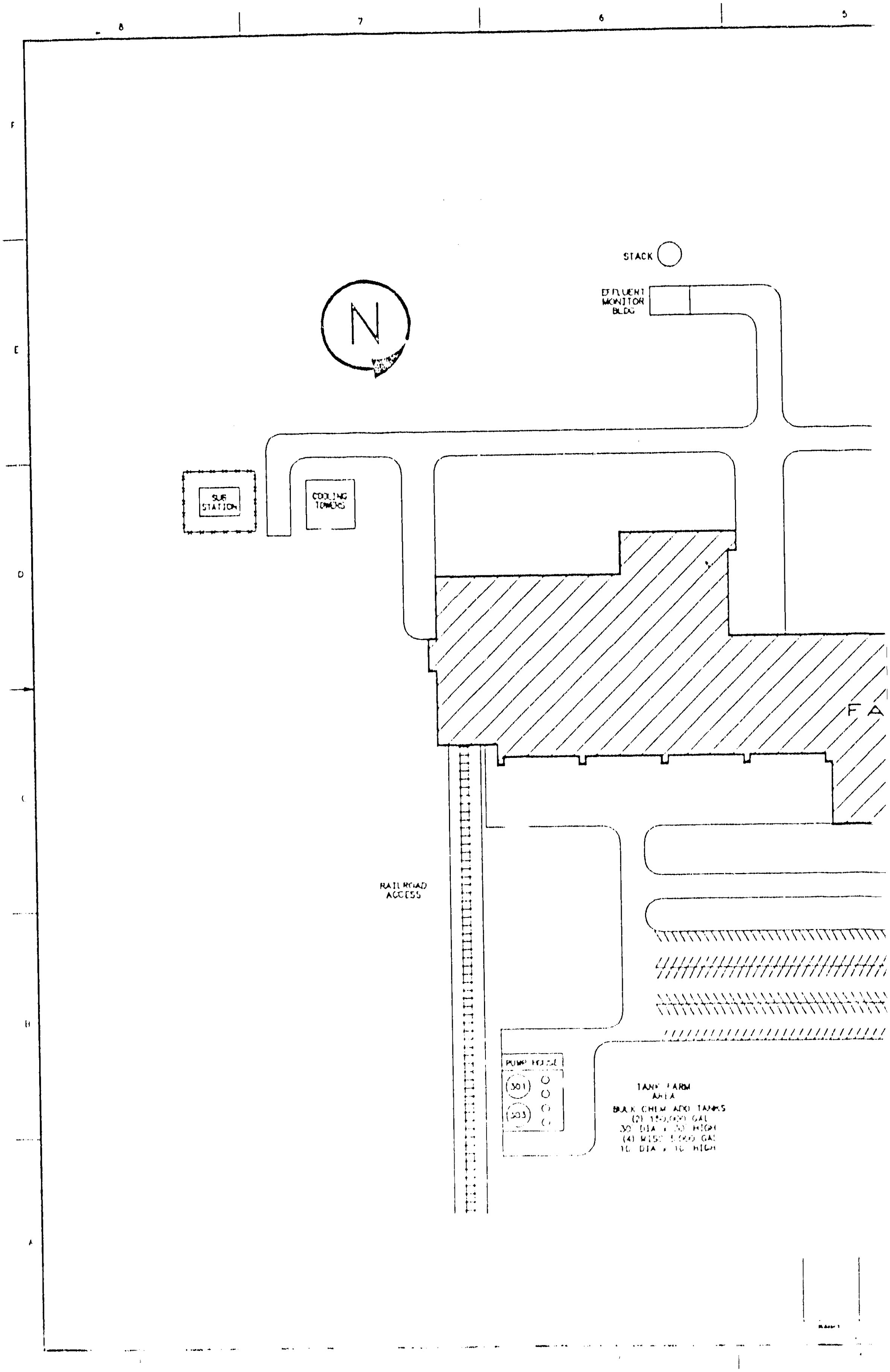
Figure G-6 illustrates what a TRUEX E' facility may look like. The building size will increase to about 797-ft long. Facility cost will increase to about $1.98 billion in 1991 dollars. This is an increase of about 16 percent over the TRUEX E facility to provide technetium removal.

- **TRUEX C**--This is the full-scale facility to process all the SST wastes and remove all radionuclides currently expected to potentially cause regulatory or safety problems for safe disposal. It is similar to the TRUEX A facility, with technetium removal added. Estimated ROM cost is $2.53 billion in 1991 dollars.

G3.2 REFERENCES

Boomer, K. D., S. K. Baker, A. L. Boldt, M. D. Britton, L. E. Engelsman, J. D. Galbraith, J. S. Garfield, K. A. Giese, G. E. Golberg, B. A. Higley, K. J. Hull, L. J. Johnson, R. P. Knight, J. S. Layman, R. S. Marusich, R. J. Parazin, M. G. Piepho, E. J. Slaathaug, T. L. Waldo, and C. E. Worcester, 1991, *Systems Engineering Study for the Closure of Single-Shell Tanks*, WHC-EP-0405, Vol. 1 and 2, Westinghouse Hanford Company, Richland, Washington.

RL, 1985, *Cost Estimating, Analysis, and Cost Standardization*, RL Order 5700.3, U.S. Department of Energy Field Office, Richland, Richland, Washington.

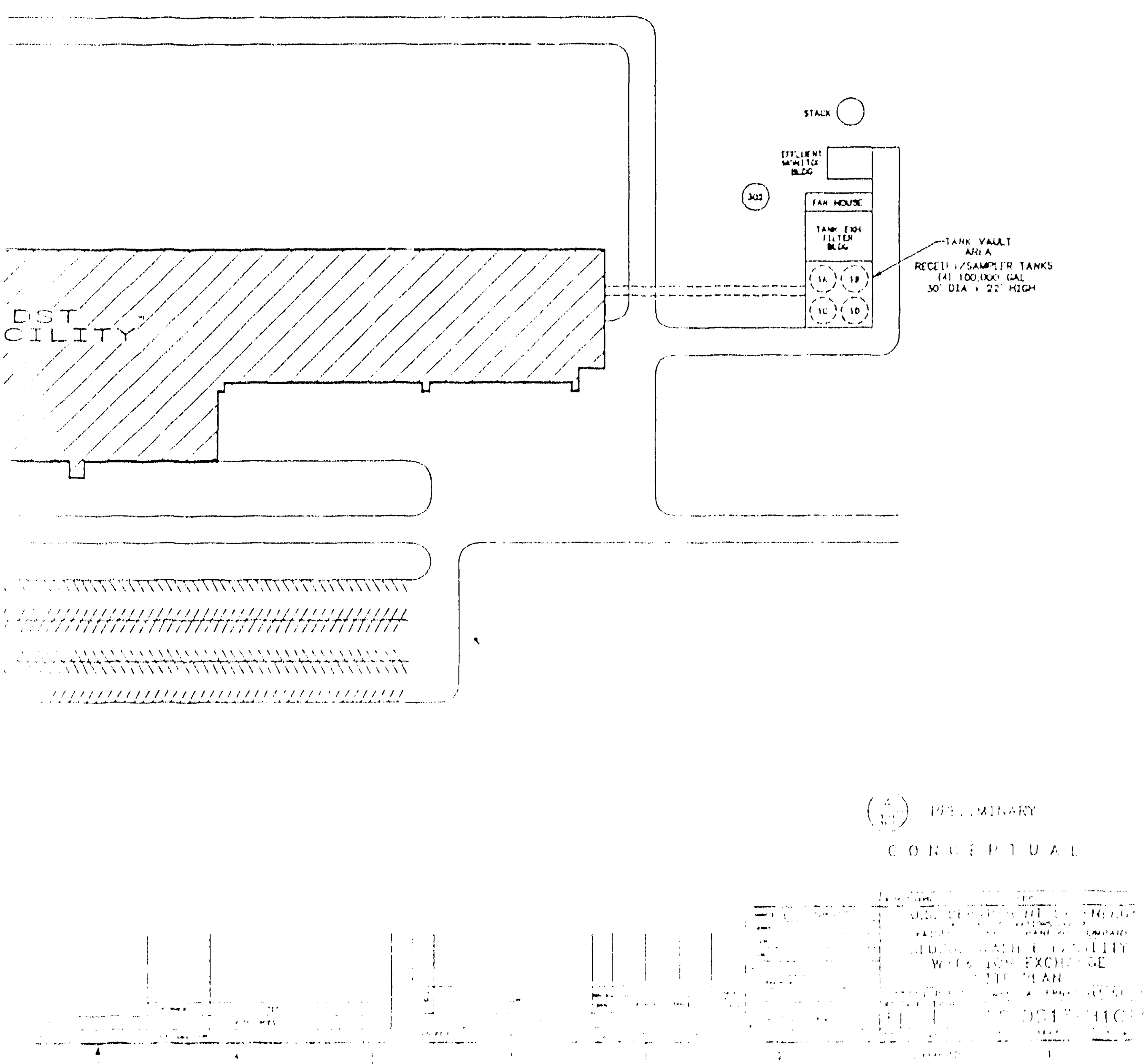


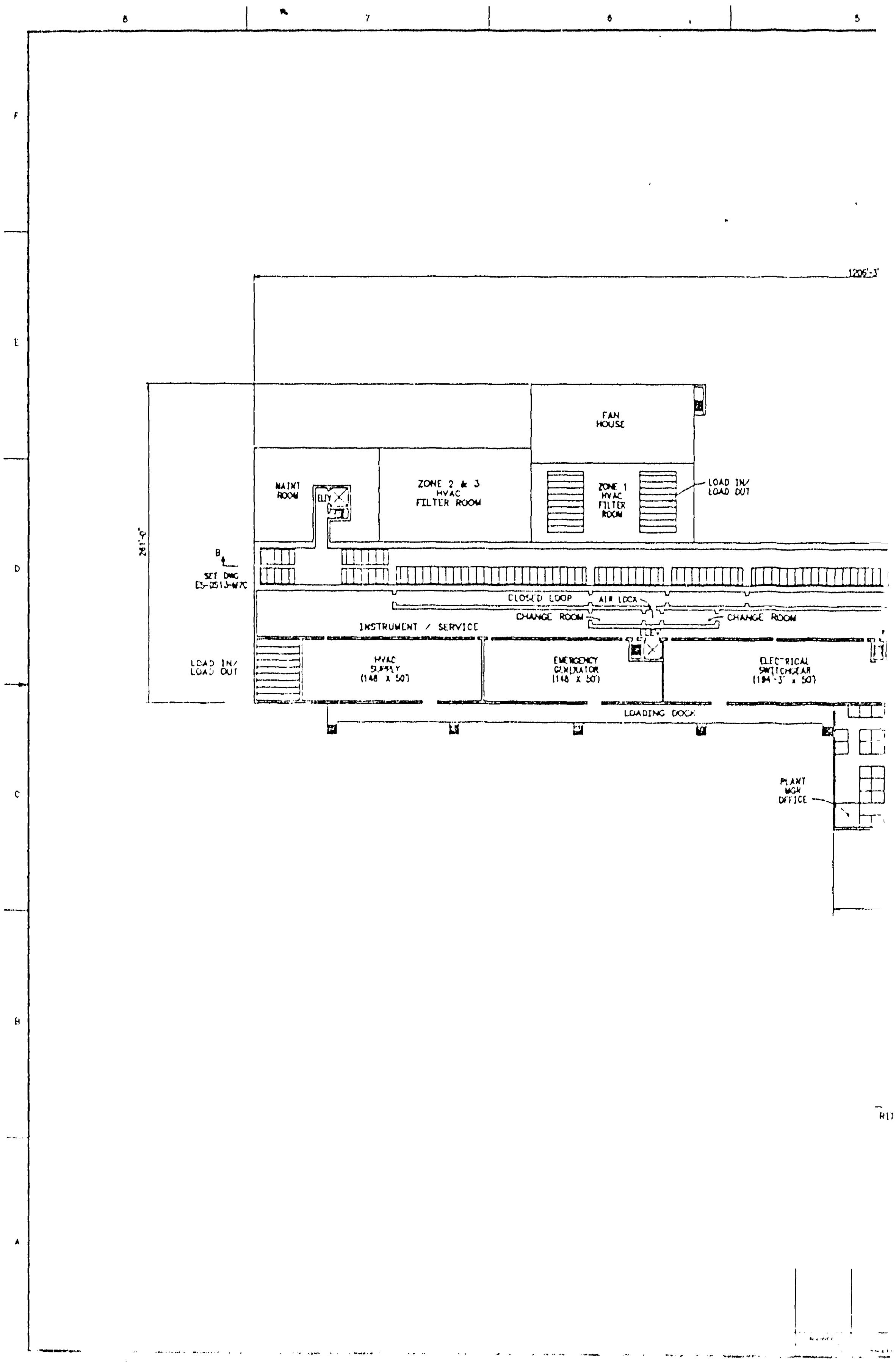
8
7
6
5
F
E
D
C
B
A
STACK
EFFLUENT MONITOR BLDG
N
SUB STATION
COOLING TOWERS
FA
RAILROAD ACCESS
301
303

EQUIPMENT LIST

EQUIPMENT NAME	EQPT ID
RECEIPT/SAMPLE TANK	TK-1A,B, C,D,E,F
BULK NITRIC ACID MAKEUP TANK	TK-301
BULK H2O MAKEUP TANK	TK-302
BULK SODIUM HYDROXIDE MAKEUP TANK	TK-303

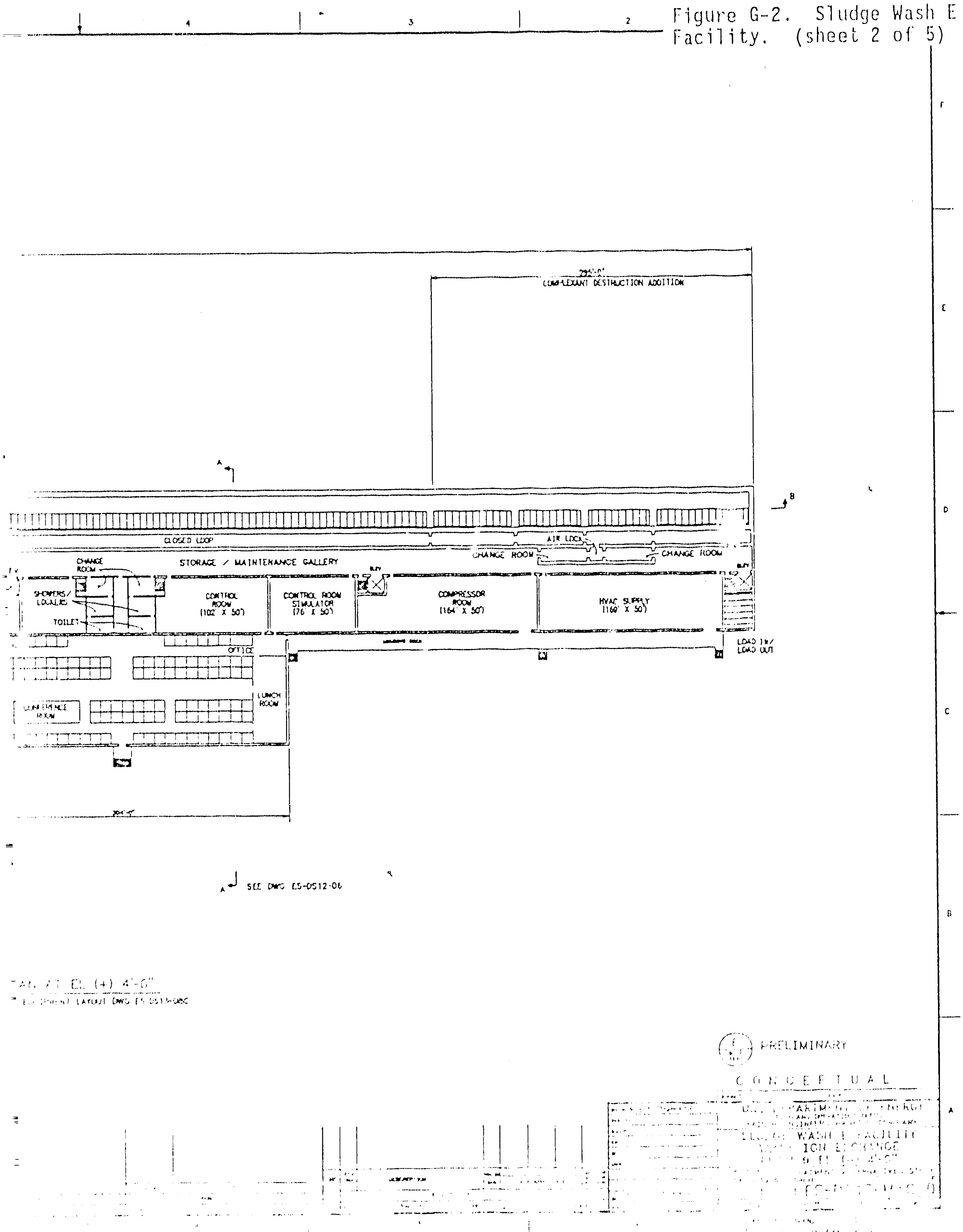
Figure G-2. Sludge Wash E
Facility. (sheet 1 of 5)

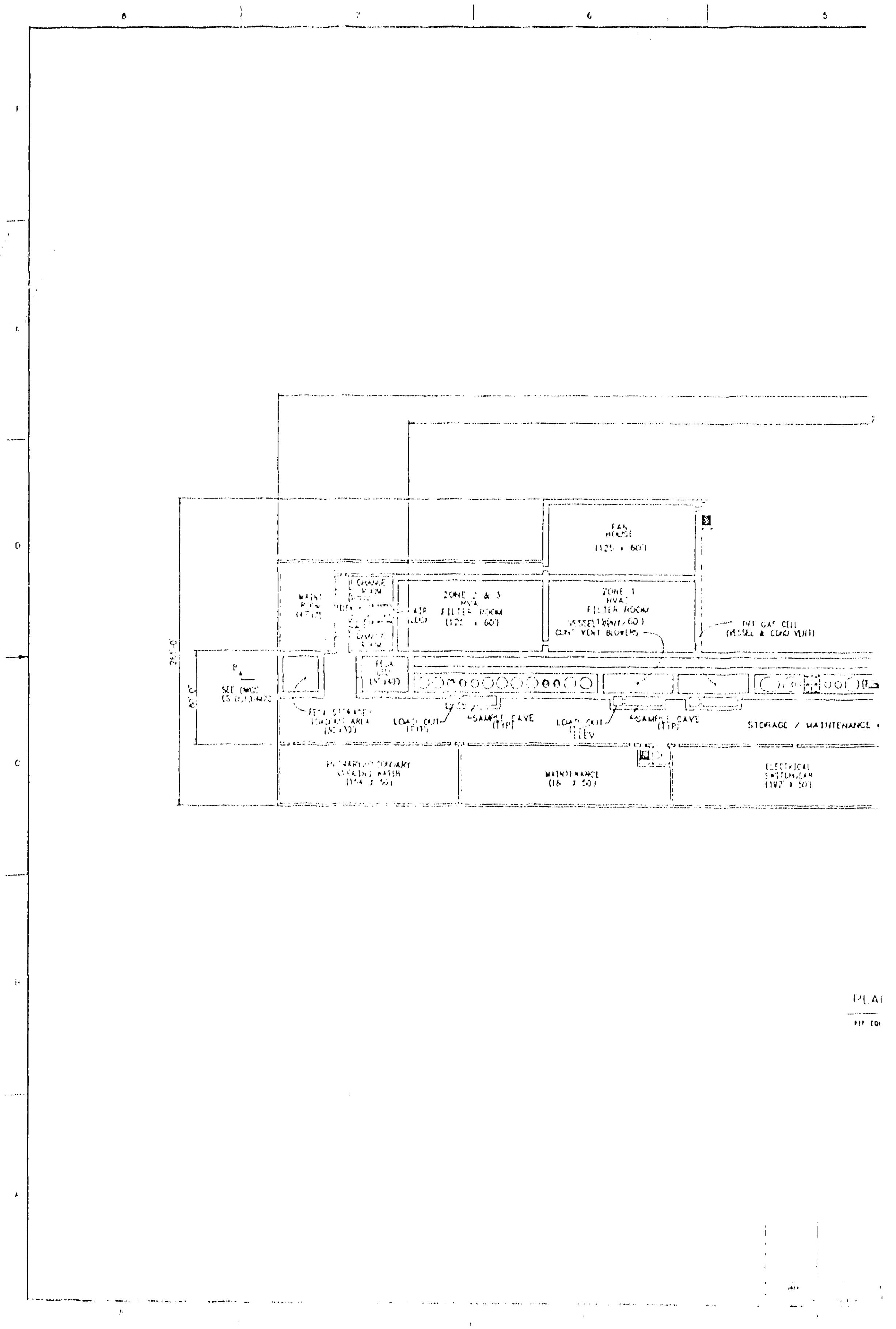




FAN HOUSE
MAINT ROOM
ELEV
ZONE 2 & 3 HVAC FILTER ROOM
ZONE 1 HVAC FILTER ROOM
LOAD IN/ LOAD OUT
SEE DWG
CLOSED LOOP
AIR LOCK
CHANGE ROOM
CHANGE ROOM
INSTRUMENT / SERVICE
LOAD IN/ LOAD OUT
HVAC SUPPLY (148' X 50')
EMERGENCY GENERATOR (148' X 50')
ELECTRICAL SWITCHGEAR
LOADING DOCK
PLANT MGR OFFICE

Figure G-2. Sludge Wash E
Facility. (sheet 2 of 5)





FAN HOUSE
(125 x 60')
ZONE 1 HVAC FILTER ROOM
CONT VENT BLOWERS
ZONE 2 & 3 HVAC FILTER ROOM
(125 x 60')
AIR LOCK
CHANGE ROOM
OFF GAS CELL
(VESSEL & COND VENT)
SEE DWGS
LOAD OUT
SAMPLE CAVE
(TYP)
STORAGE / MAINTENANCE
MAINTENANCE
ELECTRICAL SWITCHGEAR

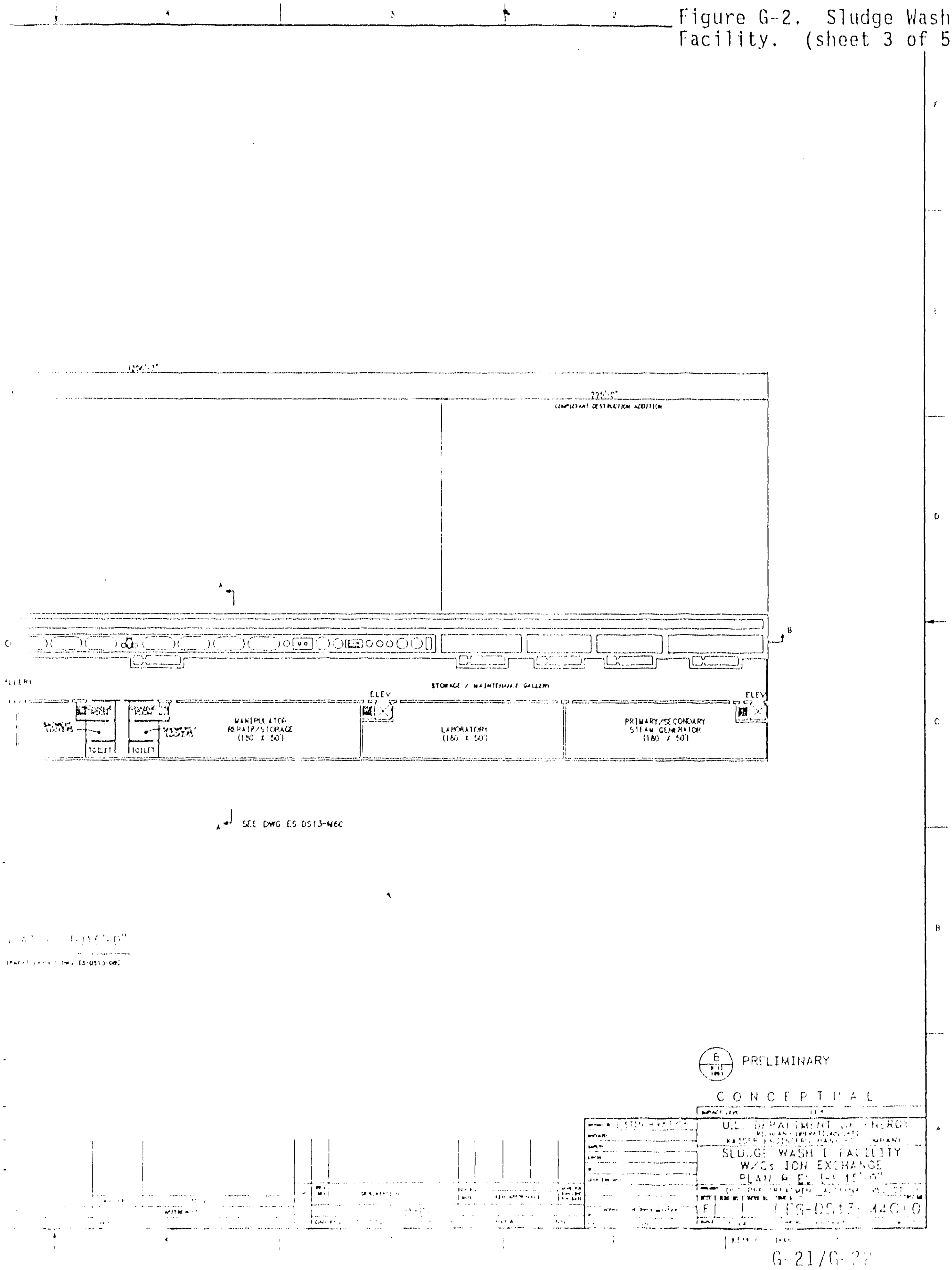
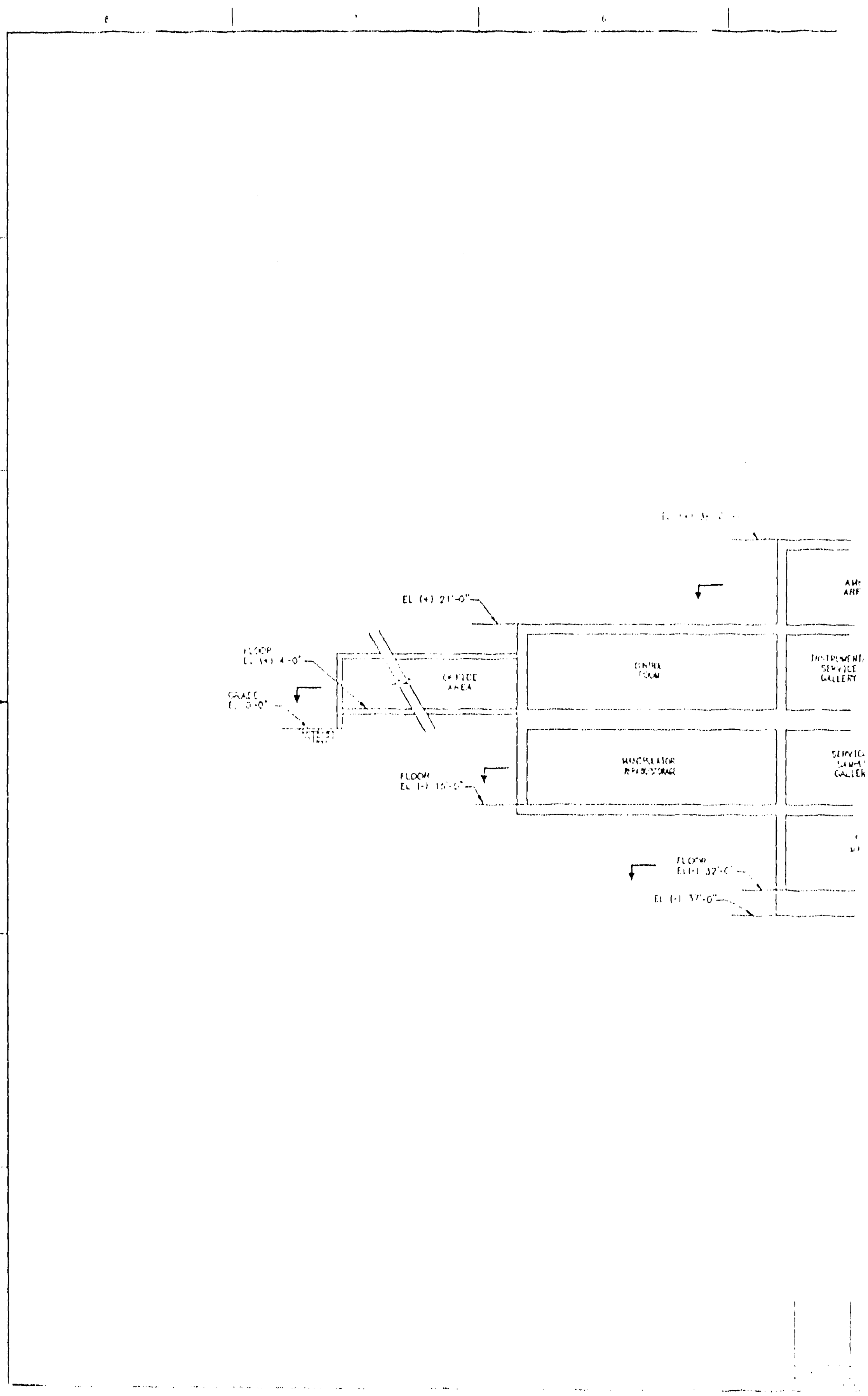
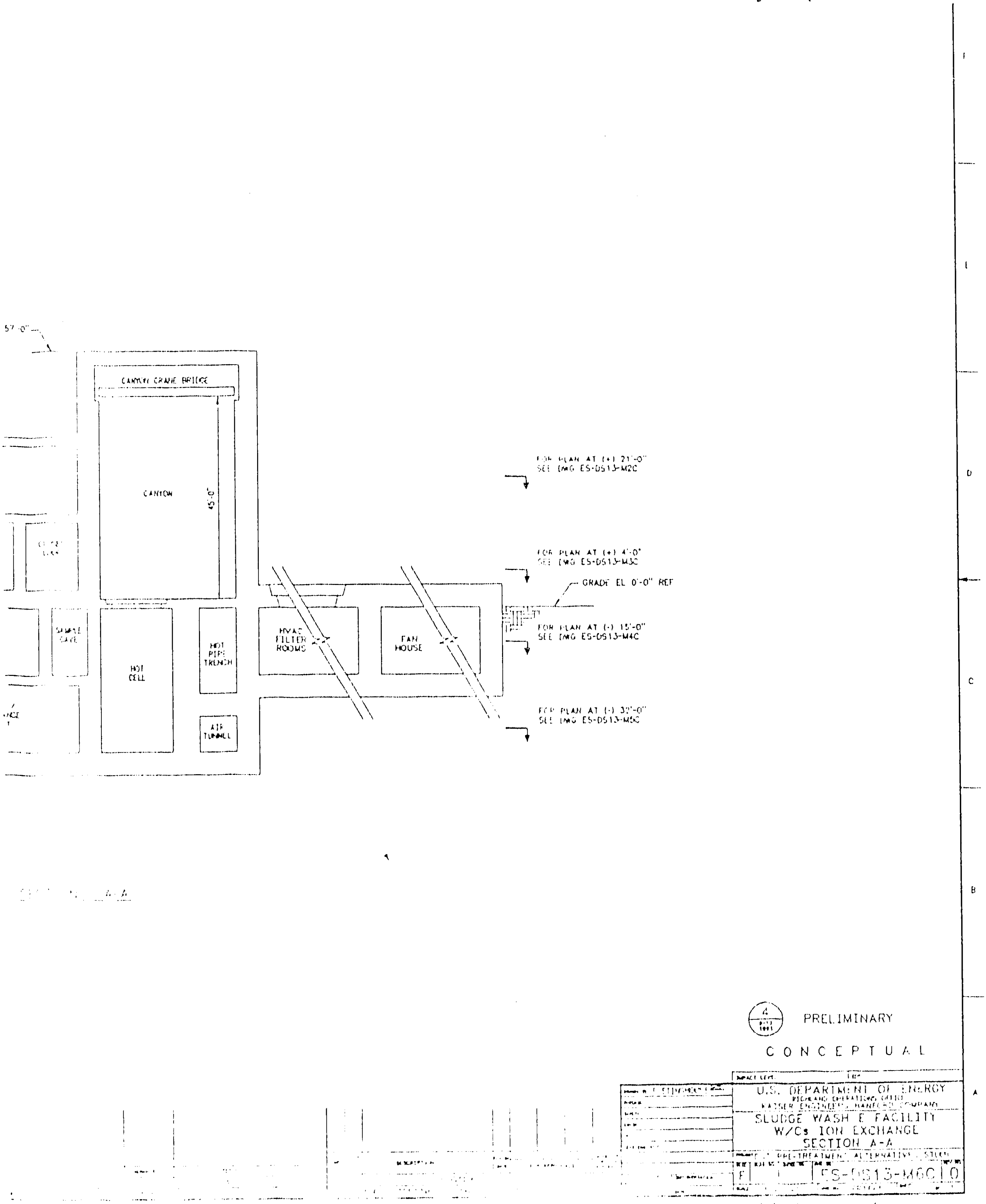


Figure G-2. Sludge Wash E Facility. (sheet 3 of 5)



EL (+) 21'-0"
FLOOR
OFFICE
AREA
INSTRUMENT
SERVICE
GALLERY
FLOOR
EL (+) 15'-0"
FLOOR
EL (+) 32'-0"
EL (+) 37'-0"

Figure G-2. Sludge Wash E Facility. (sheet 4 of 5)



EQUIPMENT NAME	EQUIP ID
SW CENTRIFUGE FEED TANK	TK-2A,B
SW CENTRIFUGE (w HELICAL CONVEYOR)	G-1A,B
SW CENTRIFUGE CATCH TANK	TK-3A,B
SW SOLIDS SLURRY TANK	TK-4
SW SOLIDS SLURRY SAMPLE TANK	TK-5
SW SOLIDS SLURRY TRANSFER TANK	TK-6
SW CENTRATE RECEIVER TANK	TK-7A,B
SW INERTIAL FILTER FEED TANK	TK-8A,B
INERTIAL FILTER	FI-1A,B
SW INERTIAL FILTER CATCH TANK	TK-9A,B
Cs IX SAMPLE TANK	TK-10
1st CYCLE IX FEED TANK	TK-11
SAND FILTER	FS-1
1st CYCLE CESIUM ION EXCHANGE COLUMN	IX-1A,1B, 1C,1D
1st CYCLE Cs IX ACID REGEN FEED TANK	TK-12
1st CYCLE Cs IX CAUSTIC REGEN FEED TANK	TK-13
1st CYCLE IX ELUANT CATCH TANK	TK-14

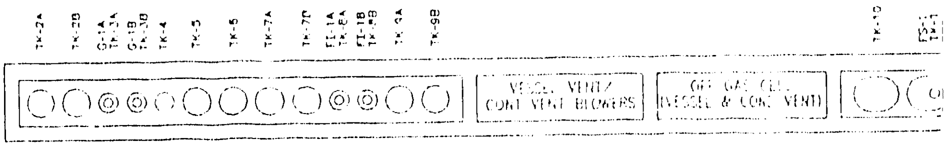
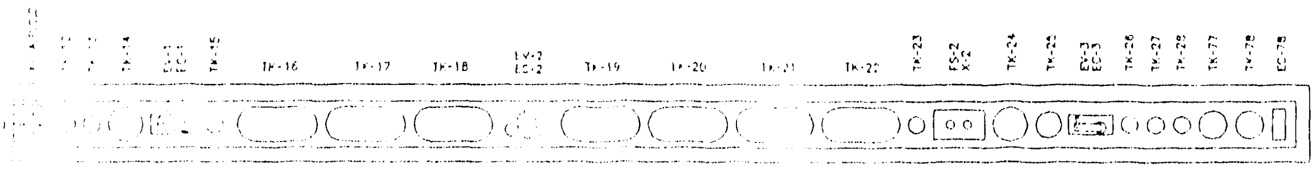


Figure G-2. Sludge Wash E Facility. (sheet 5 of 5)

EQUIPMENT LIST

EQUIPMENT NAME	EQPT ID	EQUIPMENT NAME	EQPT ID
1st CYCLE CESIUM IX CONCENTRATOR	EV-1	2nd CYCLE IX ELUANT CATCH TANK	TK-25
CONDENSER (1st CYCLE)	EC-1	2nd CYCLE CESIUM IX CONCENTRATOR	EV-3
CONCENTRATOR CATCH TANK	TK-15	CONDENSER (2nd CYCLE)	EC-3
1st CYCLE IX WASTE TANK	TK-16	CESIUM CONCENTRATOR CATCH TANK	TK-26
IX WASTE SAMPLE TANK	TK-17	2nd CYCLE CESIUM CONCENTRATE SAMPLE TANK	TK-27
EVAPORATOR FEED TANK FOR CLARIFIED SUPERNATE	TK-18	CESIUM NEUTRALIZATION AND TRANSFER TANK	TK-28
SUPERNATANT EVAPORATOR	EV-2	SUMP COLLECTION AND SAMPLE TANK	TK-77
CONDENSER (SUPERNATANT)	EC-2	ORGANIC DIGEST SAMPLE TANK	TK-78
EVAPORATOR FEED TANK FOR SOLIDS SLURRY AND TANK FARM SEPARATIONS	TK-19	ORGANIC DIGEST CONDENSER	EC-78
EVAPORATOR CATCH TANK	TK-20		
CONCENTRATED SUPERNATANT SAMPLE TANK	TK-21		
SUPERNATANT TRANSFER TANK	TK-22		
PURIFICATION COLUMN FEED TANK	TK-23		
SAND FILTER	FS-2		
2nd CYCLE IX COLUMN	IX-2		
2nd CYCLE IX LOADING WASTE TANK	TK-24		

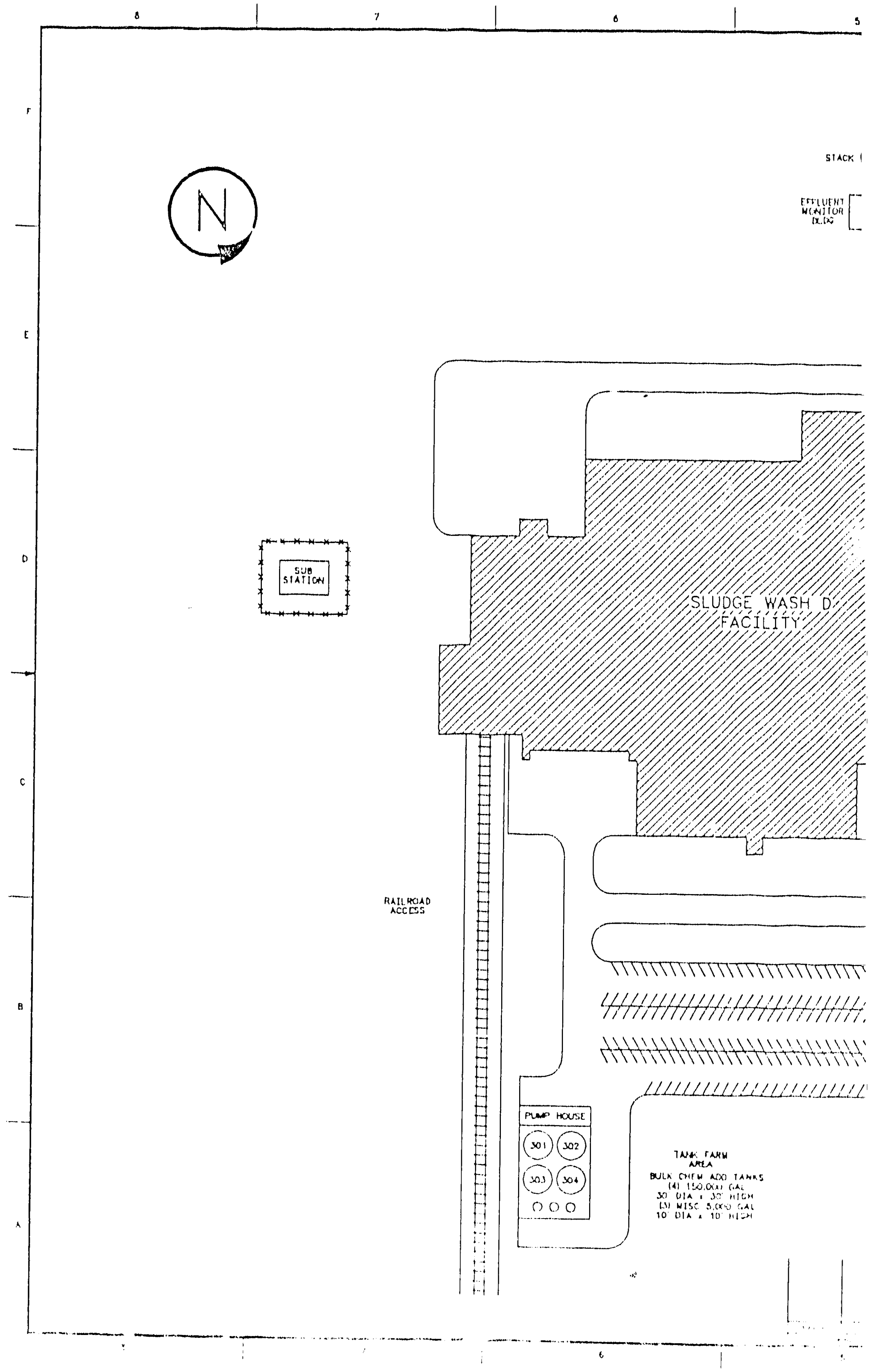


PRELIMINARY

CONCEPTUAL

U.S. DEPARTMENT OF ENERGY

SLUDGE WASH FACILITY
W/Cs ION EXCHANGE
EQUIPMENT LAYOUT



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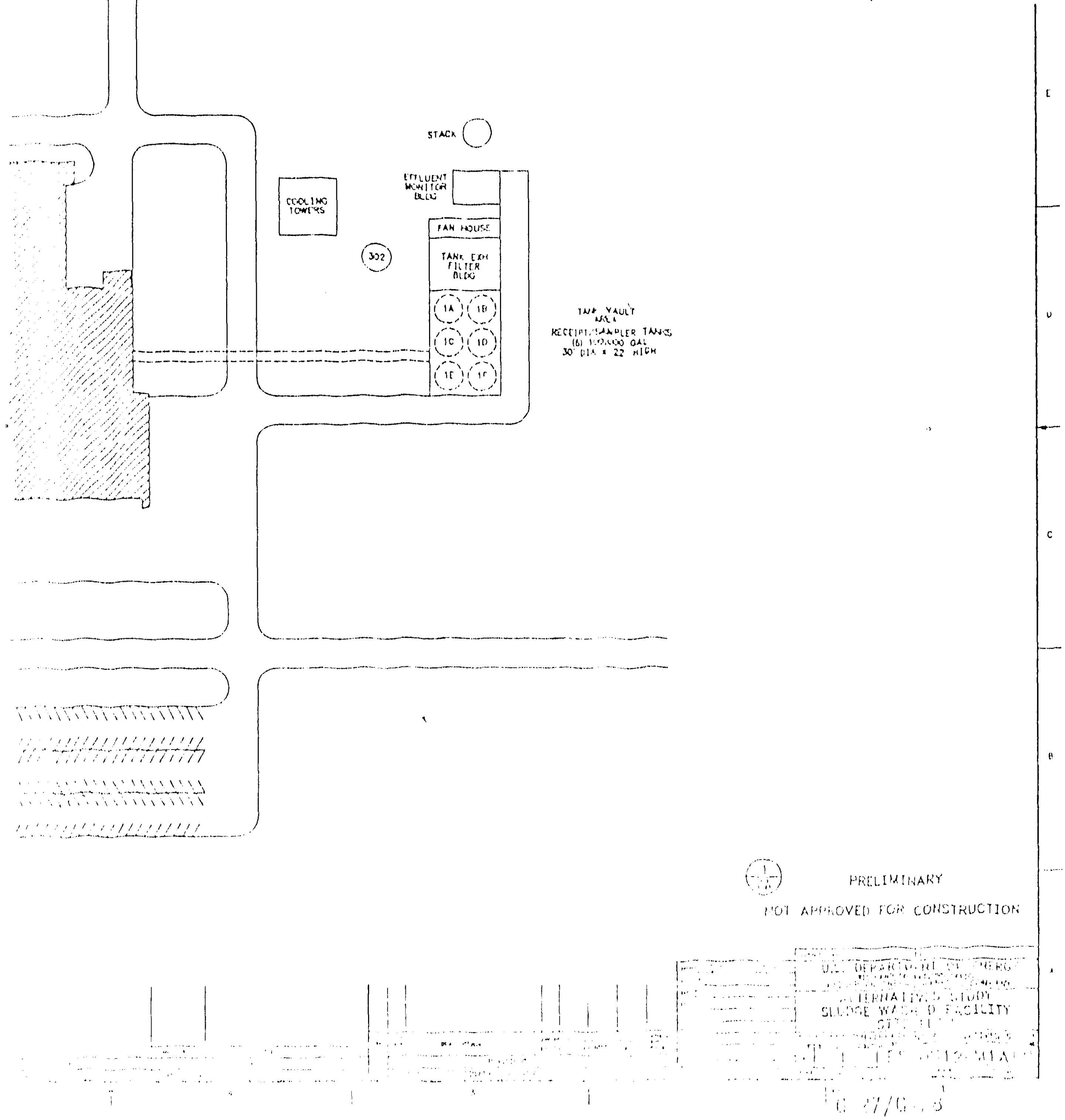
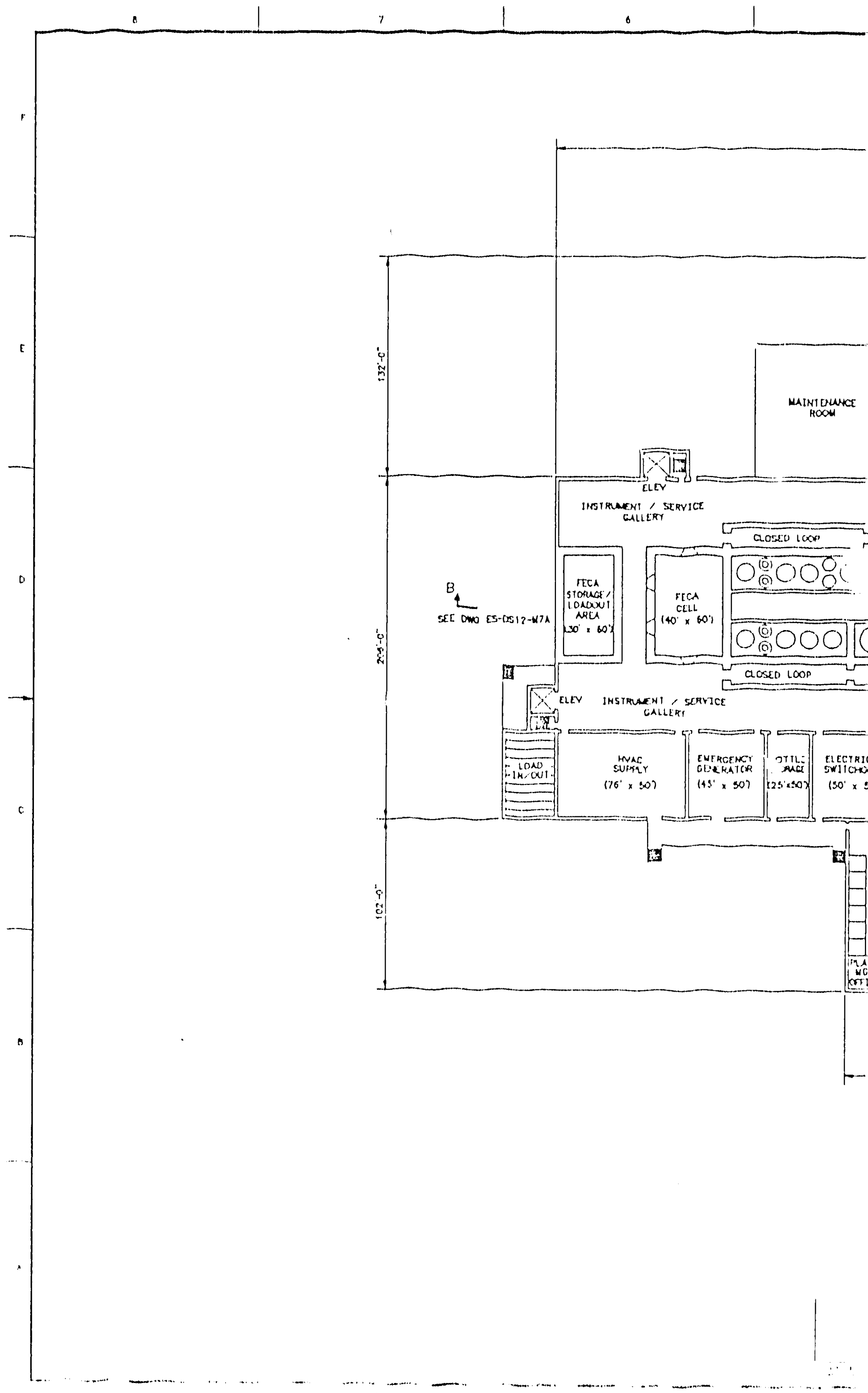
N
STACK
EFFLUENT MONITOR BLDG
SUB STATION
SLUDGE WASH D
FACILITY
RAILROAD ACCESS
PUMP HOUSE
301
302
303
304
TANK FARM AREA
BULK CHEM ADD TANKS
(4) 150,000 GAL
30' DIA x 30' HIGH
(3) MISC 5,000 GAL
10' DIA x 10' HIGH

EQUIPMENT NAME	EQPT ID
RECEIPT/SAMPLE TANK	TK-1A,B, C,D,E,F
BULK NITRIC ACID MAKEUP TANK	TK-301
BULK H2O MAKEUP TANK	TK-302
BULK SODIUM HYDROXIDE MAKEUP TANK	TK-303
BULK H_2O_2 STORAGE TANK	TK-304

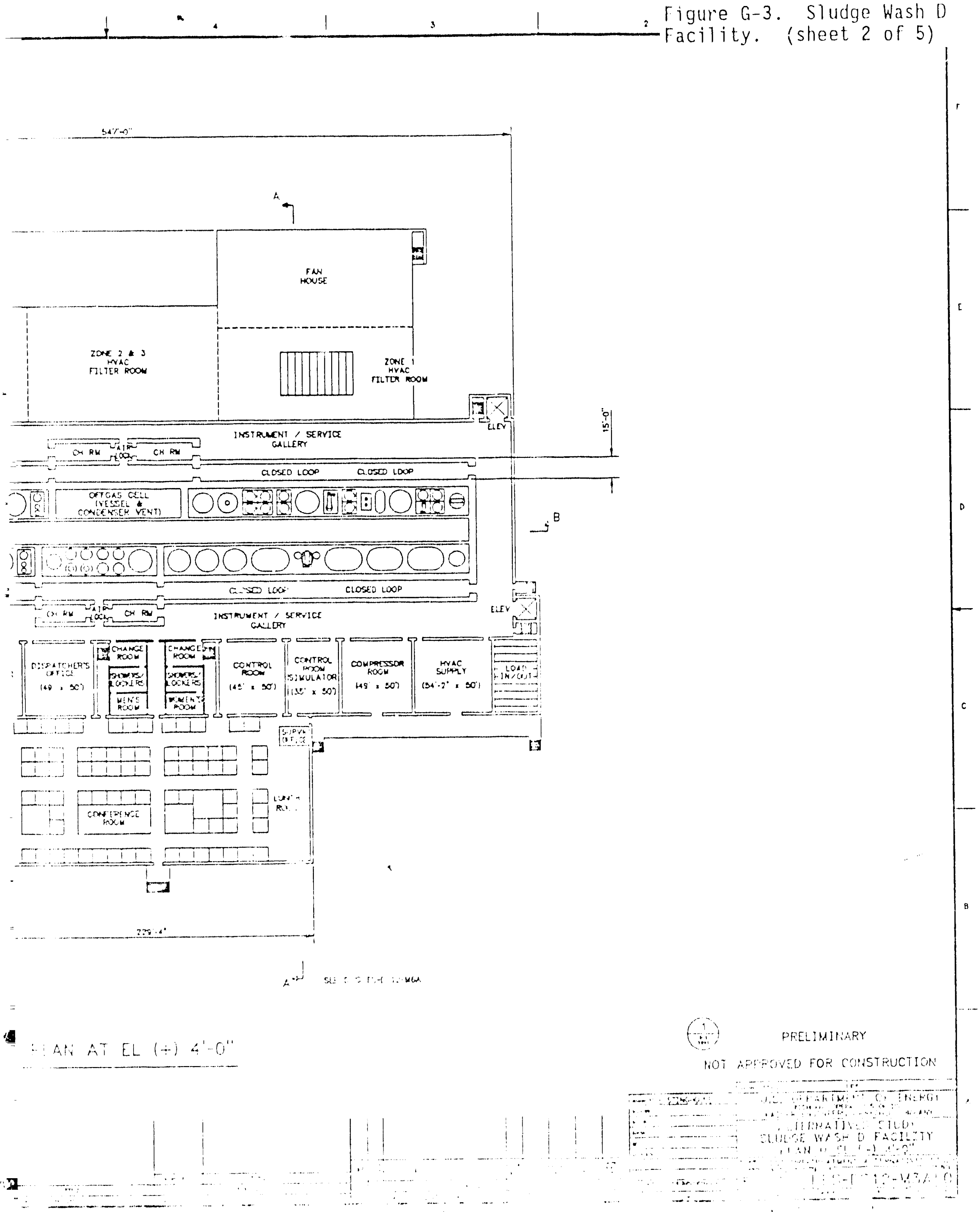
Figure G-3. Sludge Wash D Facility. (sheet 1 of 5)

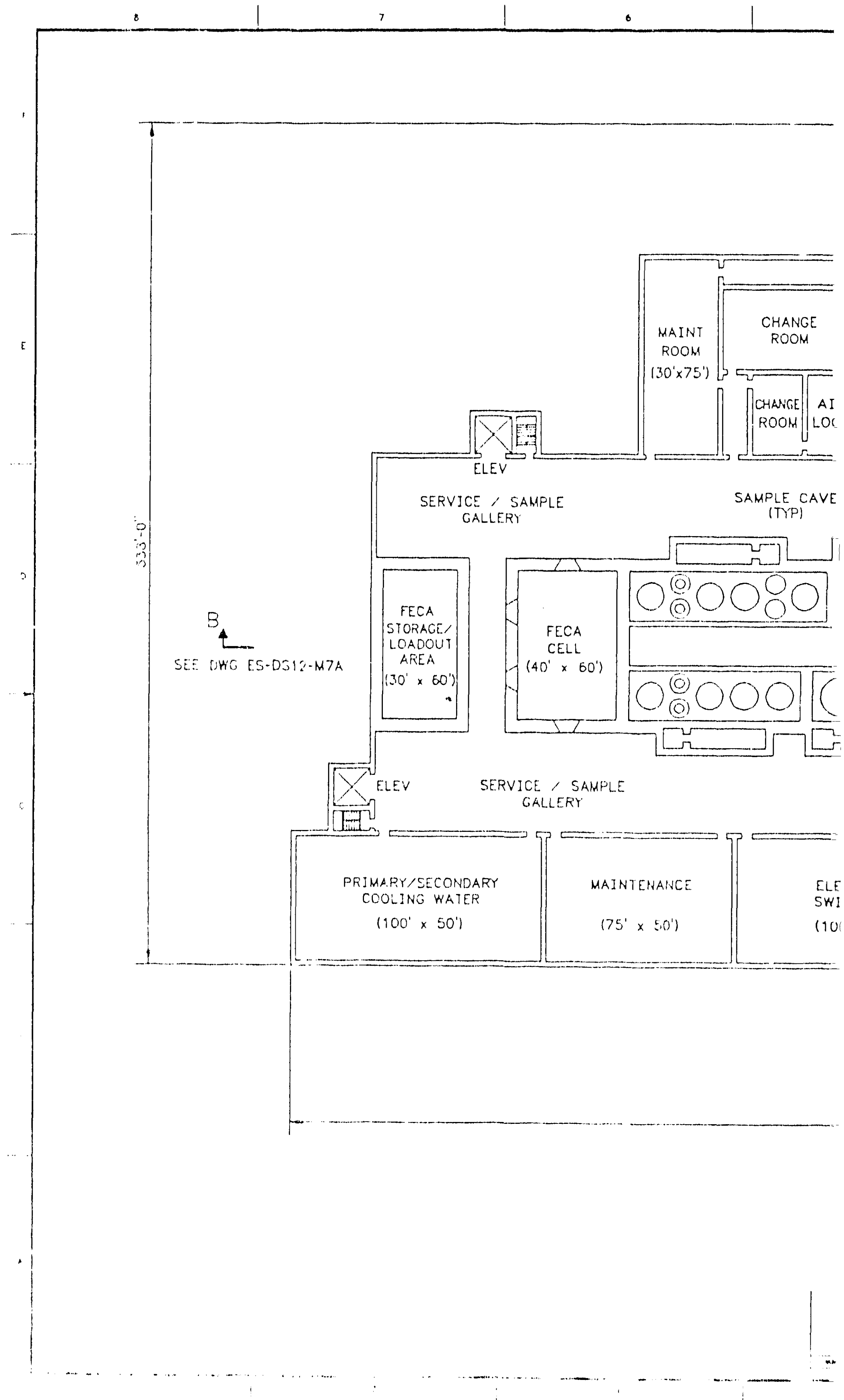




MAINTENANCE ROOM
ELEV
INSTRUMENT / SERVICE GALLERY
CLOSED LOOP
FECA STORAGE/ LOADOUT AREA (30' x 60')
FECA CELL (40' x 60')
B
SEE DWG ES-DS12-M7A
CLOSED LOOP
ELEV
INSTRUMENT / SERVICE GALLERY
LOAD IN/OUT
HVAC SUPPLY (76' x 50')
EMERGENCY GENERATOR (45' x 50')
(25'x50')
ELECTRICA SWITCHGEA (50' x 50'
PLANT MGR OFFICE
132'-0"
102'-0"

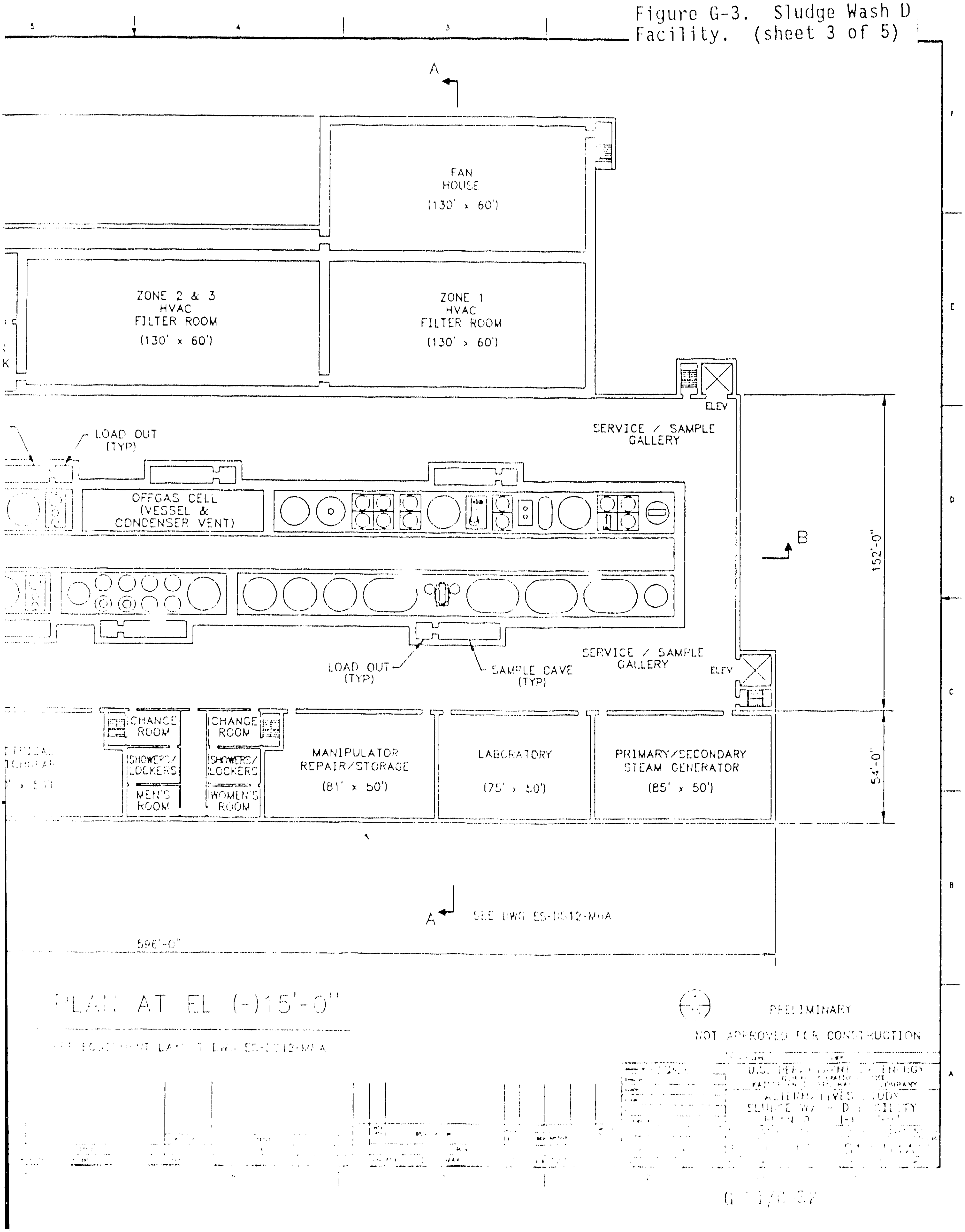
Figure G-3. Sludge Wash D Facility. (sheet 2 of 5)

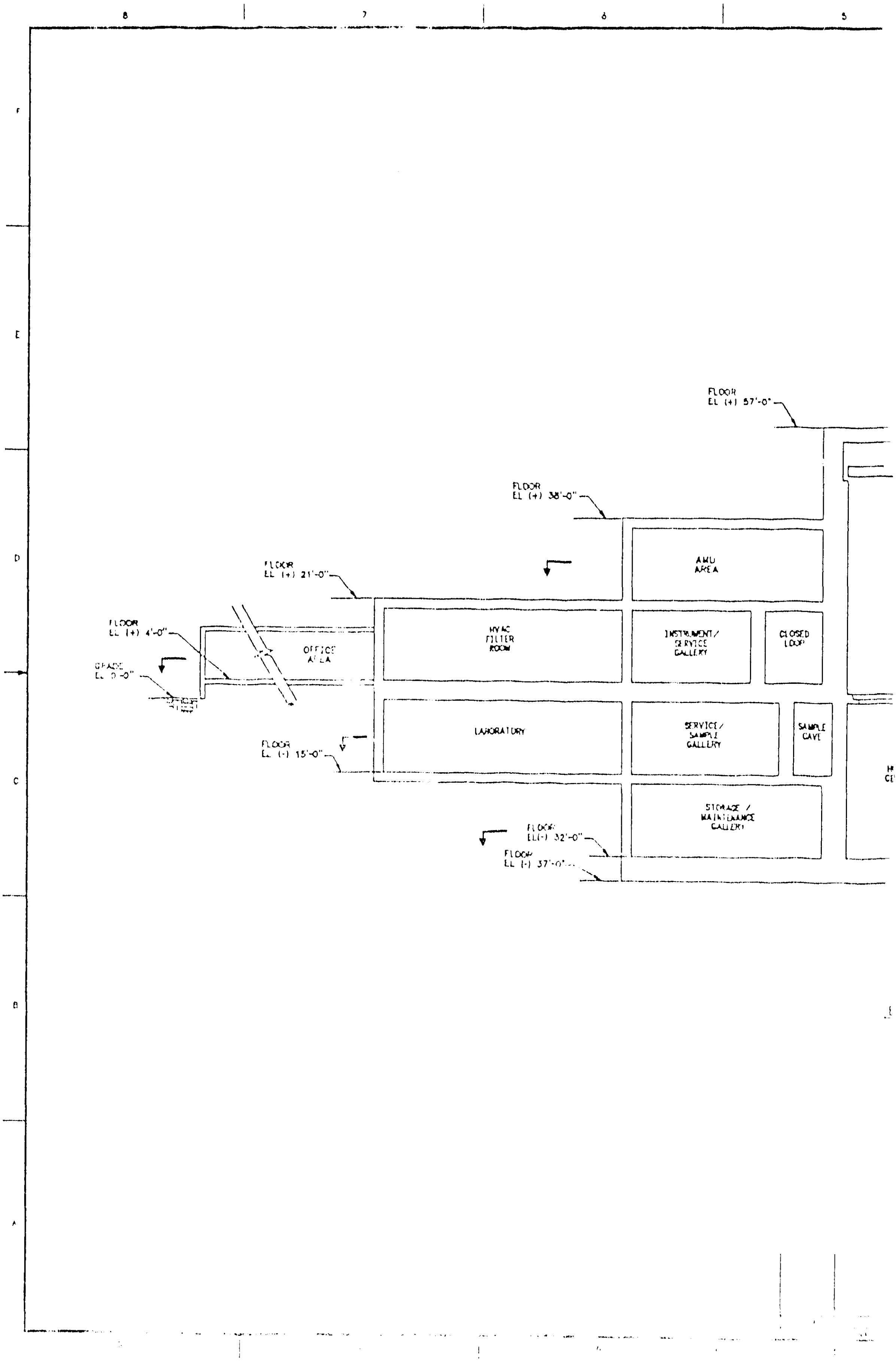




8
7
6
MAINT ROOM (30'x75')
CHANGE ROOM
CHANGE ROOM
ELEV
SERVICE / SAMPLE GALLERY
SAMPLE CAVE (TYP)
333'-0"
B
SEE DWG ES-DS12-M7A
FECA STORAGE/ LOADOUT AREA (30' x 60')
FECA CELL (40' x 60')
ELEV
SERVICE / SAMPLE GALLERY
PRIMARY/SECONDARY COOLING WATER (100' x 50')
MAINTENANCE (75' x 50')

Figure G-3. Sludge Wash D Facility. (sheet 3 of 5)





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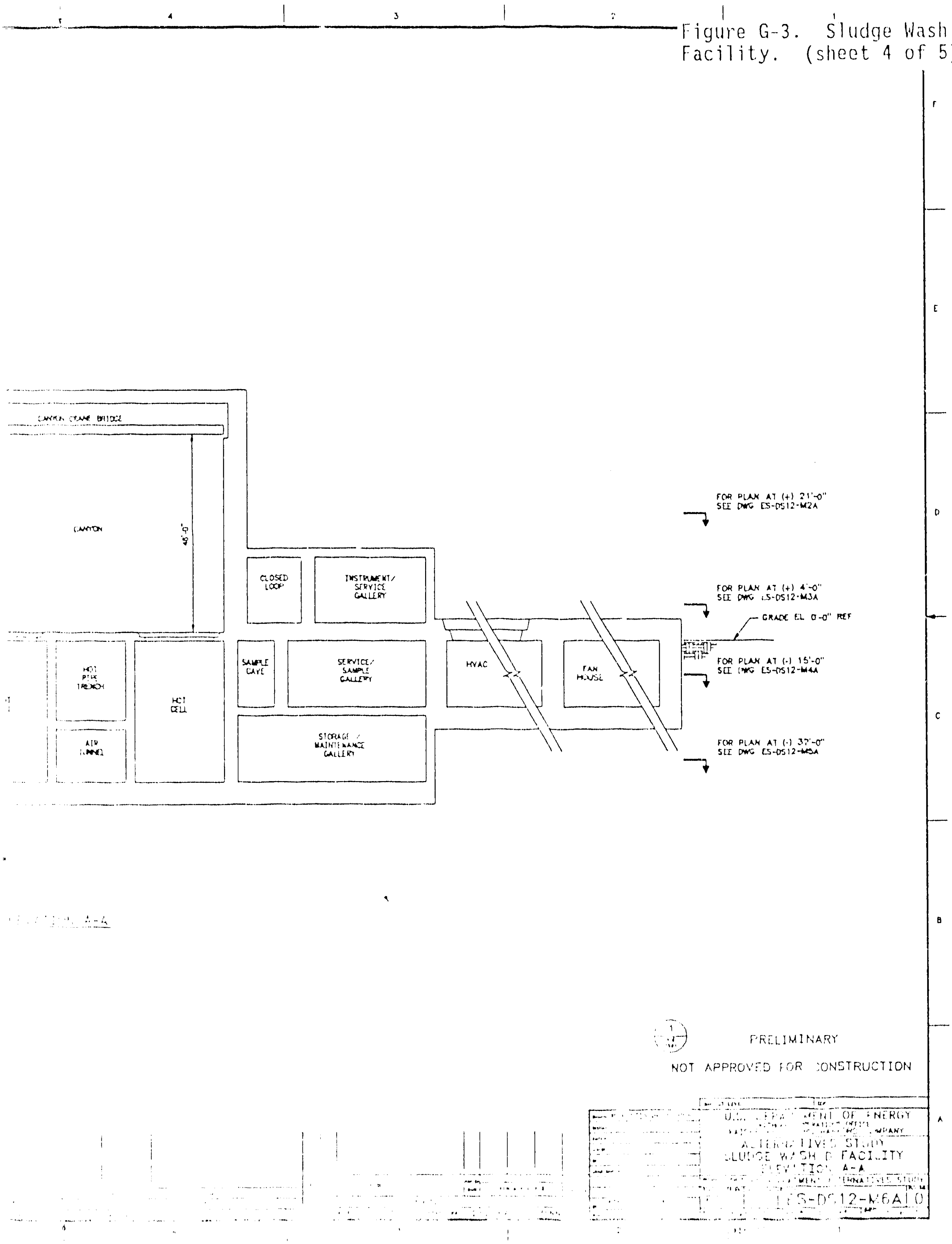
C
B
A
FLOOR
EL (+) 57'-0"
FLOOR
EL (+) 38'-0"
FLOOR
EL (+) 21'-0"
FLOOR
EL (+) 4'-0"
GRADE
EL 0'-0"
AMU
AREA
HVAC
FILTER
ROOM
INSTRUMENT/
SERVICE
GALLERY
CLOSED
LOOP
OFFICE
AREA
LABORATORY
SERVICE/
SAMPLE
GALLERY
SAMPLE
CAVE
FLOOR
EL (-) 15'-0"
STORAGE /
MAINTENANCE
GALLERY
FLOOR
EL(-) 32'-0"
FLOOR
EL (-) 37'-0"

Figure G-3. Sludge Wash D Facility. (sheet 4 of 5)



EQUIPMENT NAME	EQPT ID	EQUIPMENT NAME	EQPT ID	EQUIPMENT NAME
SW CENTRIFUGE FEED TANK	TK-2A,B	1st CYCLE IX FEED TANK	TK-11	IX WASTE SAMPLE TANK
SW CENTRIFUGE (w/ HELICAL CONVEYOR)	G-1A,B	SAND FILTER	FS-1	EVAPORATOR FEED TANK FOR CLARIFIED SUPERNATE
SW CENTRIFUGE CATCH TANK	TK-3A,B	1st CYCLE CESIUM ION-EXCHANGE COLUMN	X-1A,B, C,D	SUPERNATANT EVAPORATOR
SW SOLIDS SLURRY TANK	TK-4	1st CYCLE Cs IX ACID REGEN FEED TANK	TK-12	CONDENSER (SUPERNATANT)
SW SOLIDS SLURRY SAMPLE TANK	TK-5	1st CYCLE Cs IX CAUSTIC REGEN FEED TANK	TK-13	EVAPORATOR FEED TANK FOR SOLIDS SLURRY AND TANK FARM OPERATIONS
SW SOLIDS SLURRY TRANSFER TANK	TK-6	1st CYCLE IX ELUANT CATCH TANK	TK-14	EVAPORATOR CATCH TANK
SW CENTRATE RECEIVER TANK	TK-7A,B	1st CYCLE CESIUM IX CONCENTRATOR	EV-1	CONCENTRATED SUPERNATANT SAMPLE TANK
SW INERTIAL FILTER FEED TANK	TK-8A,B	CONDENSER (1st CYCLE)	[illegible]-1	SUPERNATANT TRANSFER TANK
INERTIAL FILTER	FI-1A,B	CONCENTRATOR CATCH TANK	TK-15	PURIFICATION COLUMN FEED TANK
SW INERTIAL FILTER CATCH TANK	TK-9A,B	1st CYCLE IX WASTE TANK	TK-16	SAND FILTER
Cs IX SAMPLE TANK	TK-10			

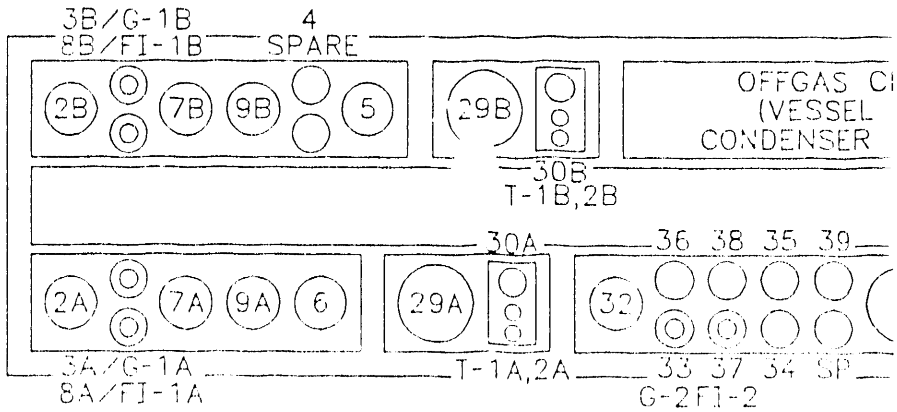
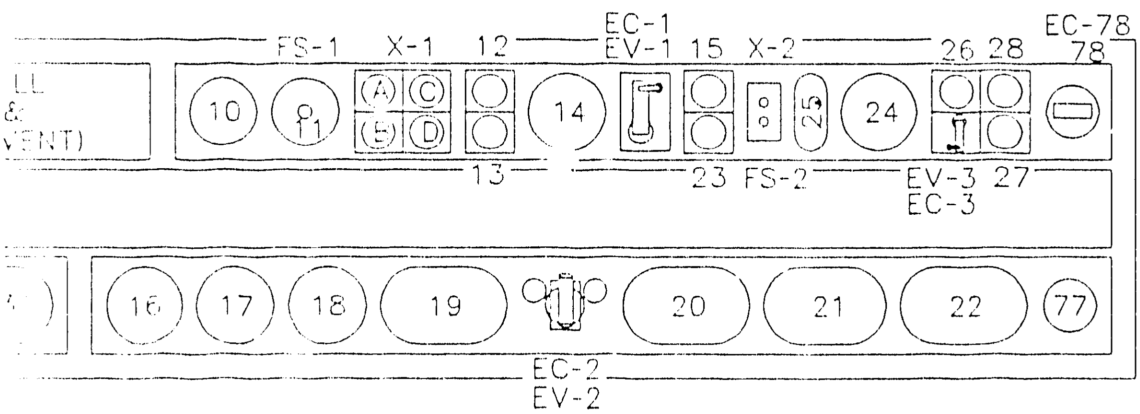


Figure G-3. Sludge Wash D Facility. (sheet 5 of 5)

EQUIPMENT LIST

EQPT ID	EQUIPMENT NAME	EQPT ID	EQUIPMENT NAME	EQPT ID	EQUIPMENT NAME	EQPT ID
TK-17	2nd CYCLE IX COLUMN	X-2	SOLIDS DISSOLVER	TK-29A,B	DISSOLVER SOLIDS SAMPLE TANK	TK-35
TK-18	2nd CYCLE IX LOADING WASTE TANK	TK-24	DOWN DRAFT CONDENSER	T-1A,B	DISSOLVER CENTRATE RECEIVER TANK	TK-36
EV-2	2nd CYCLE IX ELUANT CATCH TANK	TK-25	SCRUBBER	T-2A,B	DISSOLVER FILTER FEED TANK	TK-37
EC-2	2nd CYCLE CESIUM IX CONCENTRATOR	EV-3	SCRUBBER CATCH TANK	TK-30A,B	DISSOLVER INERTIAL FILTER	FI-2
TK-19	CONDENSER (2nd CYCLE)	EC-3	DISSOLVER CATCH/ SAMPLE TANK	TK-31	DISSOLVER IF CATCH TANK	TK-38
TK-20	CESIUM CONCENTRATOR CATCH TANK	TK-26	DISSOLVER NEUTRALIZATION AND CENTRIFUGE TANK	TK-32	DISSOLVER SOLIDS TRANSFER TANK	TK-39
TK-21	2nd CYCLE CESIUM CONCENTRATE SAMPLE TANK	TK-27	DISSOLVER CENTRIFUGE	G-2	SUMP COLLECTION AND SAMPLE TANK	TK-77
TK-22	CESIUM NEUTRALIZATION AND TRANSFER TANK	TK-28	DISSOLVER CENTRIFUGE CATCH TANK	TK-33	ORGANIC DIGEST/SAMPLE TANK	TK-78
TK-23			DISSOLVER SOLIDS SLURRY TANK	TK-34	ORGANIC DIGEST CONDENSER	EC-78
FS-2						



PRELIMINARY

NOT APPROVED FOR CONSTRUCTION

U.S. DEPARTMENT OF ENERGY

KAISER ENGINEERS HANFORD COMPANY

ALTERNATIVES STUDY
SLUDGE WASH D FACILITY
EQUIPMENT LAYOUT

ES-D312-M8A

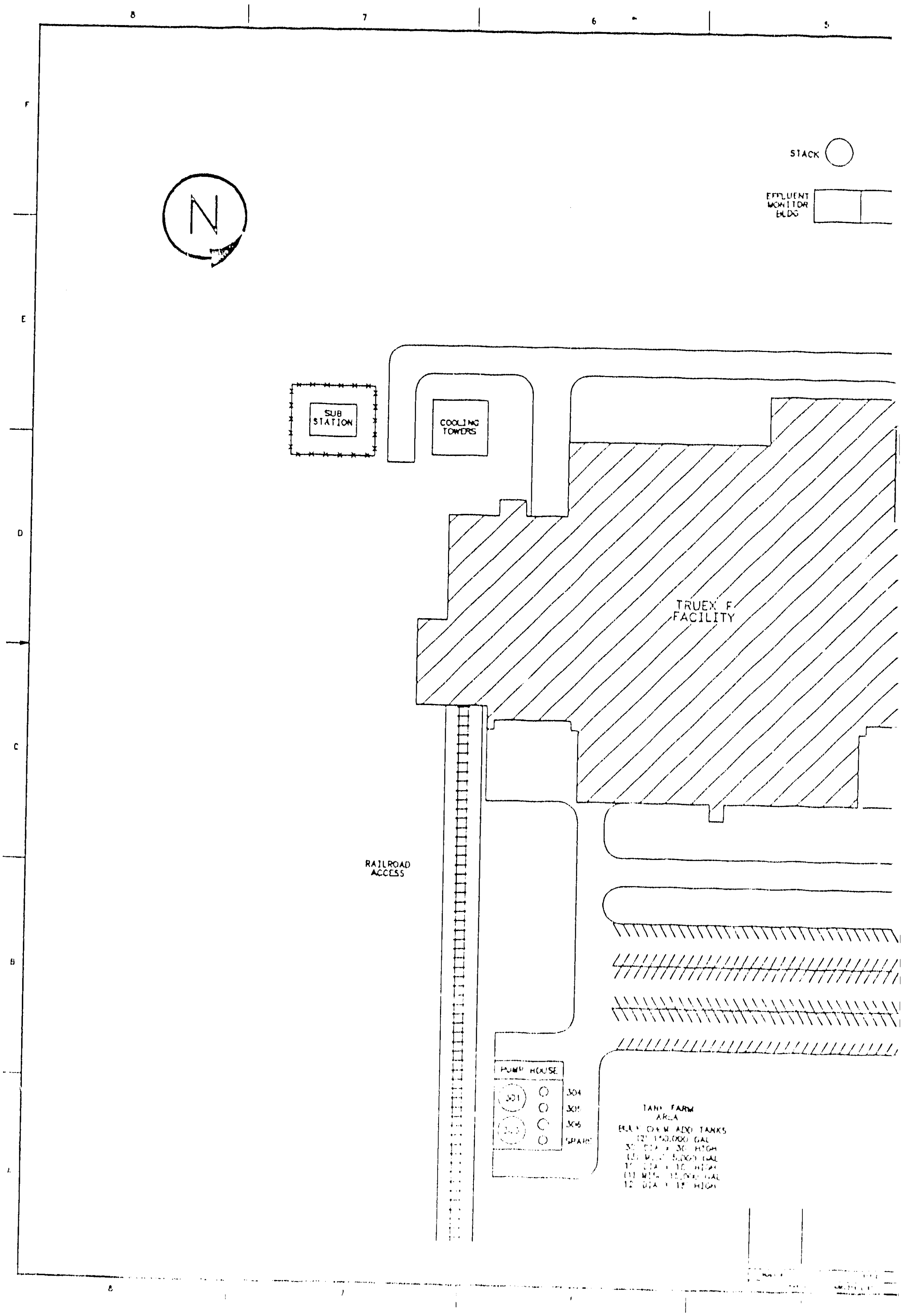
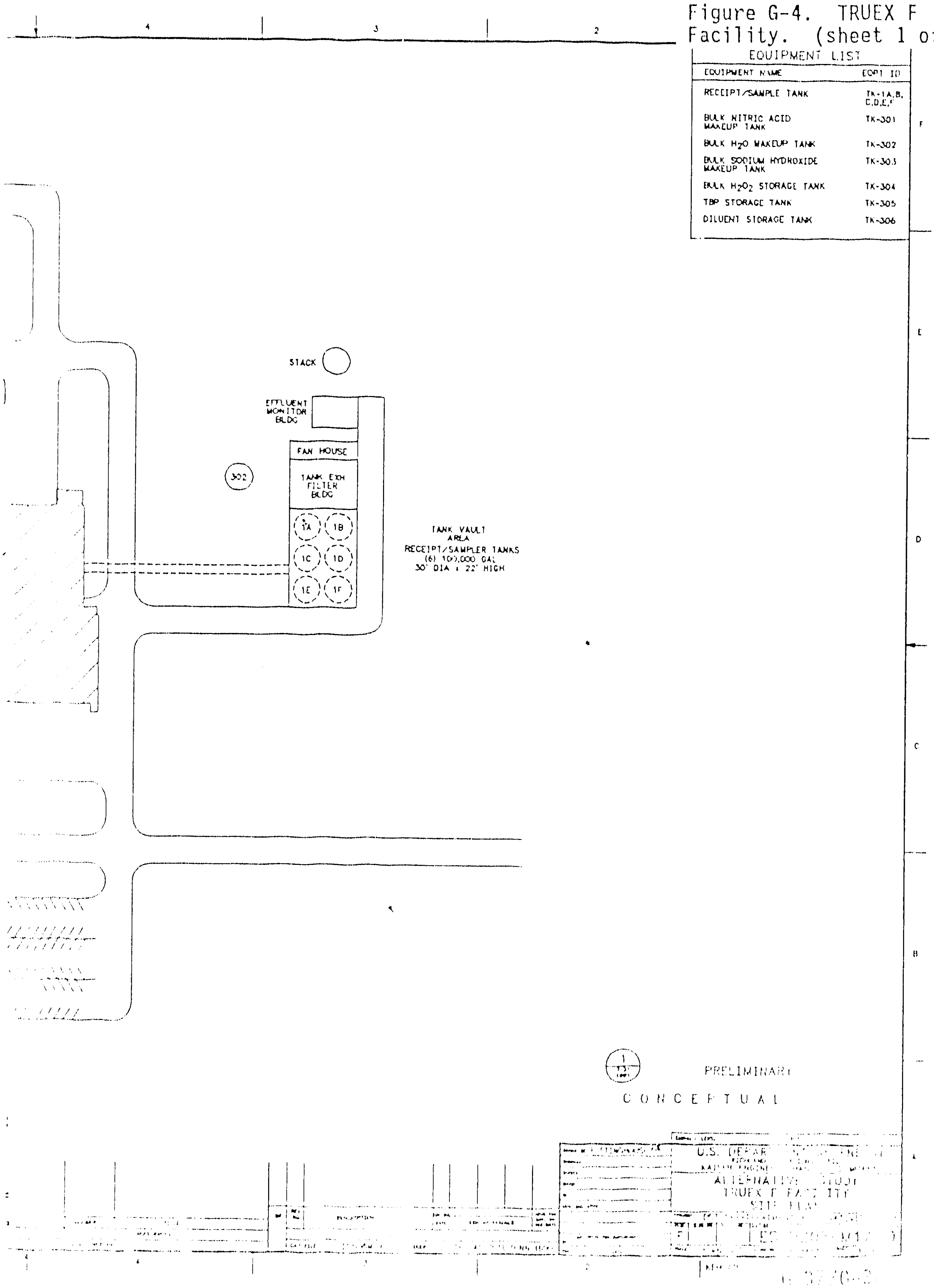
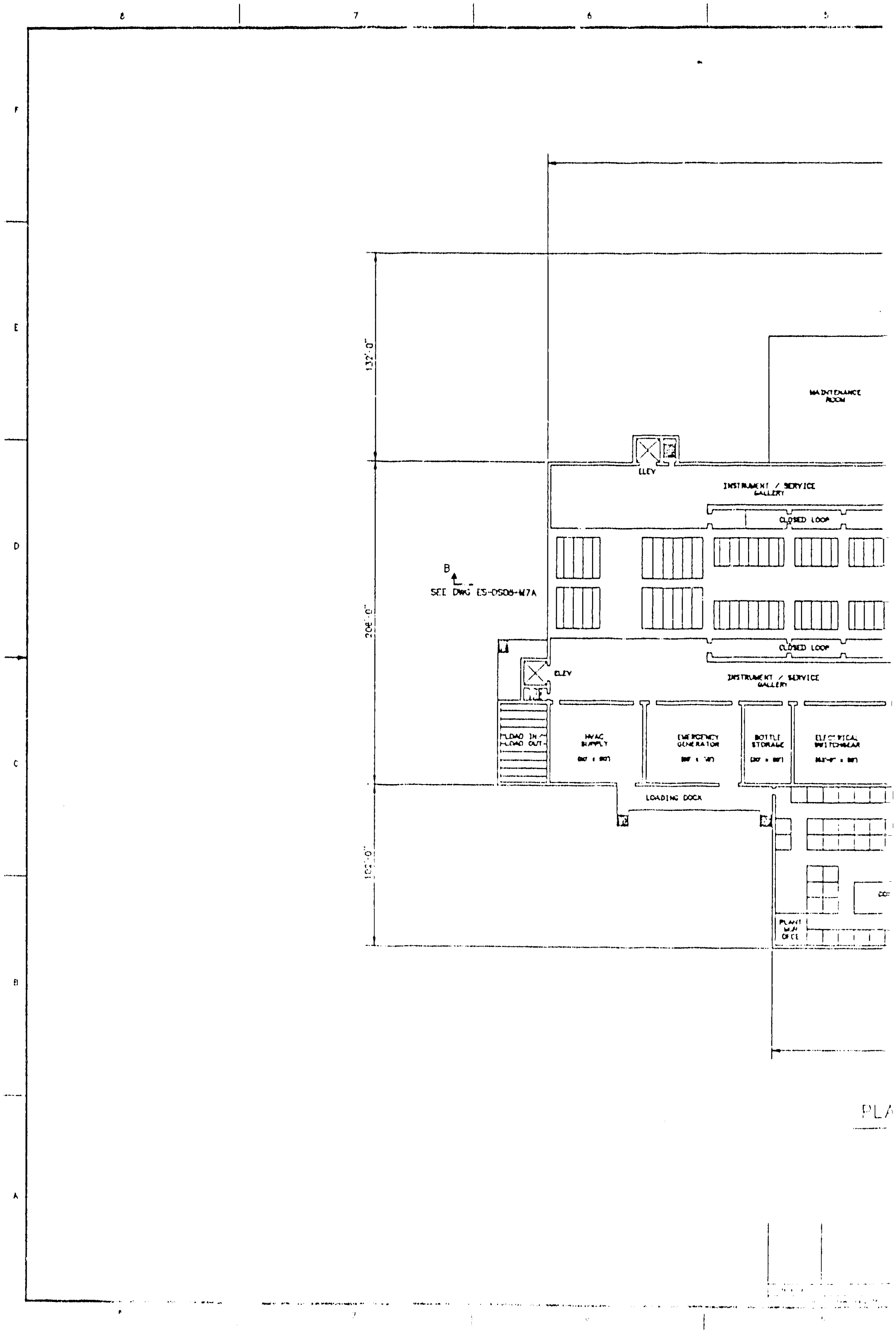

STACK
EFFLUENT MONITOR BLDG
SUB STATION
COOLING TOWERS
TRUEX F FACILITY
RAILROAD ACCESS
PUMP HOUSE
304
306
SPARE

Figure G-4. TRUEX F Facility. (sheet 1 of 5)

EQUIPMENT LIST

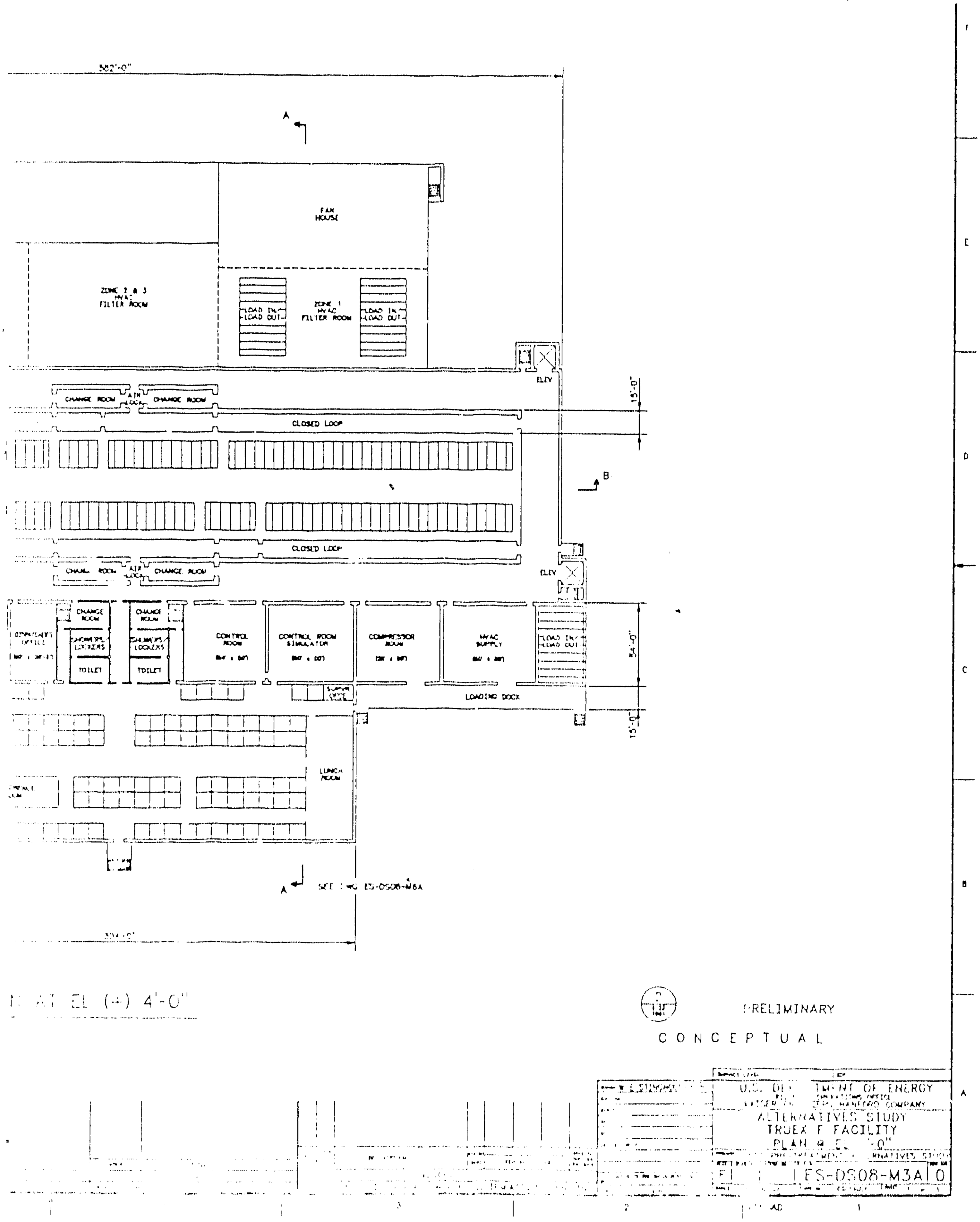
EQUIPMENT NAME	EQPT ID
RECEIPT/SAMPLE TANK	TK-1A,B,C,D,E,F
BULK NITRIC ACID MAKEUP TANK	TK-301
BULK H_2O MAKEUP TANK	TK-302
BULK SODIUM HYDROXIDE MAKEUP TANK	TK-303
BULK H_2O_2 STORAGE TANK	TK-304
TBP STORAGE TANK	TK-305
DILUENT STORAGE TANK	TK-306

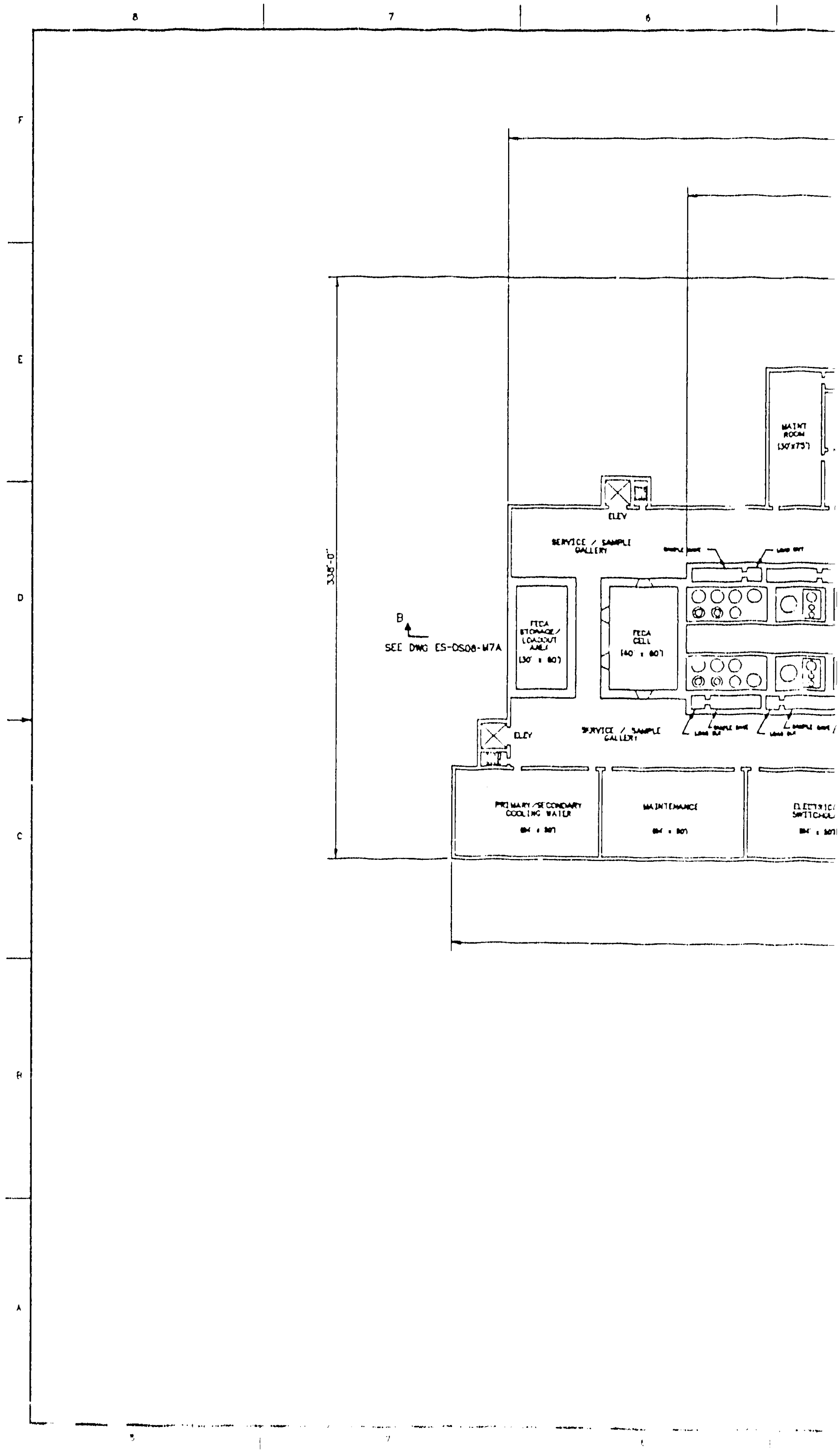




132'-0"
208'-0"
192'-0"
B
SEE DWG ES-DS08-M7A
MAINTENANCE ROOM
ELEV
INSTRUMENT / SERVICE GALLERY
CLOSED LOOP
CLOSED LOOP
ELEV
INSTRUMENT / SERVICE GALLERY
LOAD IN / LOAD OUT
HVAC SUPPLY
EMERGENCY GENERATOR
BOTTLE STORAGE
ELECTRICAL SWITCHGEAR
LOADING DOCK
PLANT MGR OFCE
PLA

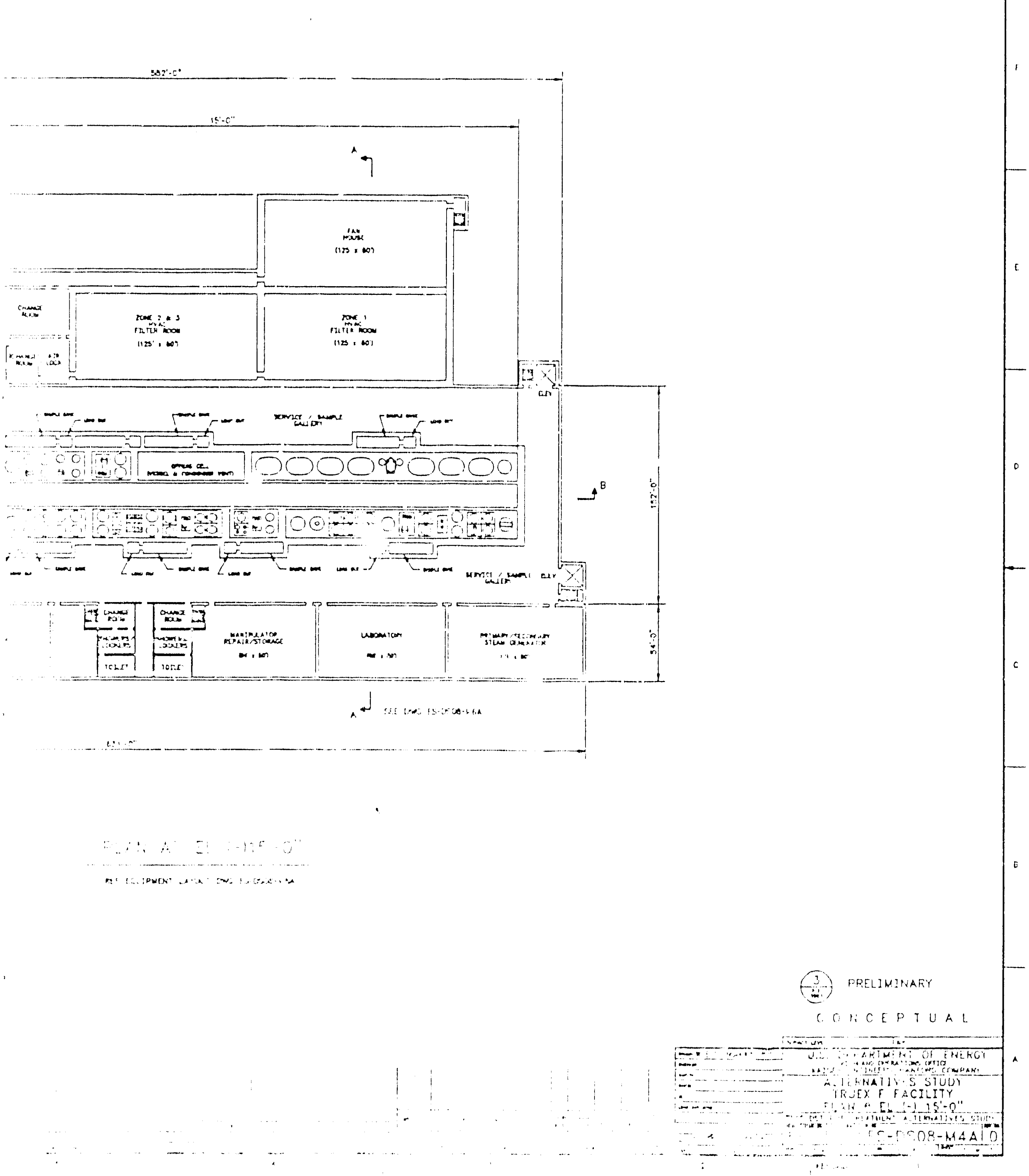
Figure G-4. TRUEX F Facility. (sheet 2 or 5)

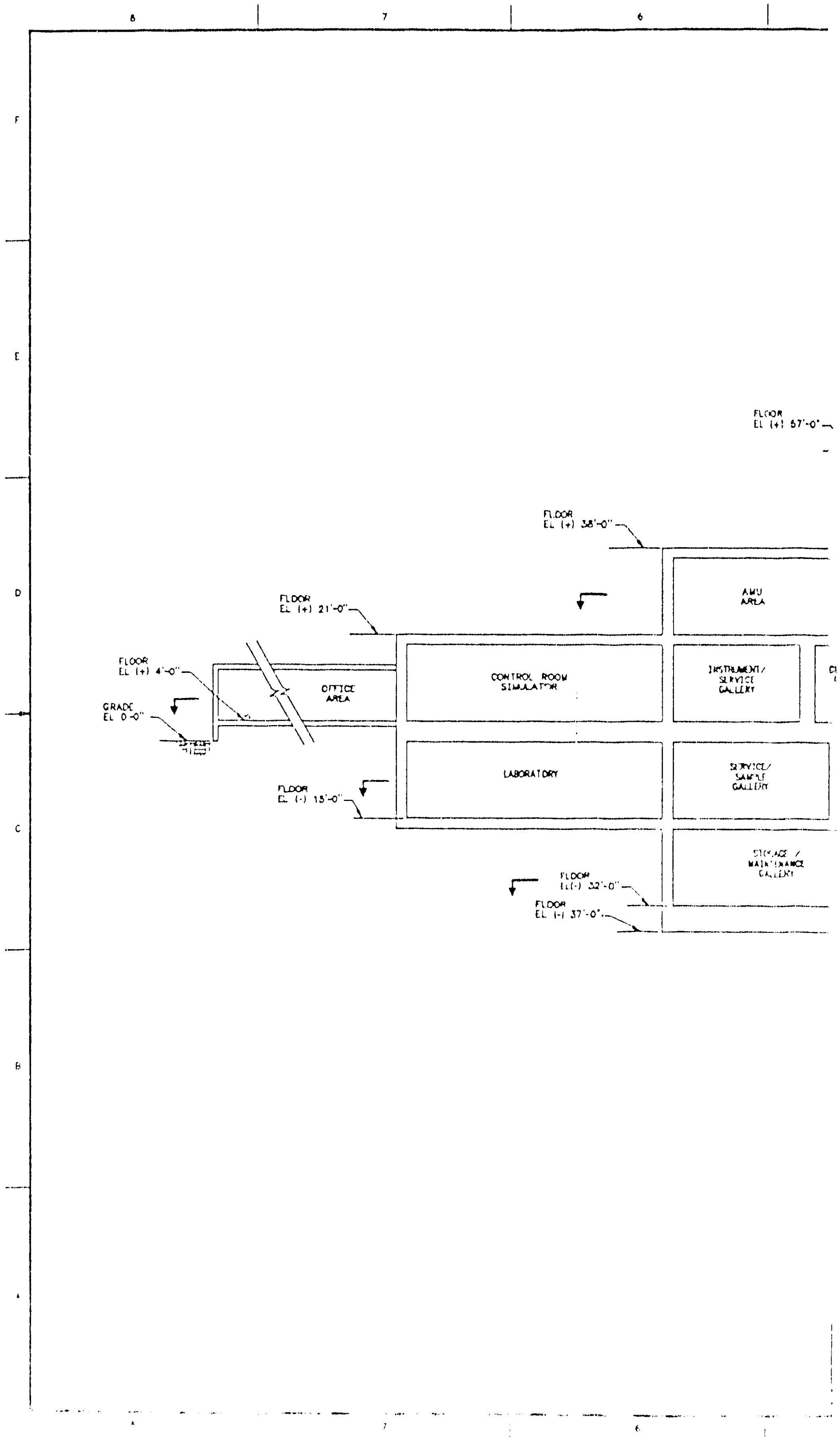




8
7
6
F
E
D
C
B
A
MAINT ROOM (30'x75')
ELEV
SERVICE / SAMPLE GALLERY
FECA STORAGE/ LOADOUT AREA (30' x 80')
FECA CELL (40' x 80')
338'-0"
B
SEE DWG ES-DS08-M7A
ELEV
SERVICE / SAMPLE GALLERY
PRIMARY/SECONDARY COOLING WATER
MAINTENANCE

Figure G-4. TRUEX F Facility. (sheet 3 of 5)





8
7
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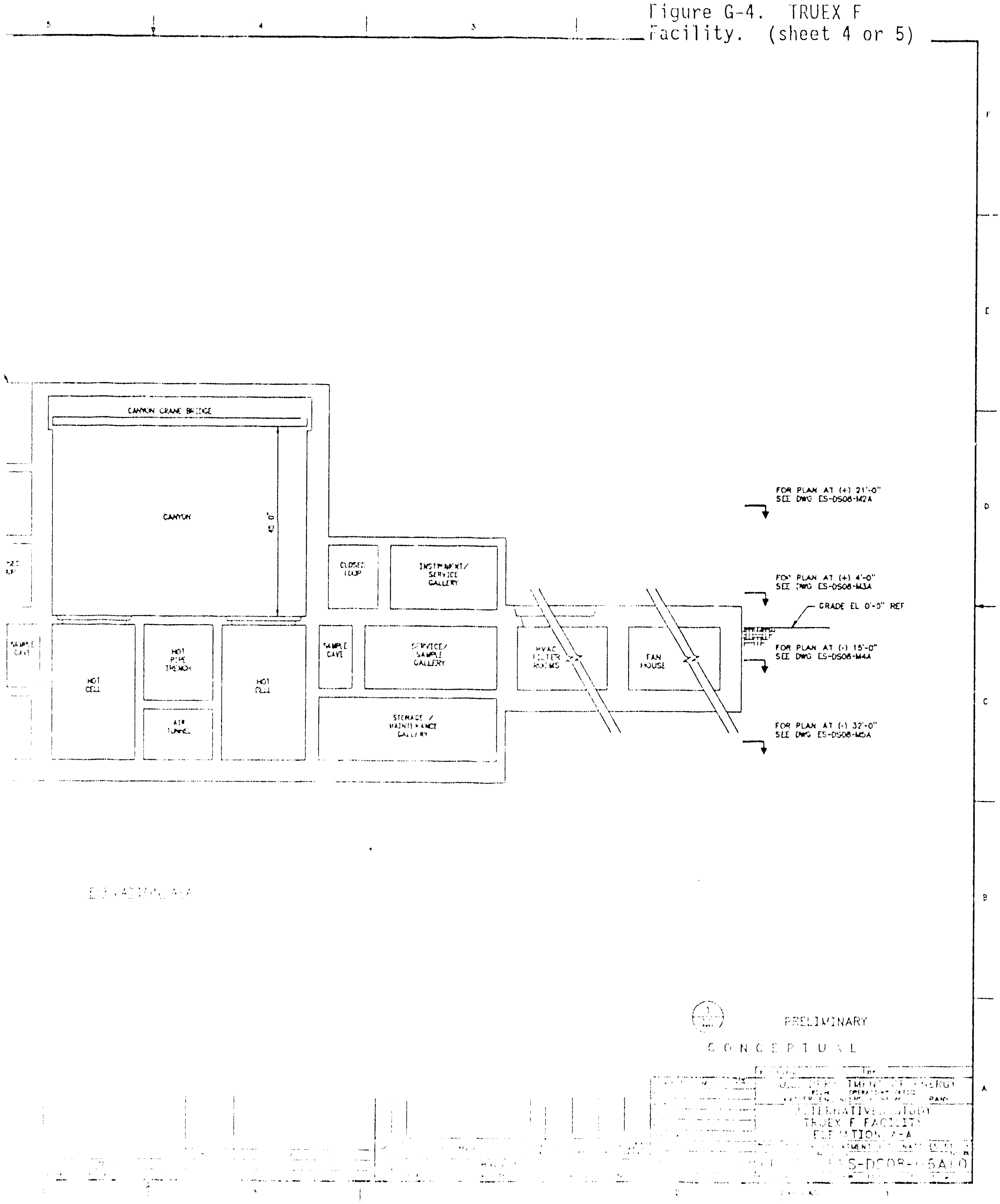
F
E
D
C
B
A
FLOOR
EL (+) 57'-0"
FLOOR
EL (+) 38'-0"
AMU
AREA
FLOOR
EL (+) 21'-0"
FLOOR
EL (+) 4'-0"
GRADE
EL 0'-0"
OFFICE
AREA
CONTROL ROOM
SIMULATOR
INSTRUMENT/
SERVICE
GALLERY
LABORATORY
SERVICE/
SAMPLE
GALLERY
FLOOR
EL (-) 15'-0"
STORAGE /
MAINTENANCE
GALLERY
FLOOR
EL (-) 32'-0"
FLOOR
EL (-) 37'-0"

Figure G-4. TRUEX F Facility. (sheet 4 or 5)



8 | 7 | 6

EQUIPMENT NAME	EQPT ID
SW CENTRIFUGE FEED TANK	TK-2A,B
SW CENTRIFUGE (w/ HELICAL CONVEYOR)	C-1A,B
SW CENTRIFUGE CATCH TANK	TK-3A,B
SW SOLIDS SLURRY TANK	TK-4
SW SOLIDS SLURRY SAMPLE TANK	TK-5
SW SOLIDS SLURRY TRANSFER TANK	TK-6
SW CENTRATE RECEIVER TANK	TK-7A,B
SW INERTIAL FILTER FEED TANK	TK-8A,B
INERTIAL FILTER	FI-1A,B
SW INERTIAL FILTER CATCH TANK	TK-9A,B
Cs IX SAMPLE TANK	TK-10
1st CYCLE IX FEED TANK	TK-11
SAND FILTER	FS-1
1st CYCLE CESIUM ION-EXCHANGE COLUMN	X-1A,1B, 1C,,1D
1st CYCLE Cs IX ACID REGEN FEED TANK	TK-12
1st CYCLE Cs IX CAUSTIC REGEN FEED TANK	TK-13
1st CYCLE IX ELUANT CATCH TANK	TK-14

EQUIPMENT NAME	EQPT ID
1st CYCLE CESIUM IX CONCENTRATOR	EV-1
CONDENSER (1st CYCLE)	EC-1
CONCENTRATOR CATCH TANK	TK-15
1st CYCLE IX WASTE TANK	TK-16
IX WASTE SAMPLE TANK	TK-17
EVAPORATOR FEED TANK FOR CLARIFIED SUPERNATE	TK-18
SUPERNATANT EVAPORATOR	EV-2
CONDENSER (SUPERNATANT)	EC-2
EVAPORATOR FEED TANK FOR SOLIDS SLURRY AND TANK FARM OPERATIONS	TK-19
EVAPORATOR CATCH TANK	TK-20
CONCENTRATED SUPERNATANT SAMPLE TANK	TK-21
SUPERNATANT TRANSFER TANK	TK-22
PURIFICATION COLUMN FEED TANK	TK-23
SAND FILTER	FS-2
2nd CYCLE IX COLUMN	X-2
2nd CYCLE IX LOADING WASTE TANK	TK-24

EQUIPMENT NAME	EQPT ID
2nd CYCLE IX ELUANT CATCH TANK	TK-25
2nd CYCLE CESIUM IX CONCENTRATOR	EV-3
CONDENSER (2nd CYCLE)	EC-3
CESIUM CONCENTRATOR CATCH TANK	TK-26
2nd CYCLE CESIUM CONCENTRATE SAMPLE TANK	TK-27
CESIUM NEUTRALIZATION AND TRANSFER TANK	TK-28
SOLIDS DISSOLVER	TK-29A,B
DOWN DRAFT CONDENSER	T-1A,1B
SCRUBBER	T-2A,2B
SCRUBBER CATCH TANK	TK-30A,B
DISSOLVER CATCH/ SAMPLE TANK	TK-31
DISSOLVER CENTRIFUGE FEED TANK	TK-32
DISSOLVER CENTRIFUGE	G-2
DISSOLVER CENTRIFUGE CATCH TANK	TK-33
DISSOLVER SOLIDS SLURRY TANK	TK-34
DISSOLVER SOLIDS SAMPLE TANK	TK-35

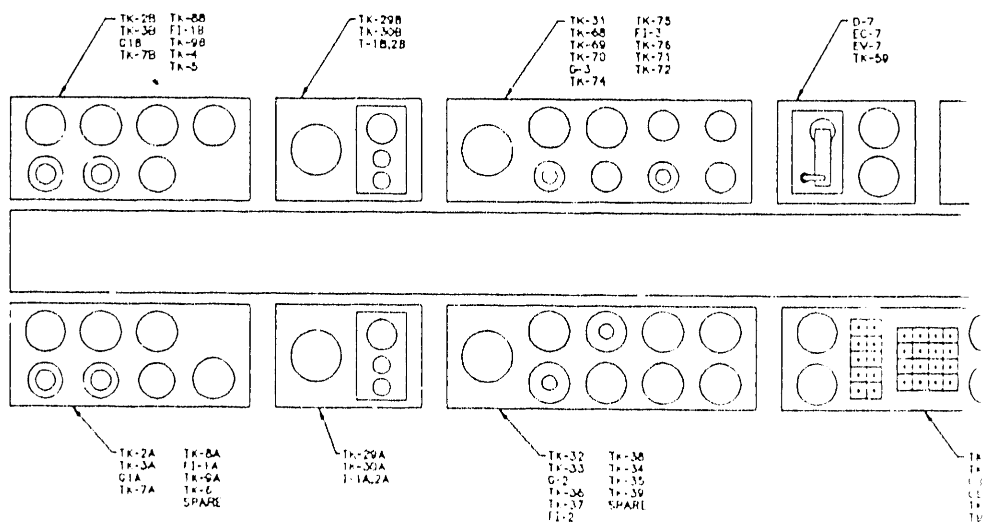
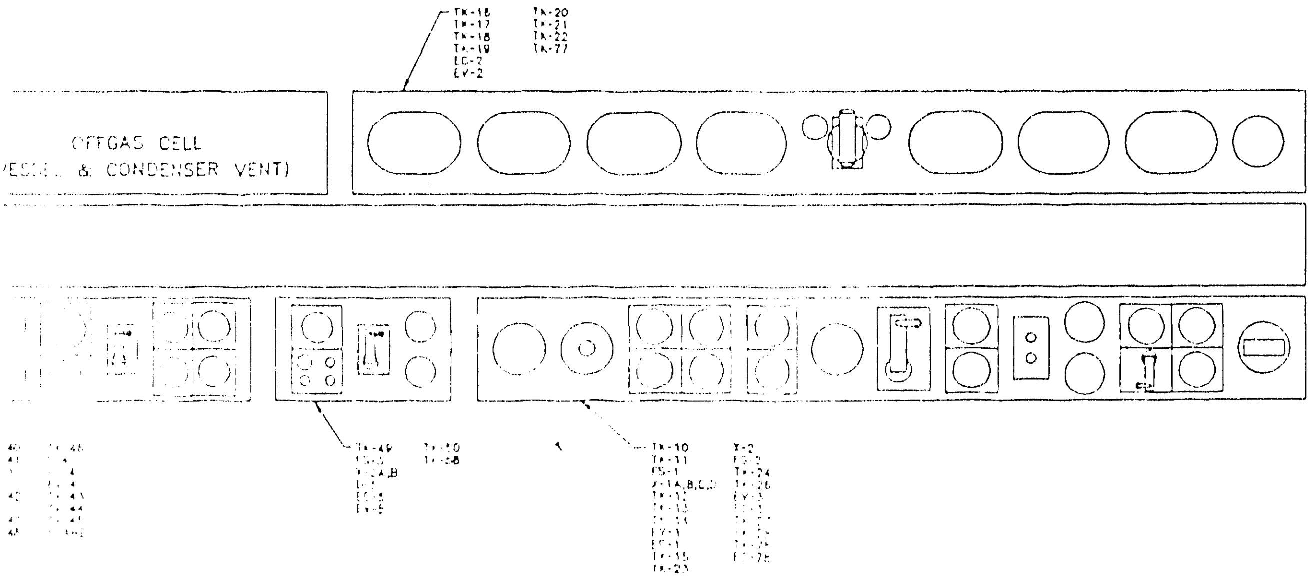


Figure G-4. TRUEX F Facility. (sheet 5 of 5)

EQUIPMENT LIST

EQUIPMENT NAME	EQPT ID	EQUIPMENT NAME	EQPT ID	EQUIPMENT NAME	EQPT ID
DISSOLVER CENTRATE RECEIVER TANK	TK-36	TRUEX SOLVENT FEED TANK	TK-47	TRUEX WASTE CENTRIFUGE CATCH TANK	TK-70
DISSOLVER FILTER FEED TANK	TK-37	Tc RECOVERY FEED TANK	TK-48	TRUEX SOLIDS WASTE SAMPLE TANK	TK-71
DISSOLVER INERTIAL FILTER	FI-2	SAND FILTER	FS-3	TRUEX WASTE TRANSFER TANK	TK-72
DISSOLVER IF CATCH TANK	TK-38	SORPTION/REGENERATION	IX-3A,B	SPARE	TK-73
TRUEX FEED ADJUSTMENT TANK	TK-39	Tc ELUANT TANK	TK-49	TRUEX CENTRATE RECEIVER TANK	TK-74
TRUEX FEED TANK	TK-40	U WASTE CONCENTRATOR	EV-5	TRUEX FILTER FEED TANK	TK-75
TRUEX RAFFINATE TANK	TK-41	CONDENSER (URANIUM)	EC-5	TRUEX INERTIAL FILTER	FI-3
TRU EXTRACTION/SCRUB 6/4 CONTACTORS	CB-1	DECANTER	D-5	TRUEX IF CATCH TANK	TK-76
TRU STRIP (U-Tc STRIP/Sr STRIP 6/6/4 CONTACTORS	CB-2	U WASTE SAMPLE TANK	TK-50	SUMP COLLECTION AND SAMPLE TANK	TK-77
TRU/Tc CONCENTRATOR	EV-4	U WASTE NEUTRALIZATION & TRANSFER TANK	TK-58	ORGANIC DIGEST/SAMPLE TANK WITH HEATING COIL	TK-78
CONDENSER (TRU/Tc)	EC-4	TRUEX RAFFINATE CONCENTRATOR	EV-7	ORGANIC DIGEST CONDENSER	EC-78
DECANTER	D-4	TRUEX RAFFINATE CONDENSER	EC-7		
TRU/Tc CONCENTRATE CATCH TANK	TK-43	TRUEX DECANTER	D-7		
TRU/Tc SAMPLE TANK	TK-44	TRUEX RAFFINATE WASTE CONCENTRATE RECEIVER	TK-59		
TRU/Tc NEUTRALIZATION & TRANSFER TANK	TK-45	TRUEX WASTE CONCENTRATE SAMPLE TANK	TK-67		
TRUEX TURBO MIXER TANK	TM-1	TRUEX WASTE NEUTRALIZATION TANK	TK-68		
TRUEX WASH RAFFINATE SAMPLE TANK	TK-46	TRUEX WASTE CENTRIFUGE FEED TANK	TK-69		
		TRUEX WASTE CENTRIFUGE	G-3		



PRELIMINARY

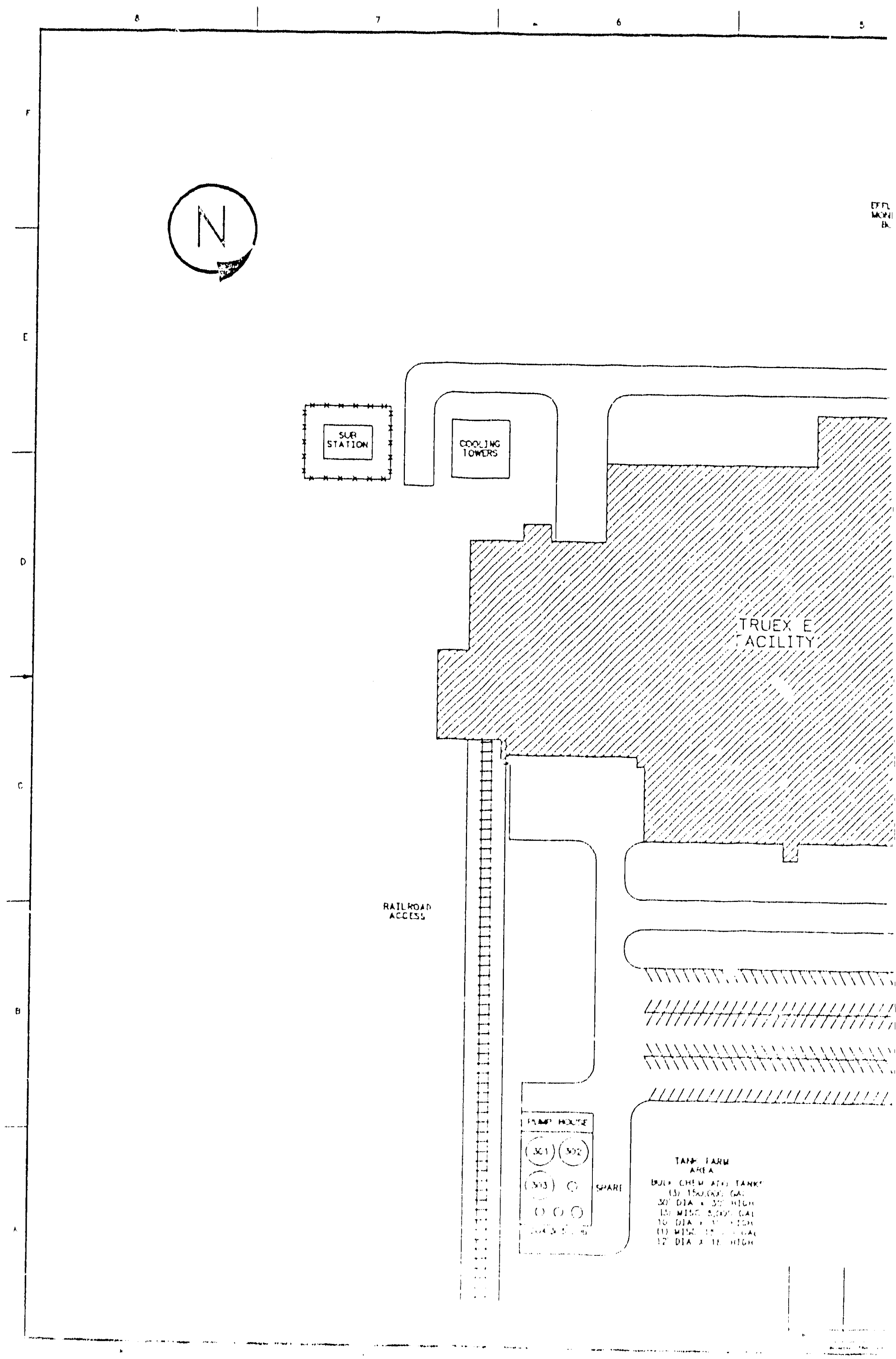
CONCEPTUAL

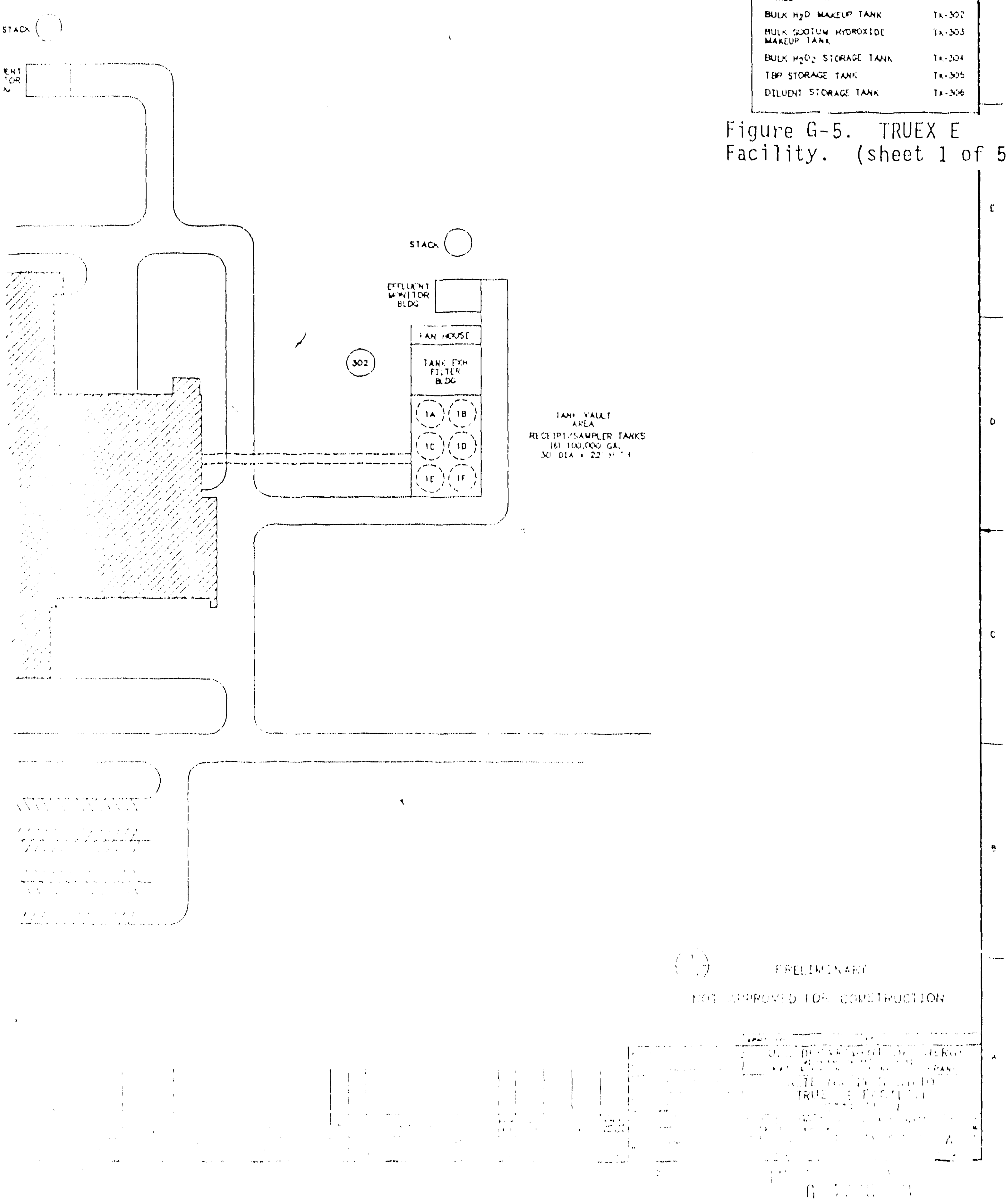
U.S. DEPARTMENT OF ENERGY

KAISER ENGINEERS HANFORD COMPANY

ALTERNATIVES STUDY TRUEX FACILITY LAYOUT

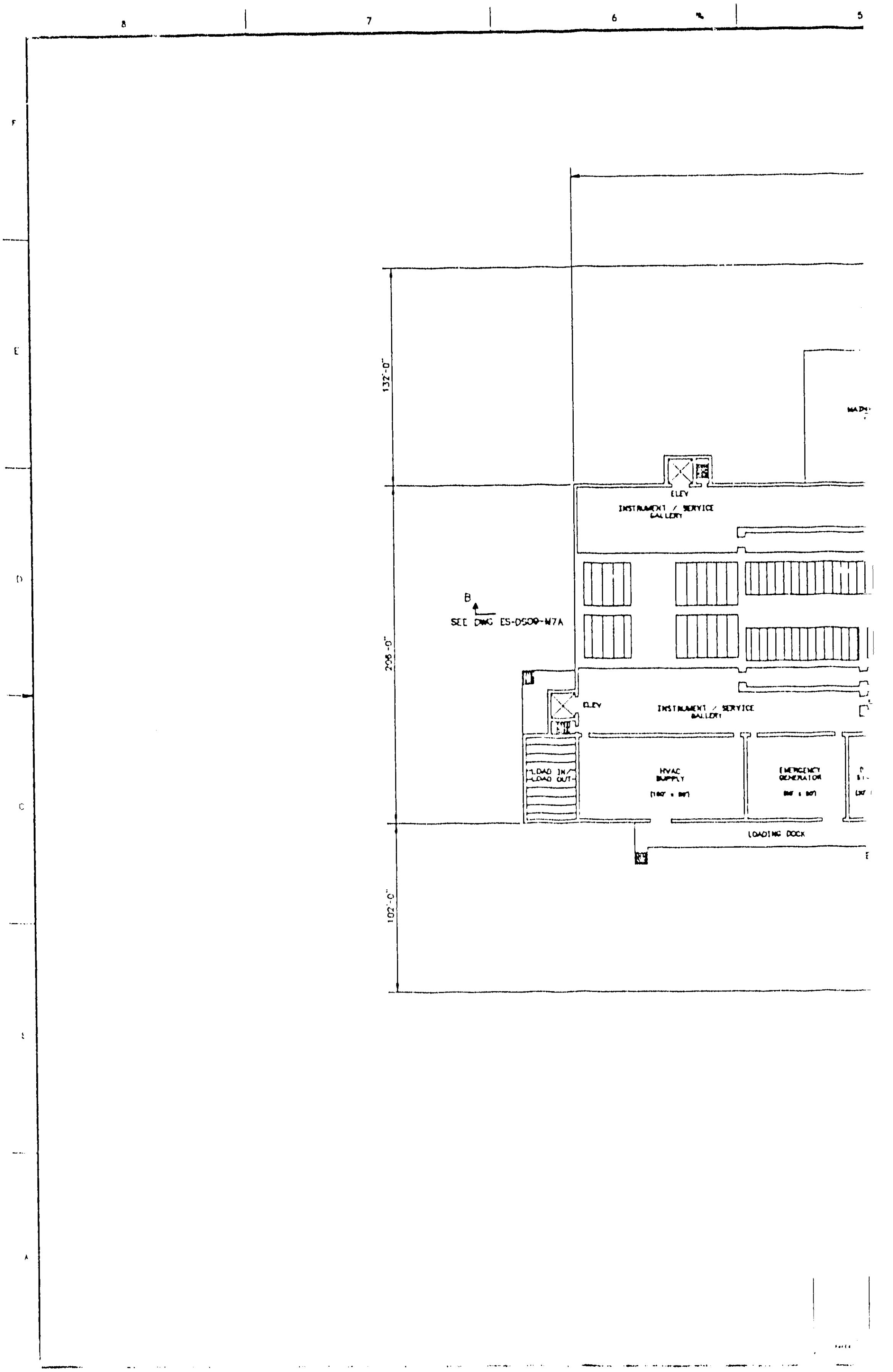
08-M8A 0


8
7
6
5
F
E
D
C
B
A
N
SUB STATION
COOLING TOWERS
TRUEX E
FACILITY
RAILROAD ACCESS
PUMP HOUSE
301
302
303
SPARE
TANK FARM AREA



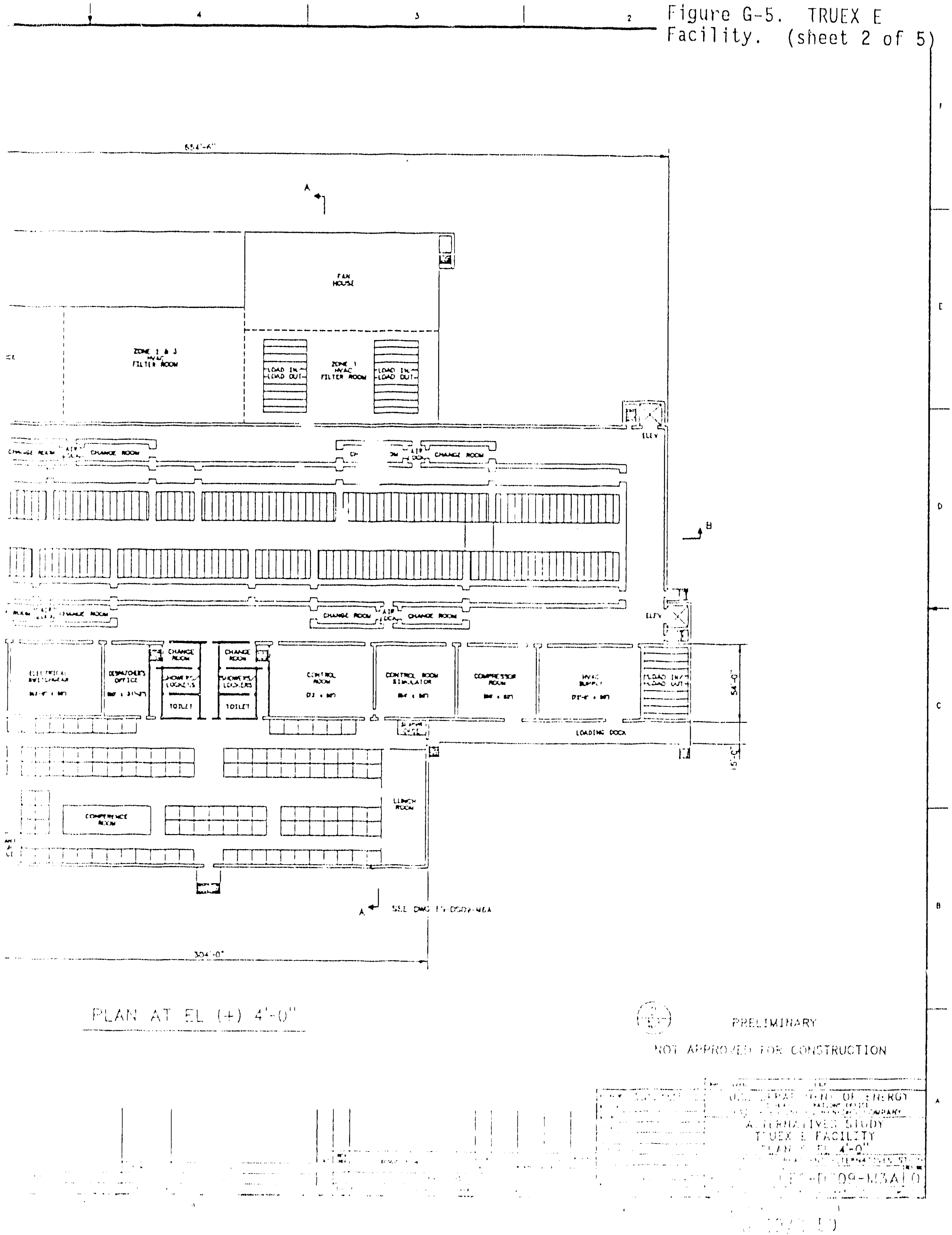
EQUIPMENT LIST	
EQUIPMENT NAME	EQPT ID
RECEIPT/SAMPLE TANK	TK-1A,B, C,D,E,F
BULK NITRIC ACID MAKEUP TANK	TK-301
BULK H_2O MAKEUP TANK	TK-302
BULK SODIUM HYDROXIDE MAKEUP TANK	TK-303
BULK H_2O_2 STORAGE TANK	TK-304
TBP STORAGE TANK	TK-305
DILUENT STORAGE TANK	TK-306

Figure G-5. TRUEX E Facility. (sheet 1 of 5)



8
7
6
5
F
E
D
C
A
132'-0"
296'-0"
102'-0"
ELEV
INSTRUMENT / SERVICE GALLERY
B
SEE DWG ES-DS09-M7A
ELEV
INSTRUMENT / SERVICE GALLERY
LOAD IN/ LOAD OUT
HVAC SUPPLY
EMERGENCY GENERATOR
LOADING DOCK

Figure G-5. TRUEX E Facility. (sheet 2 of 5)



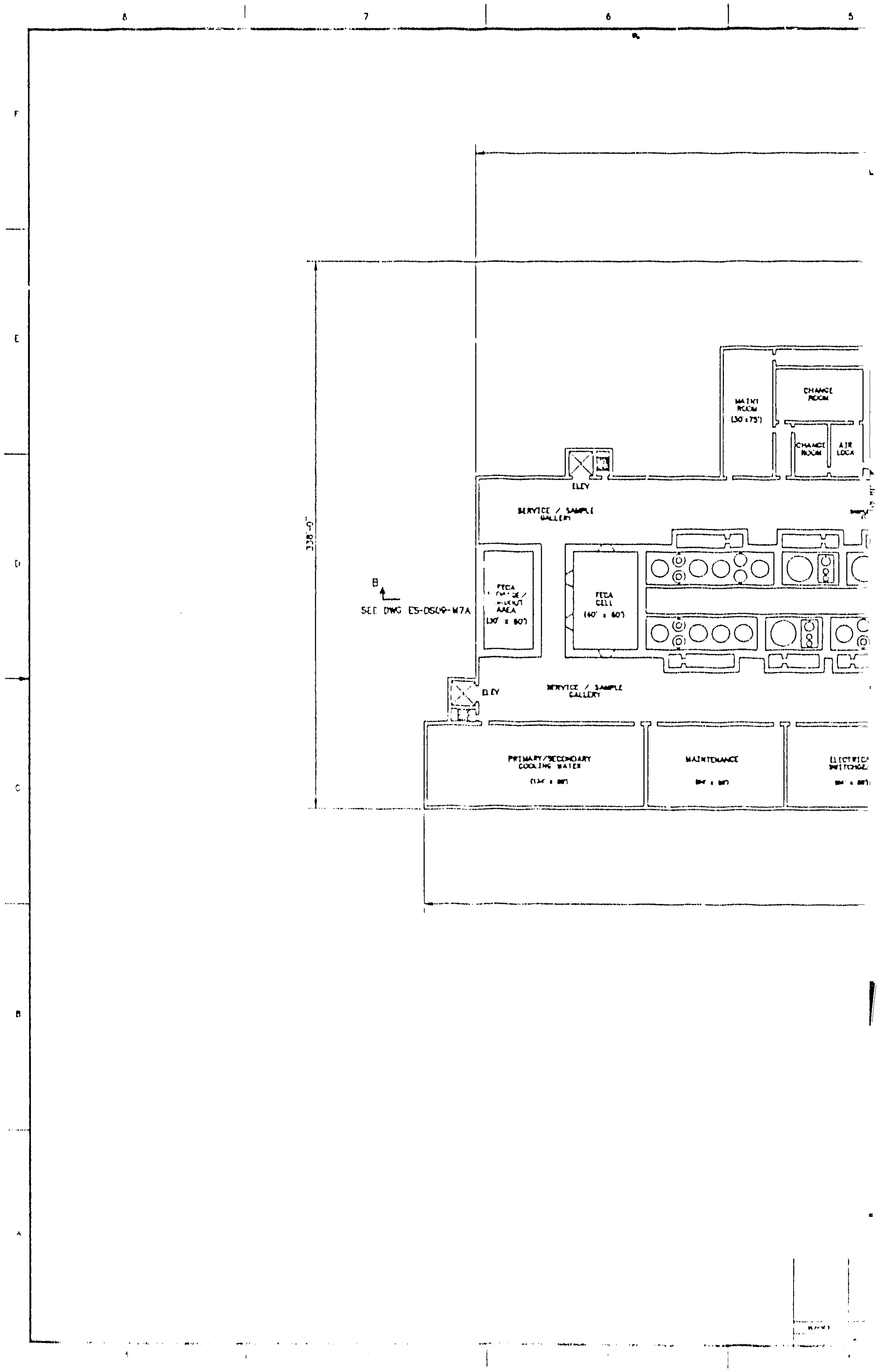
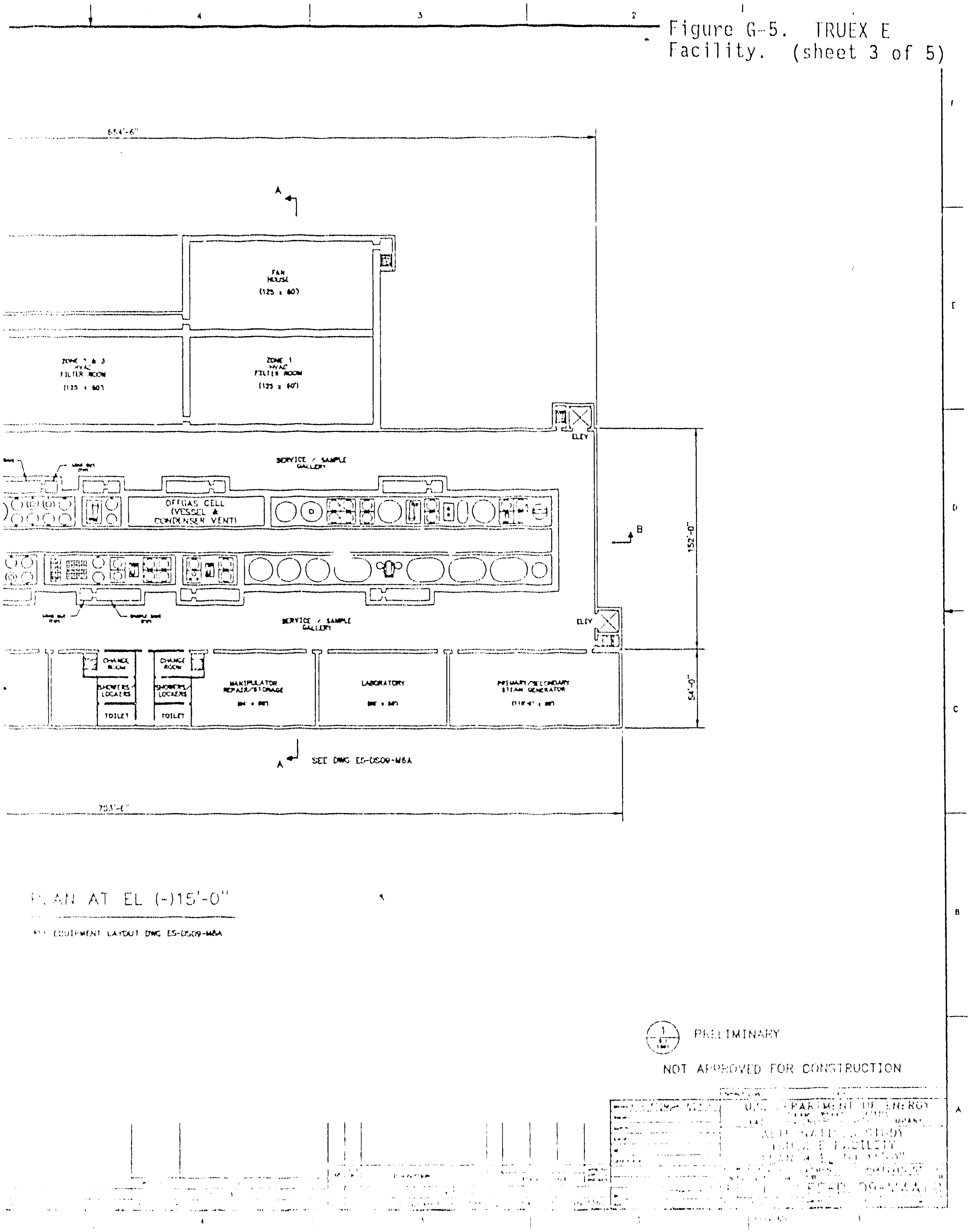

8
7
6
5
F
E
D
C
B
A
338'-0"
B
SEE DWG ES-DS09-M7A
CHANGE ROOM
MAINT ROOM (30' x 75')
CHANGE ROOM
AIR LOCK
ELEV
SERVICE / SAMPLE GALLERY
FECA CELL (40' x 60')
(30' x 60')
ELEV
SERVICE / SAMPLE GALLERY
PRIMARY/SECONDARY COOLING WATER
MAINTENANCE

Figure G-5. TRUEX E Facility. (sheet 3 of 5)



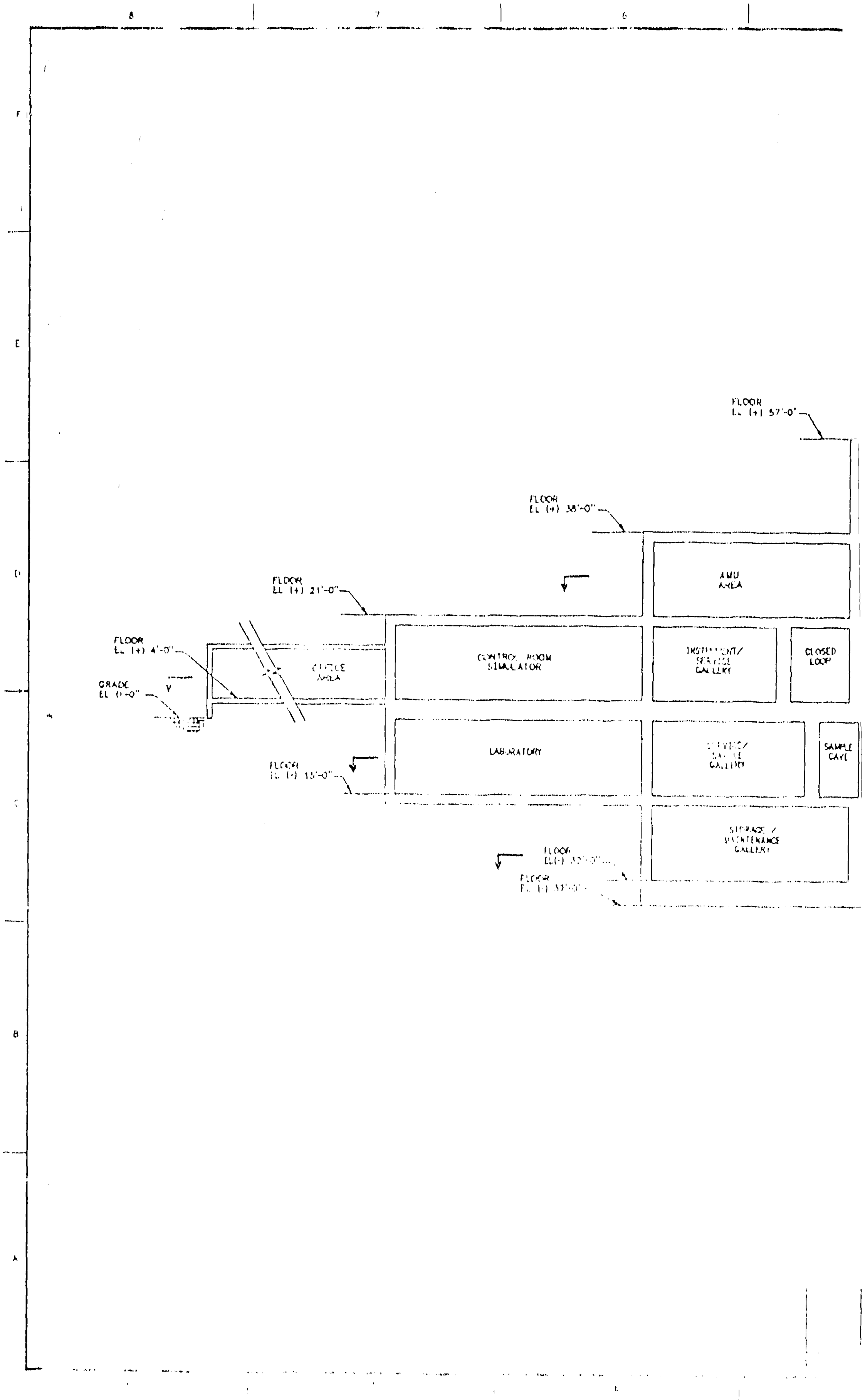
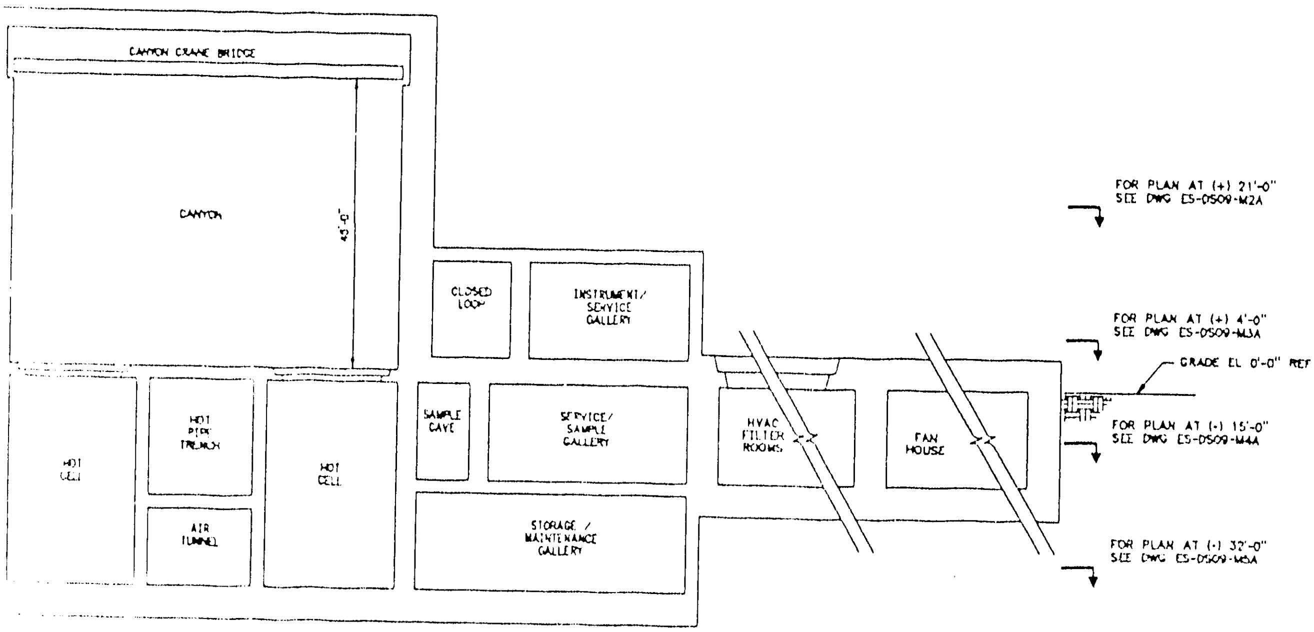

FLOOR
EL (+) 57'-0"
FLOOR
EL (+) 38'-0"
AMU
AREA
FLOOR
EL (+) 21'-0"
FLOOR
EL (+) 4'-0"
CONTROL ROOM
SIMULATOR
CLOSED
LOOP
GRADE
LABORATORY
SAMPLE
CAVE
FLOOR
EL (-) 15'-0"
STORAGE /
MAINTENANCE
GALLERY
FLOOR

Figure G-5. TRUEX-E Facility. (sheet 4 of 5)



ELEVATION A-A

PRELIMINARY

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U.S. DEPARTMENT OF ENERGY
RICHLAND OPERATIONS OFFICE
KAISER ENGINEERS HANFORD COMPANY
ALTERNATIVES STUDY
TRUEX E FACILITY
ELEVATION A-A

ES-DS09-M6A 0

EQUIPMENT LIST

EQUIPMENT NAME	EQPT ID
SW CENTRIFUGE FEED TANK	TK-2A,B
SW CENTRIFUGE (w/ HELICAL CONVEYOR)	G-1A,B
SW CENTRIFUGE CATCH TANK	TK-3A,B
SW SOLIDS SLURRY TANK	TK-4
SW SOLIDS SLURRY SAMPLE TANK	TK-5
SW SOLIDS SLURRY TRANSFER TANK	TK-6
SW CENTRATE RECEIVER TANK	TK-7A,B
SW INERTIAL FILTER FEED TANK	TK-8A,B
INERTIAL FILTER	FI-1A,B
SW INERTIAL FILTER CATCH TANK	TK-9A,B
Cs IX SAMPLE TANK	TK-10
1st CYCLE IX FEED TANK	TK-11
SAND FILTER	FS-1
1st CYCLE CESIUM ION-EXCHANGE COLUMN	X-1A,1B 1C,,1D
1st CYCLE Cs IX ACID REGEN FEED TANK	TK-12
1st CYCLE Cs IX CAUSTIC REGEN FEED TANK	TK-13
1st CYCLE IX ELUANT CATCH TANK	TK-14
1st CYCLE CESIUM IX EVAPORATOR	EV-1
CONDENSER (1st CYCLE)	EC-1

EQUIPMENT NAME	EQPT ID
CONCENTRATOR CATCH TANK	TK-15
1st CYCLE IX WASTE TANK	TK-16
IX WASTE SAMPLE TANK	TK-17
EVAPORATOR FEED TANK FOR CLARIFIED SUPERNATE	TK-18
SUPERNATANT EVAPORATOR	EV-2
CONDENSER (SUPERNATANT)	EC-2
EVAPORATOR FEED TANK FOR SOLIDS SLURRY AND TANK FARM OPERATIONS	TK-19
EVAPORATOR CATCH TANK	TK-20
CONCENTRATED SUPERNATANT SAMPLE TANK	TK-21
SUPERNATANT TRANSFER TANK	TK-22
PURIFICATION COLUMN FEED TANK	TK-23
SAND FILTER	FS-2
2nd CYCLE IX COLUMN	X-2
2nd CYCLE IX LOADING WASTE TANK	TK-24
2nd CYCLE IX ELUANT CATCH TANK	TK-25
2nd CYCLE CESIUM IX CONCENTRATOR	EV-3
CONDENSER (2nd CYCLE)	EC-3
CESIUM CONCENTRATOR CATCH TANK	TK-26

EQUIPMENT NAME	EQPT ID
2nd CYCLE CESIUM CONCENTRATE SAMPLE TANK	TK-27
CESIUM NEUTRALIZATION AND TRANSFER TANK	TK-28
SOLIDS DISSOLVER	TK-29A,B
DOWN DRAFT CONDENSER	T-1A,B
SCRUBBER	T-2A,B
SCRUBBER CATCH TANK	TK-30A,B
DISSOLVER CATCH/ SAMPLE TANK	TK-31
DISSOLVER CENTRIFUGE FEED TANK	TK-32
DISSOLVER CENTRIFUGE	G-2
DISSOLVER CENTRIFUGE CATCH TANK	TK-33
DISSOLVER SOLIDS SLURRY TANK	TK-34
DISSOLVER SOLIDS SAMPLE TANK	TK-35
DISSOLVER CENTRATE RECEIVER TANK	TK-36
DISSOLVER FILTER FEED TANK	TK-37
DISSOLVER INERTIAL FILTER	FI-2

EQUIPMENT NAME
TRU EXTRACTION/SC 6/4 CONTACTORS
TRU STRIP/U-Tc STR 6/6/4 CONTACTORS
TRU/Tc CONCENTRAT
CONDENSER (TRU/Tc)
DECANTER
TRU/Tc CONCENTRATE CATCH TANK
TRU/Tc SAMPLE TANK
TRU/Tc NEUTRALIZAT TRANSFER TANK
TRUEX TURBO MIXER
TRUEX WASH RAFFINA SAMPLE TANK
TRUEX SOLVENT FEED
Tc RECOVERY FEED T
SAND FILTER
Tc SORPTION/REGENE
Tc ELUANT TANK
U WASTE CONCENTRATOR
CONDENSER (URANIUM)
DECANTER
U WASTE SAMPLE TAN

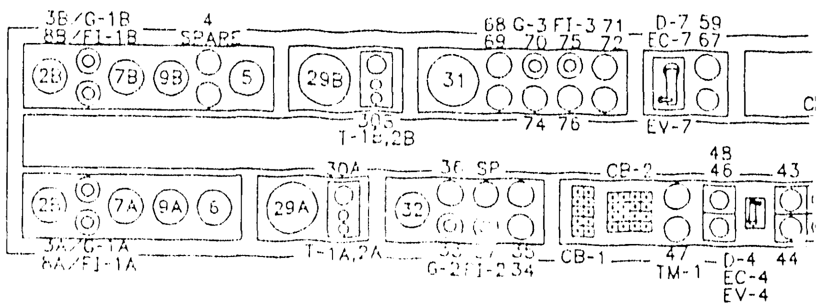
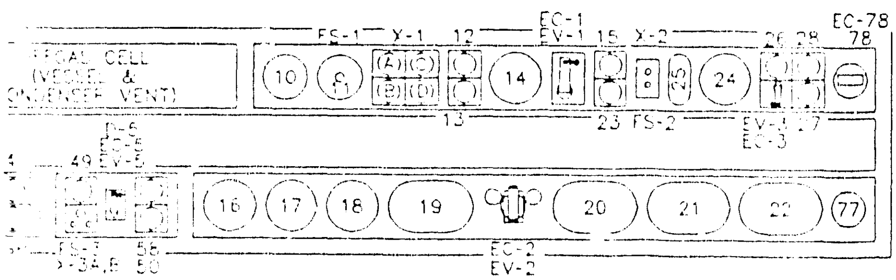


Figure G-5. TRUEX E Facility. (sheet 5 of 5)

	EQPT ID
DB	CB-1
P... STRIP	CB-2
	EV-4
	EC-4
	D-4
	TK-43
	TK-44
ON &	TK-45
ANK	TM-1
E	TK-46
TANK	TK-47
NK	TK-48
	FS-3
ATION	-3A,B
	TK-49
	EV-5
	EC-5
	D-5
	TK-50

EQUIPMENT NAME	EQPT ID
U WASTE NEUTRALIZATION & TRANSFER TANK	TK-58
TRUEX RAFFINATE CONCENTRATOR	EV-7
TRUEX RAFFINATE CONDENSER	EC-7
DECANTER	D-7
TRUEX RAFFINATE WASTE CONCENTRATE RECEIVER	TK-59
TRUEX WASTE CONCENTRATE SAMPLE TANK	TK-67
TRUEX WASTE NEUTRALIZATION TANK	TK-68
TRUEX WASTE CENTRIFUGE FEED TANK	TK-69
TRUEX WASTE CENTRIFUGE	G-3
TRUEX WASTE CENTRIFUGE CATCH TANK	TK-70
TRUEX SOLIDS WASTE SAMPLE TANK	TK-71
TRUEX WASTE TRANSFER TANK	TK-72
TRUEX CENTRATE RECEIVER TANK	TK-74
TRUEX FILTER FEED TANK	TK-75
TRUEX INERTIAL FILTER	FI-3
TRUEX IF CATCH TANK	TK-76
SUMP COLLECTION AND SAMPLE TANK	TK-77
ORGANIC DIGEST/SAMPLE TANK	TK-78
ORGANIC DIGEST CONDENSER	EC-78



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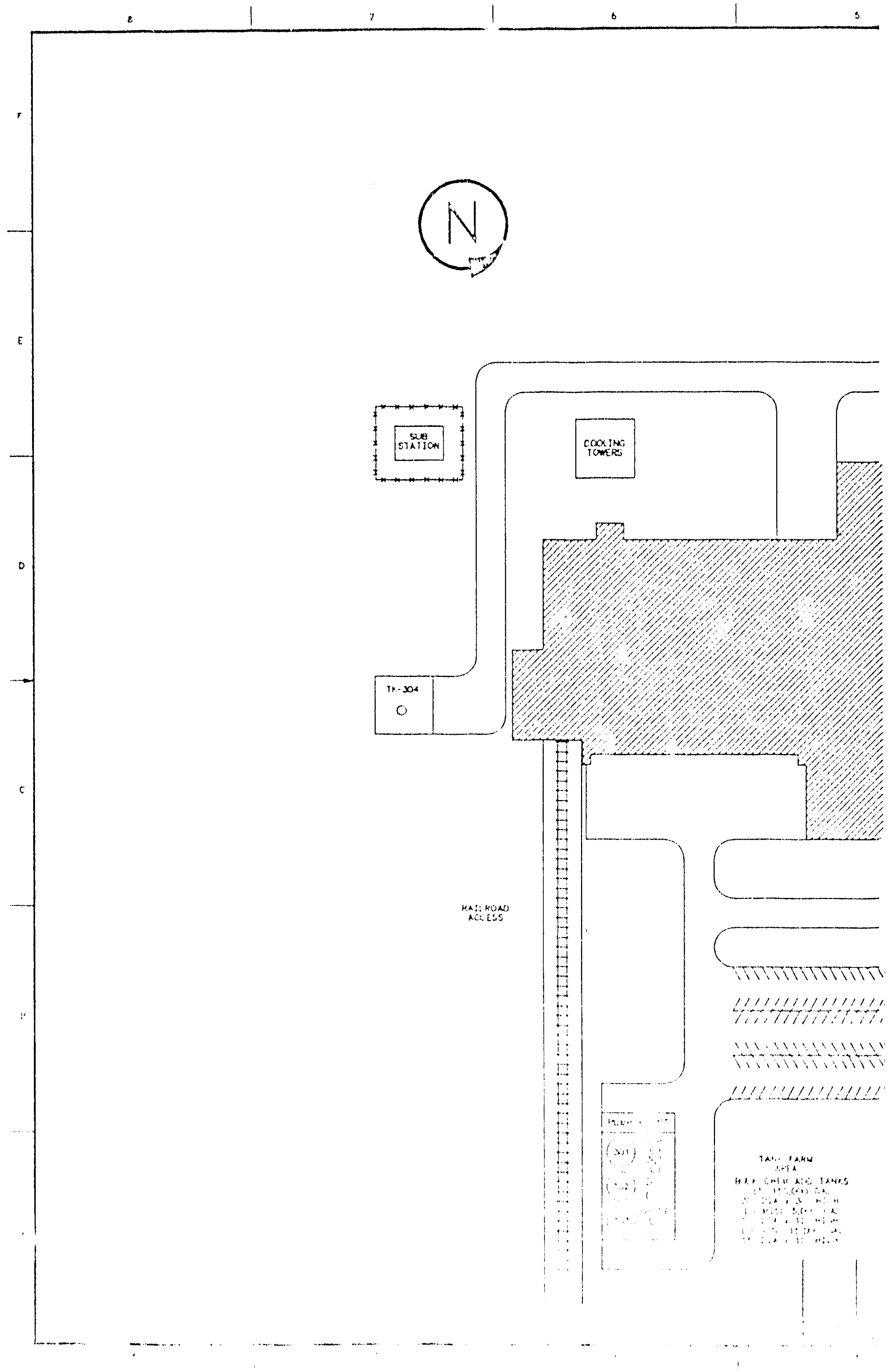
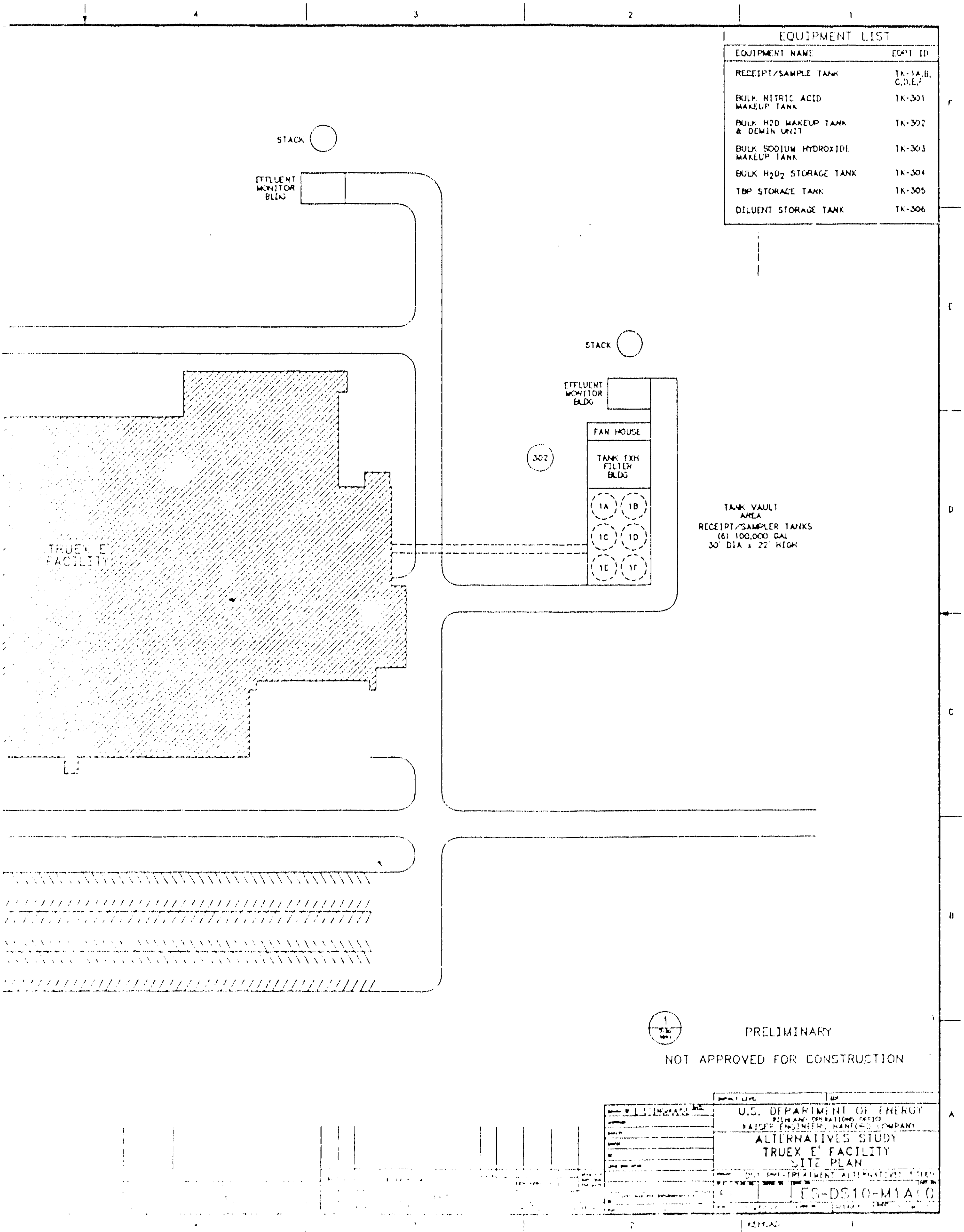
U.S. DEPARTMENT OF ENERGY
ALTERNATIVES STUDY
TRUEX E FACILITY
EQUIPMENT LAYOUT


8
7
6
5
F
E
D
C
N
SUB STATION
COOLING TOWERS
TK-304
RAILROAD ACCESS
301



EQUIPMENT LIST

EQUIPMENT NAME	EQPT ID
RECEIPT/SAMPLE TANK	TK-1A,B,C,D,E,F
BULK NITRIC ACID MAKEUP TANK	TK-301
BULK H2O MAKEUP TANK & DEMIN UNIT	TK-302
BULK SODIUM HYDROXIDE MAKEUP TANK	TK-303
BULK H_2O_2 STORAGE TANK	TK-304
TBP STORAGE TANK	TK-305
DILUENT STORAGE TANK	TK-306

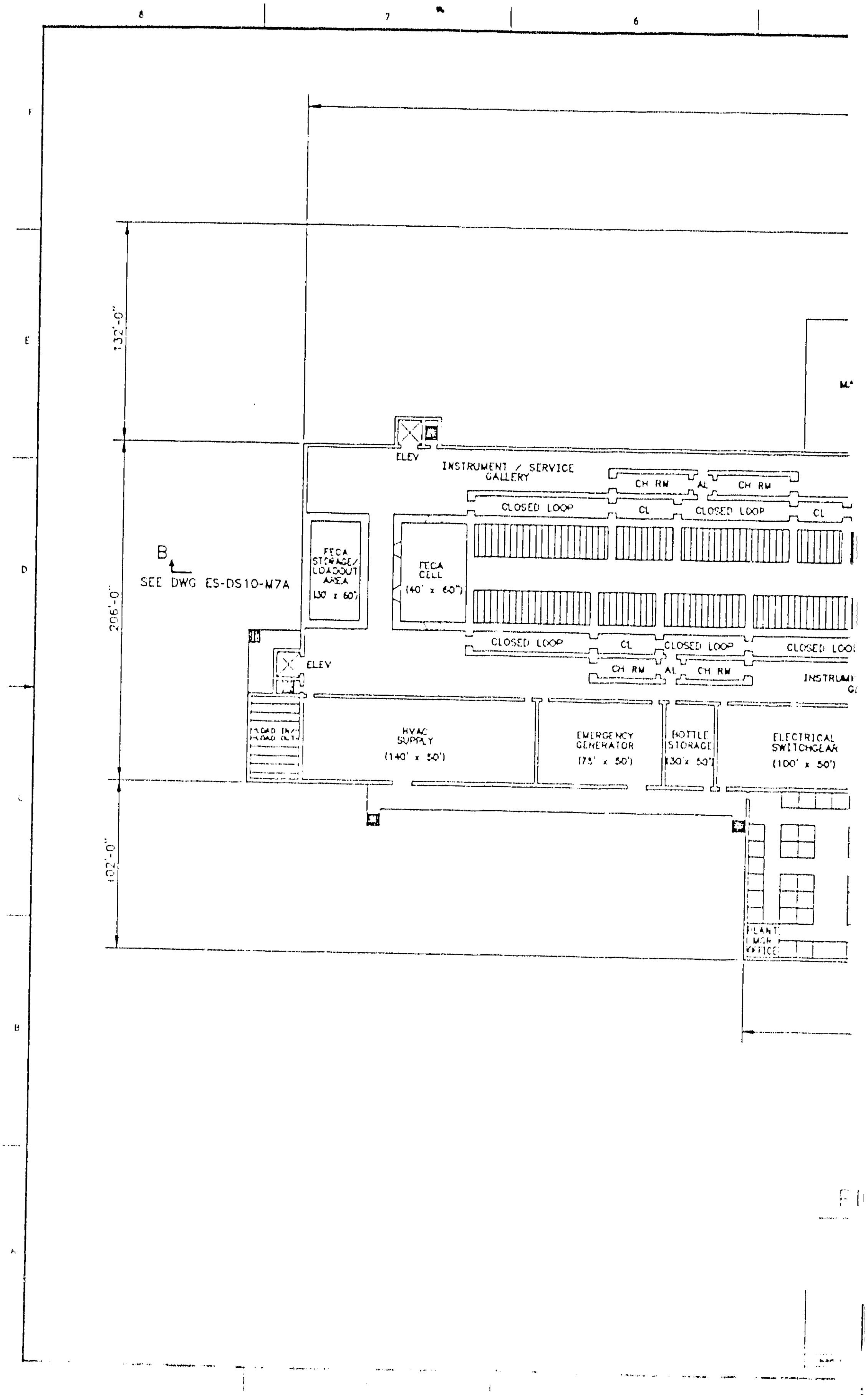
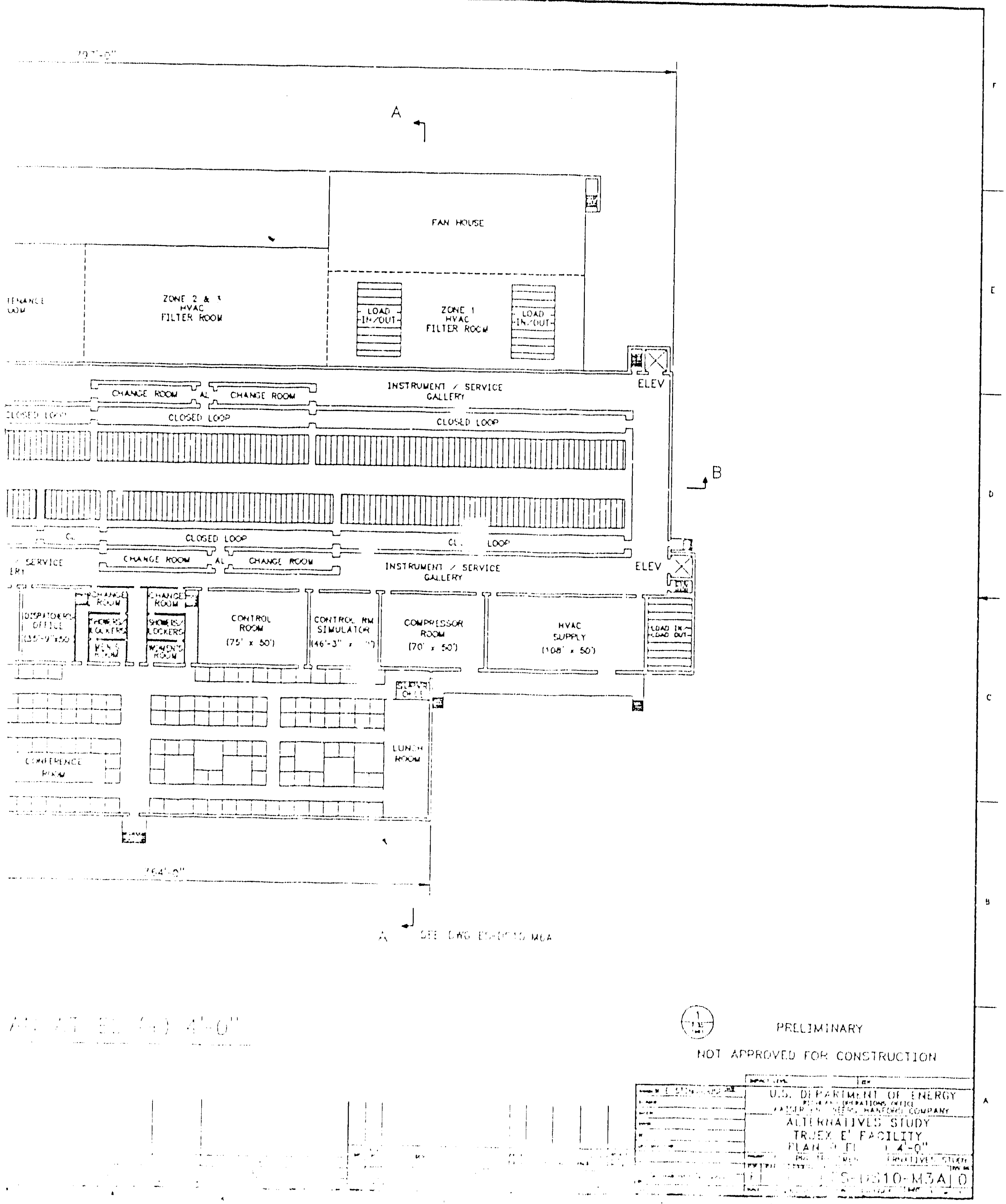
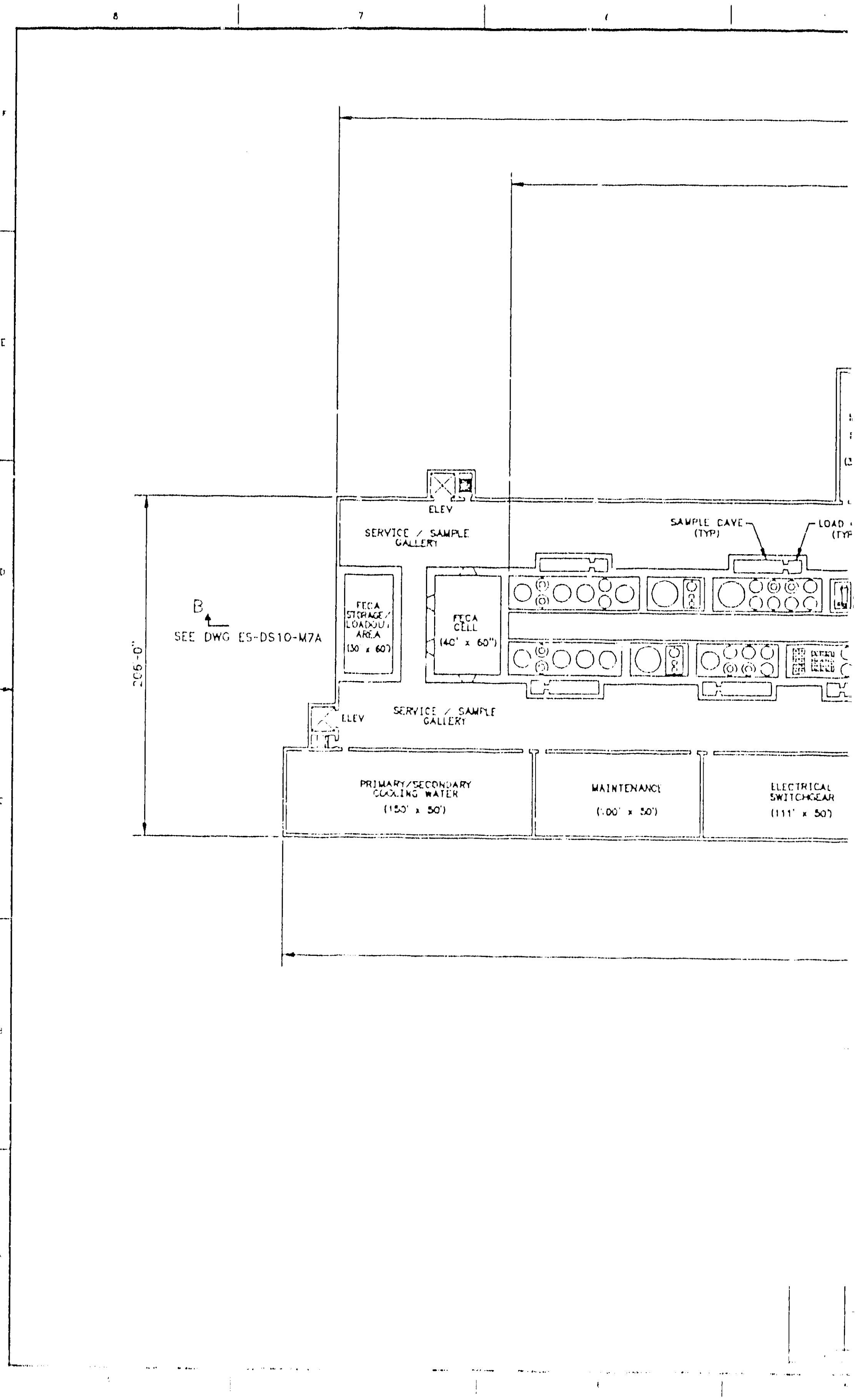

8
7
6
F
E
D
C
B
A
132'-0"
206'-0"
102'-0"
B
SEE DWG ES-DS10-M7A
ELEV
INSTRUMENT / SERVICE GALLERY
CH RM
AL
CH RM
CLOSED LOOP
CL
CLOSED LOOP
CL
FECA STORAGE/ LOADOUT AREA
(30' x 60')
FECA CELL
(40' x 60')
CLOSED LOOP
CL
CLOSED LOOP
CLOSED LOOP
CH RM
AL
CH RM
ELEV
HVAC SUPPLY
(140' x 50')
EMERGENCY GENERATOR
(75' x 50')
BOTTLE STORAGE
(30' x 50')
ELECTRICAL SWITCHGEAR
(100' x 50')
PLANT MGR OFFICE

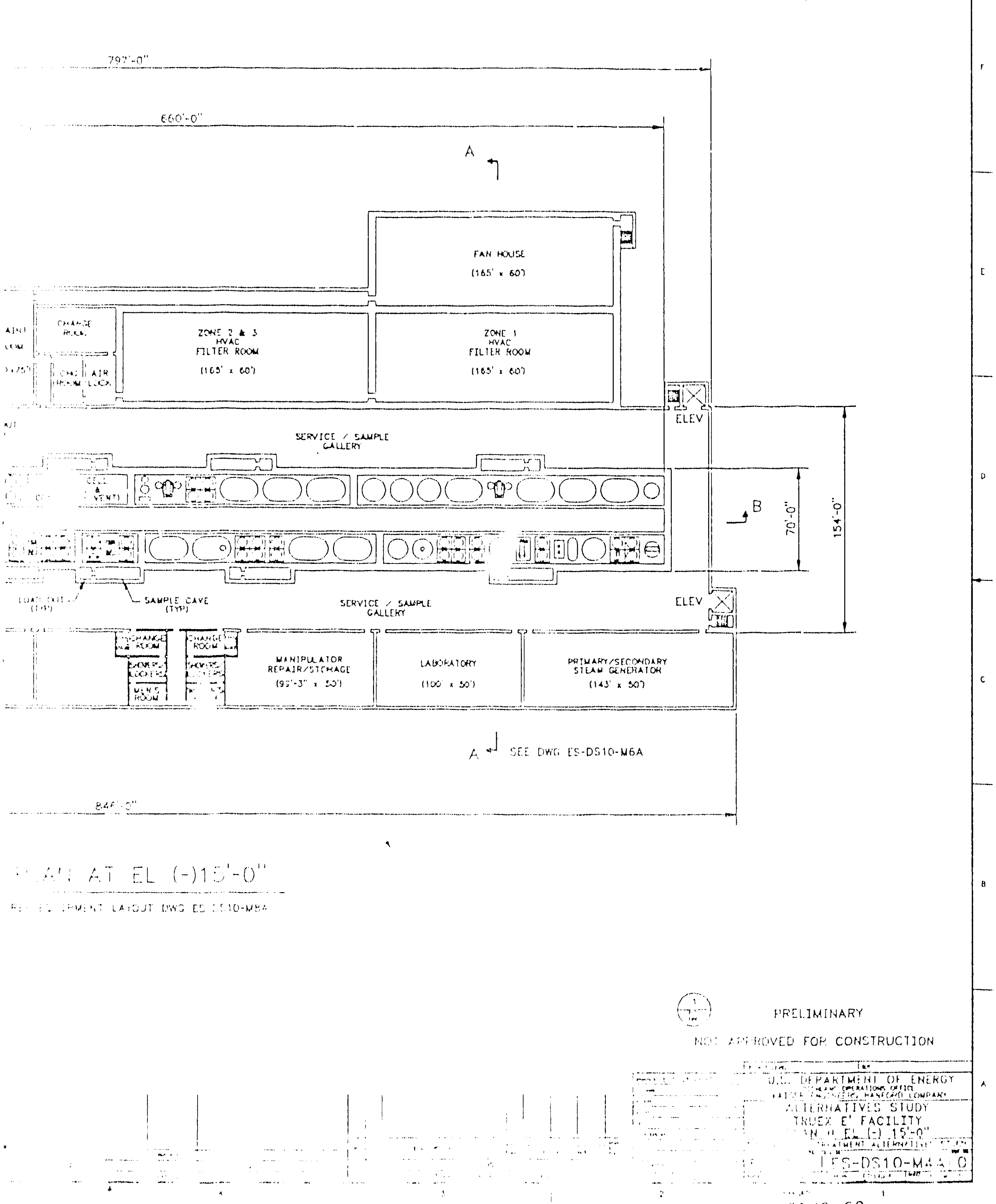
Figure G-6. TRUEX E' Facility. (sheet 2 of 5)

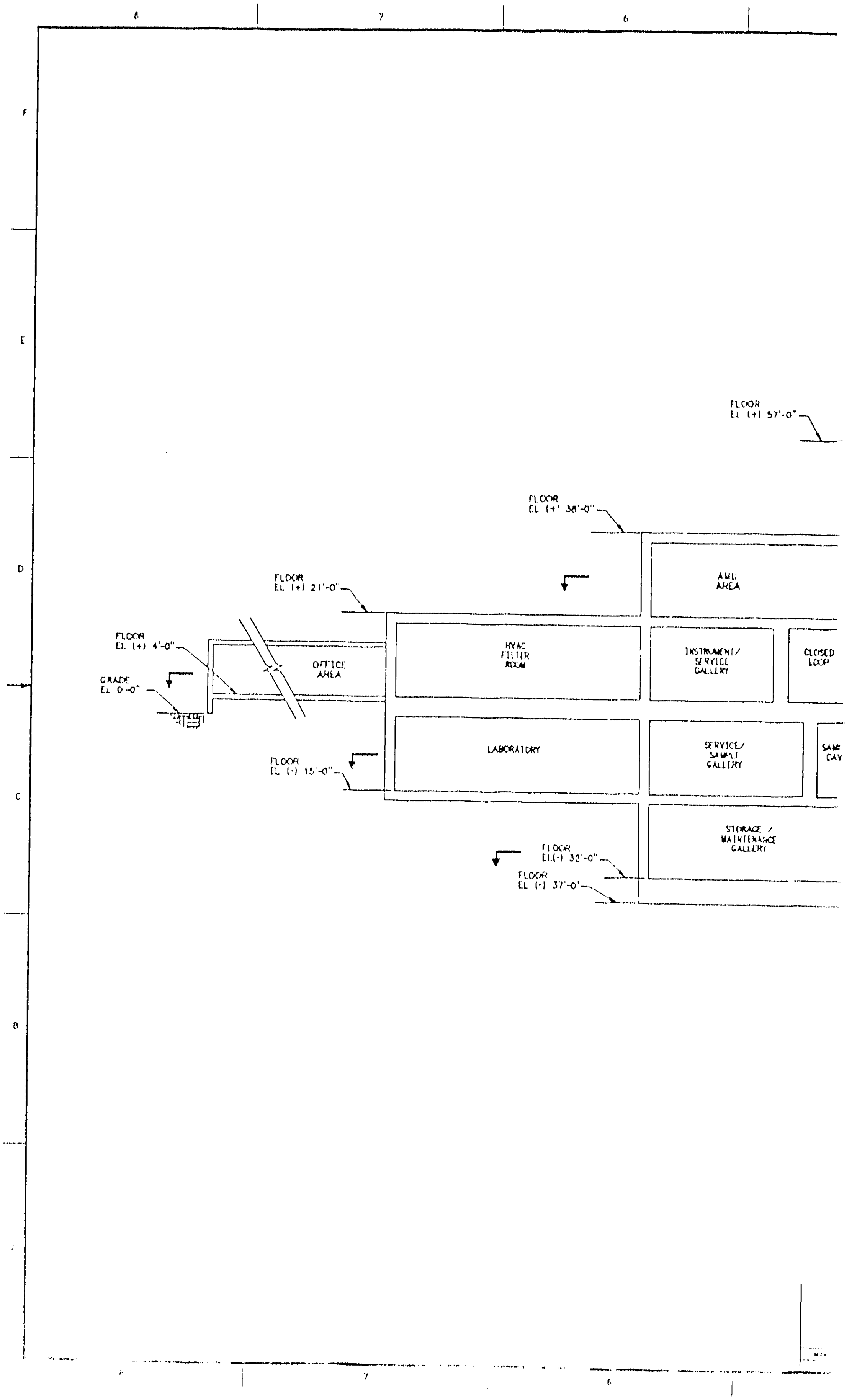




ELEV
SERVICE / SAMPLE GALLERY
SAMPLE CAVE (TYP)
FECA STORAGE/ LOADOUT AREA (30' x 60')
FECA CELL (40' x 60')
B
SEE DWG ES-DS10-M7A
205'-0"
ELEV
SERVICE / SAMPLE GALLERY
PRIMARY/SECONDARY COOLING WATER (150' x 50')
MAINTENANCE
ELECTRICAL SWITCHGEAR (111' x 50')

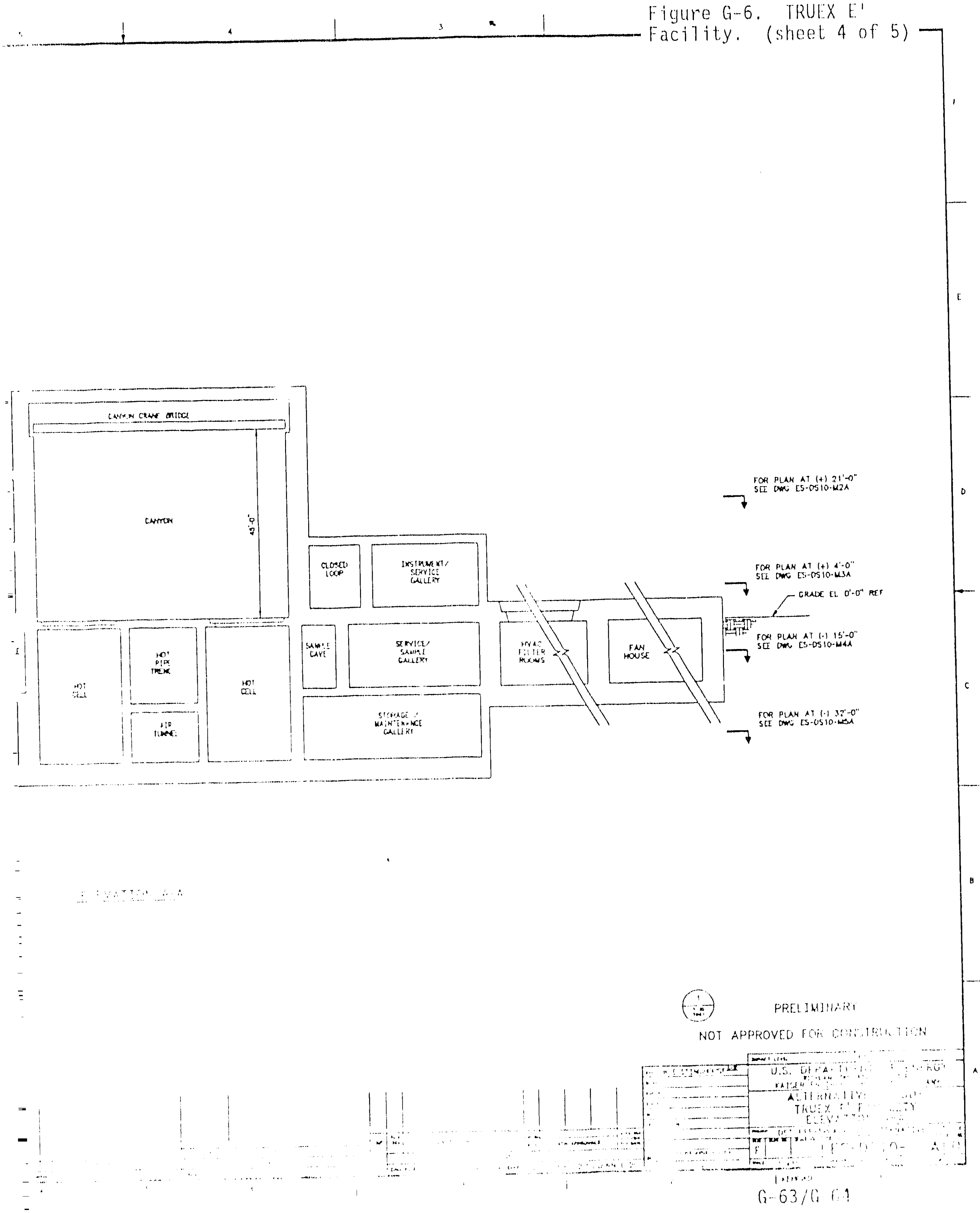
Figure G-6. TRUEX E' Facility. (sheet 3 of 5)





8
7
6
F
E
D
C
B
FLOOR
EL (+) 57'-0"
FLOOR
EL (+) 38'-0"
AMU
AREA
FLOOR
EL (+) 21'-0"
FLOOR
EL (+) 4'-0"
GRADE
EL 0'-0"
OFFICE
AREA
HVAC
FILTER
ROOM
INSTRUMENT/
SERVICE
GALLERY
CLOSED
LOOP
LABORATORY
SERVICE/
SAMPLE
GALLERY
FLOOR
EL (-) 15'-0"
STORAGE /
MAINTENANCE
GALLERY
FLOOR
EL (-) 32'-0"
FLOOR
EL (-) 37'-0"

Figure G-6. TRUEX E' Facility. (sheet 4 of 5)



8 | 7 | 6

EQUIPMENT NAME	EQPT ID
SW CENTRIFUGE FEED TANK	TK-2A,B
SW CENTRIFUGE (w/ HELICAL CONVEYOR)	O-1A,B
SW CENTRIFUGE CATCH TANK	TK-3A,B
SW SOLIDS SLURRY TANK	TK-4
SW SOLIDS SLURRY SAMPLE TANK	TK-5
SW SOLIDS SLURRY TRANSFER TANK	TK-6
SW CENTRATE RECEIVER TANK	TK-7A,B
SW INERTIAL FILTER FEED TANK	TK-8A,B
INERTIAL FILTER	FI-1A,B
SW INERTIAL FILTER CATCH TANK	TK-9A,B
Cs IX SAMPLE TANK	TK-10
1st CYCLE IX FEED TANK	TK-11
SAND FILTER	FS-1
1st CYCLE CESIUM ION-EXCHANGE COLUMN	X-1A,1B 1C,,1D
1st CYCLE Cs IX ACID REGEN FEED TANK	TK-12
1st CYCLE Cs IX CAUSTIC REGEN FEED TANK	TK-13
1st CYCLE IX ELUANT CATCH TANK	TK-14
1st CYCLE CESIUM IX EVAPORATOR	EV-1
CONDENSER (1st CYCLE)	EC-1

EQUIPMENT NAME	EQPT ID
CONCENTRATOR CATCH TANK	TK-15
1st CYCLE IX WASTE TANK	TK-16
IX WASTE SAMPLE TANK	TK-17
EVAPORATOR FEED TANK FOR CLARIFIED SUPERNATE	TK-18
SUPERNATANT EVAPORATOR	EV-2
CONDENSER (SUPERNATANT)	EC-2
EVAPORATOR FEED TANK FOR SOLIDS SLURRY AND TANK FARM OPERATIONS	TK-19
EVAPORATOR CATCH TANK	TK-20
CONCENTRATED SUPERNATANT SAMPLE TANK	TK-21
SUPERNATANT TRANSFER TANK	TK-22
PURIFICATION COLUMN FEED TANK	TK-23
SAND FILTER	FS-2
2nd CYCLE IX COLUMN	X-2
2nd CYCLE IX LOADING WASTE TANK	TK-24
2nd CYCLE IX ELUANT CATCH TANK	TK-25
2nd CYCLE CESIUM IX CONCENTRATOR	EV-3
CONDENSER (2nd CYCLE)	EC-3
CESIUM CONCENTRATOR CATCH TANK	TK-26

EQUIPMENT NAME	EQPT ID
2nd CYCLE CESIUM CONCENTRATE SAMPLE TANK	TK-27
CESIUM NEUTRALIZATION AND TRANSFER TANK	TK-28
SOLIDS DISSOLVER	TK-29A,B
DOWN DRAFT CONDENSER	T-1A,B
SCRUBBER	T-2A,B
SCRUBBER CATCH TANK	TK-30A,B
DISSOLVER CATCH/ SAMPLE TANK	TK-31
DISSOLVER CENTRIFUGE FEED TANK	TK-32
DISSOLVER CENTRIFUGE	O-2
DISSOLVER CENTRIFUGE CATCH TANK	TK-33
DISSOLVER SOLIDS SLURRY TANK	TK-34
DISSOLVER SOLIDS SAMPLE TANK	TK-35
DISSOLVER CENTRATE RECEIVER TANK	TK-36
DISSOLVER FILTER FEED TANK	TK-37
DISSOLVER INERTIAL FILTER	FI-2

EQUIPMENT NAME
TRU EXTRACTIO 6/4 CONTACTOR
TRU STRIP/U-T 6/6/4 CONTACT
TRU/Tc CONCEN
CONDENSER (TRU
DECANTER
TRU/Tc CONCEN CATCH TANK
TRU/Tc SAMPLE
TRU/Tc NEUTRAL TRANSFER TANK
TRUEX TURBO MI
TRUEX WASH RA SAMPLE TANK
TRUEX SOLVENT
Tc RECOVERY FEE
SAND FILTER
Tc SORPTION/RE
Tc ELUANT TANK
U WASTE CONCENTRATOR
CONDENSER (URAN
DECANTER
U WASTE SAMPLE

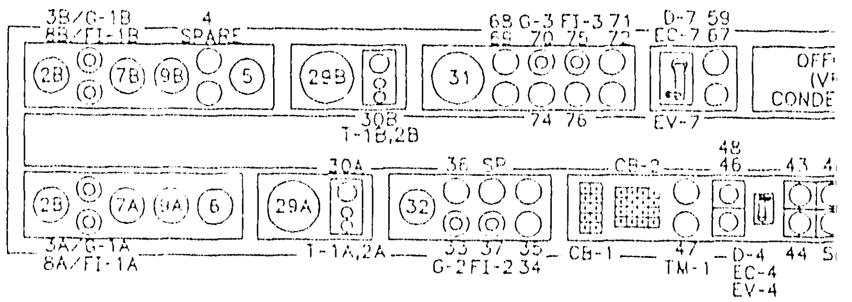


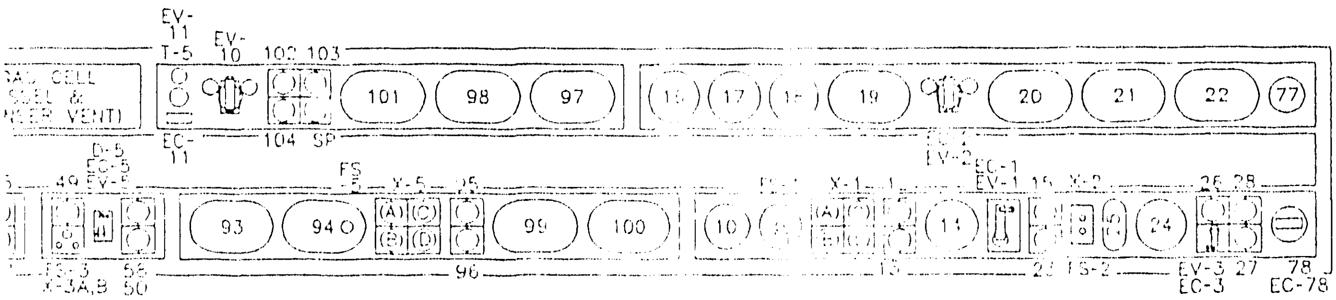
Figure G-6. TRUEX E' Facility. (sheet 5 of 5)

EQUIPMENT LIST

EQUIPMENT NAME	EQPT ID
SCRUB	CB-1
STRIP (SO STRIP)	CB-2
ATOR	EV-4
(Tc)	EC-4
	D-4
ATE	TK-43
AN	TK-44
ZATION &	TK-45
(R) TANK	TM-1
INATE	TK-46
ED TANK	TK-47
TANK	TK-48
	FS-3
ENERATION	X-3A,B
	TK-49
	EV-5
IUM	EC-5
	D-5
TANK	TK-50

EQUIPMENT NAME	EQPT ID
U WASTE NEUTRALIZATION & TRANSFER TANK	TK-58
TRUEX RAFFINATE CONCENTRATOR	EV-7
TRUEX RAFFINATE CONDENSER	EC-7
DECANTER	D-7
TRUEX RAFFINATE WASTE CONCENTRATE RECEIVER	TK-59
TRUEX WASTE CONCENTRATE SAMPLE TANK	TK-67
TRUEX WASTE NEUTRALIZATION TANK	TK-68
TRUEX WASTE CENTRIFUGE FEED TANK	TK-69
TRUEX WASTE CENTRIFUGE	G-3
TRUEX WASTE CENTRIFUGE CATCH TANK	TK-70
TRUEX SOLIDS WASTE SAMPLE TANK	TK-71
TRUEX WASTE TRANSFER TANK	TK-72
TRUEX CENTRATE RECEIVER TANK	TK-74
TRUEX FILTER FEED TANK	TK-75
TRUEX INERTIAL FILTER	FI-3
TRUEX IF CATCH TANK	TK-76
SUMP COLLECTION AND SAMPLE TANK	TK-77

EQUIPMENT NAME	EQPT ID
ORGANIC DIGEST/SAMPLE TANK	TK-78
ORGANIC DIGEST CONDENSER	EC-78
Tc IX FEED TANK	TK-93
Tc IX SAND FILTER	FS-5
Tc ION EXCHANGE COLUMN	X-5A,B,C,D
Tc IX RECYCLE TANK	TK-94
Tc IX ACID FEED TANK	TK-95
Tc IX CAUSTIC FEED TANK	TK-96
Tc IX H2O SCRUB CATCH TANK	TK-97
Tc ELUANT CATCH TANK	TK-98
Tc IX WASTE TANK	TK-99
Tc IX WASTE SAMPLE TANK	TK-100
Tc IX RECYCLE ACID TANK	TK-101
Tc CONCENTRATOR	EV-10
Tc CONCENTRATOR CATCH TANK	TK-102
FRACTIONATOR	T-5
FRACTIONATOR REBOILER	EV-11
FRACTIONATOR CONDENSER	EC-11
Tc CONCENTRATE SAMPLE TANK	TK-103
Tc NEUTRALIZATION & TRANSFER TANK	TK-104



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U.S. DEPARTMENT OF ENERGY

ALTERNATIVES STUDY

TRUEX E' FACILITY

EQUIPMENT LAYOUT

ES-DS10-M8A10

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