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INDEPENDENT ENGINEERING REVIEW OF THE HANFORD WASTE VITRIFICATION SYSTEM

OCTOBER 1991

CONDUCTED BY THE
U.S. DEPARTMENT OF ENERGY
OFFICE OF ENVIRONMENTAL RESTORATION AND
WASTE MANAGEMENT

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iii. PREFACE

This is a report of the findings of the first Independent Engineering Review of Major Projects conducted by the Office of Environmental Restoration and Waste Management at the direction of the Director, Office of Environmental Restoration and Waste Management. Conduct of this type of Engineering Review is being institutionalized by the Under Secretary following a review for the Environmental Systems Acquisition Advisory Board (ESAAB) on the Hanford Waste Vitrification Project (HWVP). The report gives the results of a Technical Assessment of the HWVP. The Project was developed to convert the high-level/transuranic radioactive waste stored in the tanks at Hanford into a glass for the purpose of disposal in a licensed deep geologic repository.

The objectives of this effort are twofold. The first independent review of a major project for DOE has two objectives. The first has been to conduct an in-depth look to determine whether the Department should proceed with the construction of a major facility by examining the state of readiness of the entire waste management complex of which the facility is just one subsystem.

The second objective has been to establish the prototype for assembling a team of experts who bring a wide breadth of knowledge to examine the complex technical aspects of a major DOE project and evaluate its readiness for construction and the probability of its timely and successful completion and operation. The value derived from this initial exercise will determine the efficacy of continuing the approach in reviewing additional major projects.

The review was conducted in the June-July 1991 time period and it examined the structure and status of the Hanford Waste Vitrification System as it was at that time. It did not examine the impact of the Hanford Waste Project Redefinition Study that was being conducted at the same time. It is acknowledged that most of the issues discussed in this document were identified in recent documents such as the Hanford System Risk Assessment and are being evaluated as part of the Double-Shell Tank Program Redefinition Study. There is no intent to imply discovery by the Independent Engineering Review Team of issues that were identified previously. It was the responsibility of the Review Team to provide an independent technical assessment of the issues and this required points, already known, to be articulated and assessed in this report. However, there are numerous instances where the Review Team members viewed the information or data in a perspective that was significantly different than that held by the Program

A follow-up, Independent Engineering Review of the Hanford Waste Project Redefinition study is planned. This will take place following completion of the redefinition study by Westinghouse Hanford Company and approval by the Richland Field Office.

I. EXECUTIVE SUMMARY

I.A Background

The Hanford Waste Vitrification Plant (HWVP) was initiated in June 1987. The HWVP is an essential element of the plan to end present interim storage practices for defense wastes and to provide for permanent disposal. The project start was justified, in part, on efficient technology and design information transfer from the prototype Defense Waste Processing Facility (DWPF). Development of other serial Hanford Waste Vitrification System (HWVS)[1] elements, such as the waste retrieval system for the double-shell tanks (DSTs), and the pretreatment system to reduce the waste volume converted into glass, also was required to accomplish permanent waste disposal. In July 1991, at the time of this review, the HWVP was in the Title II design phase.

I.B Introduction

The objective of the HWVP is to convert the high-level radioactive materials (105 MCi of radioactivity) in 10 of 28 DSTs into glass for disposal in a high-level radioactive waste repository.

In addition to the radioactive material in the DSTs, there are 1942 capsules containing $CsCl$ and SrF_2 (168 MCi of radioactivity) that must be sent to the repository and therefore may become part of the waste to be vitrified.

Although the initial mission of the HWVS is limited to vitrifying DST wastes, there is a requirement that the HWVS be capable of processing the waste in 149 single-shell tanks (SSTs) (170 MCi of radioactivity). The mass of material to be processed and the total cost of this operation is expected to be 3 to 5 times greater than that for the DSTs.

The objective of this technical assessment is to determine whether the status of the technology development and engineering practice is sufficient to provide reasonable assurance that the HWVP and the balance of the HWVS system will operate in an efficient and cost-effective manner. The criteria used to facilitate a judgment of potential successful operation are: vitrification of high-level radioactive waste from specified DSTs on a reasonably continuous basis; and glass produced with physical and chemical properties formally acknowledged as being acceptable for disposal in a repository for high-level radioactive waste. The criteria were proposed specifically for the Independent Engineering Review to focus that assessment effort. They are not represented as the criteria by which the Department will judge the prudence of the Project.

[1] The HWVS is a construct created specifically to facilitate the Independent Engineering Review of the vitrification plant and the infrastructure required to support the production of glass. This system has not been an officially defined part of the DOE-RL or WHC programmatic effort.

I.C Technical Assessment

As a result of a multiplicity of concurrent technical issues and disruptions to programmatic logic and assumptions, the detailed design of the HWVP is considered premature within the context of the system conditions in which it will function. A re-evaluation of the programmatic objectives, technology basis, management philosophy, organizational structure, and cost is required before major actions can be prudently taken. The following findings support this assessment.

I.C.1 Significant disruption in the initial and subsequent waste feed for the vitrification plant will occur as a result of two factors:

- The unacceptability of B-Plant for pretreatment of DST waste from an environmental, safety, and health perspective. A coherent and well-conceived approach to the design of processing and support facilities, without B-Plant, must be developed. Alternative approach selection and subsequent construction of facilities will significantly delay the schedule for retrieval and processing of waste from the first two [neutralized current acid waste (NCAW)] and subsequent eight (post-NCAW) tanks. If a new pretreatment process facility is to be designed and built, then the requirements for SSTs must be considered (see Finding 6).

- The slow pace of pretreatment process development [transuranic extraction (TRUEX) or an alternative] because of incomplete program integration and nonoptimum allocation of resources. Process and facility technical design requirements are unavailable because of incomplete pretreatment processing technology development. This will affect the schedule for processing waste in the last eight DSTs, which contain waste that will benefit significantly from solvent extraction or other pretreatment processing.

I.C.2 The DWPF is the prototype for the HWVP. The Department's plan was to derive technology, design, and operating experience from DWPF before the design of HWVP was frozen. There have been significant difficulties in bringing DWPF on line. Experience from DWPF will be advantageous to HWVP in understanding the nature of operating problems such as:

- hydrogen evolution in vitrification plant feed preparation equipment,

- noble metal precipitation in melter (NCAW contains more noble metals than Savannah River wastes), and

- process control system effectiveness.

I.C.3 Numerous HWVP conceptual design issues remain unresolved. Research and process design studies are being conducted in parallel with Title II design. Lessons learned from the DWPF design shortcomings have been and currently are being integrated into the facility design. There is an advantage to suspending the Title II design of the HWVP until the issues are resolved satisfactorily, the studies are completed and other start-up and operational data are available.

I.C.4 Lack of understanding of DST waste characteristics. The chemical and physical characteristics of the waste need to be understood if processing problems are to be solved. The characterization program specifies 55 samples taken from 10 tanks; only 17 have been obtained and 10 analyzed to date. The sampling program has been interrupted to support the safety program, and completion of sampling is expected in 1998.

I.C.5 Lack of a reasonable understanding of the total life-cycle cost of the proposed system and the effect of various alternatives for treating and processing the wastes on cost. Processing technology can significantly affect the total cost of the program , and tens of billions of dollars can be involved. The costs and the framework in which they are estimated need to be understood before action can be prudently taken. Full understanding of program actions, costs, and risks should be achieved and accepted before major decisions on construction projects are made.

I.C.6 The imperative to consider SST remediation now. The unavailability of B-Plant causes an immediate need to consider a new DST waste pretreatment facility. A new pretreatment plant is to be addressed with SST remediation decisions. SST processing requirements far outweigh DST requirements. Therefore, the needs of SST remediation must be addressed before an alternative processing facility and technology are proposed.

I.C.7 The HWVP and the HWVS are being managed as separate entities with little integration. Resources are allocated on two different priority scales. A fully integrated management structure and program plan, with properly allocated resources, would be prudent before any major construction activities are undertaken. The continuation of the current method of allocating funds, with HWVP receiving dedicated project funds and with balance of the system development effort competing for program funds that are distributed on a site-wide priority basis, will ensure a continually widening gap between the completion of the HWVP and the completion of the balance of the HWVS.

II. SCOPE AND METHOD OF ASSESSMENT

The HWVP facility will incorporate pretreated high-level radioactive waste from 10 of 28[1] double-shell tanks into glass for disposal in a repository.. The HWVP is one of three major subsystems, within the HWVS[2], which are necessary to convert the high-level radioactive waste into its final form. The HWVS, as it was understood by the review team at the beginning of the process, is shown in Fig. 1. The ultimate objective of the HWVS is to facilitate the total removal of the waste in the 10 double-shell tanks and convert it into a solid waste-form suitable for a high-level radioactive waste repository in an expeditious and cost-effective manner.

The HWVP facility is expected to operate nearly continuously, except for planned outages for maintenance and repair, until all high-level radioactive waste in specified double-shell tanks is converted to glass. Assuming nominal values from the baseline program for volume of waste, efficiency of pretreatment and production throughput, the glass production process could be completed in roughly five years.

HWVP operation was expected to be efficient because it was to be a copy of the existing vitrification facility at Savannah River, the DWPF, which was planned to be operational several years before the HWVP. The DWPF would provide training, technology transfer, and lessons learned.

Formal cost development schedules for the high-level radioactive waste repository, published in the Federal Register in 1987, anticipate that approximately 1500 canisters of glass will be produced and sent to the repository by the HWVP. This estimate assumes that pretreatment will be very effective and that the TRUEX process will be perfected and used on the neutralized cladding removal waste (NCRW), plutonium finishing plant (PFP) waste, and complexant concentrate (CC)wastes. Significant difficulties that might result in fragmented HWVP operating schedules or a significant increase in the number of canisters were not anticipated.

Recent reviews of waste tank safety at Hanford have shown that knowledge and understanding of the radioactive waste characteristics is far from complete and varies with the type of waste and among the tanks.

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[1]The remaining 18 tanks contain wastes that currently are classified as mixed low-level radioactive waste, and they will be handled as such.

[2] The HWVS is a construct created specifically to facilitate the independent engineering review of the vitrification plant and the infrastructure required to support the production of glass. This system has not been an officially defined part of the DOE-RL or WHC programmatic effort.

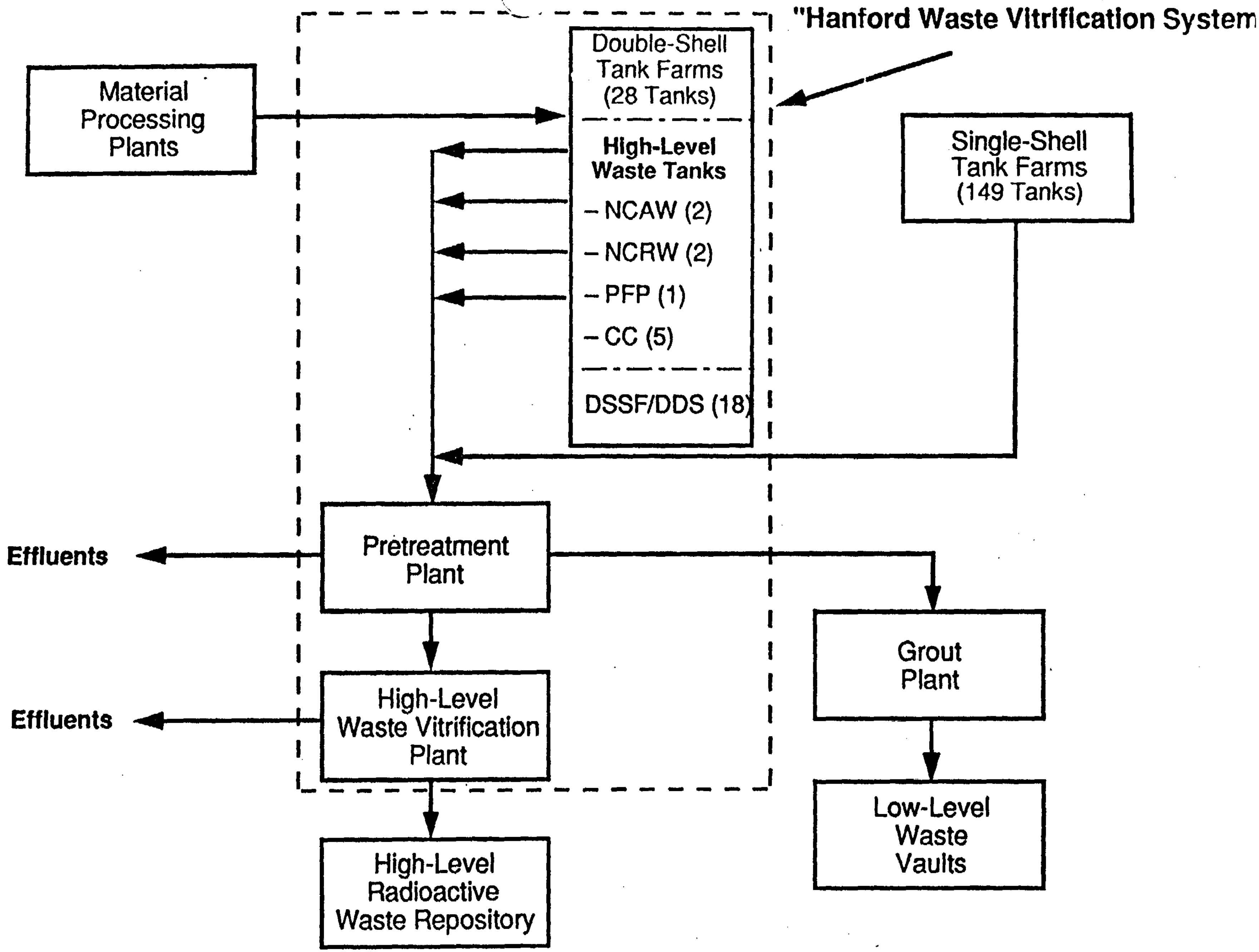

Figure 1: Initial definition of "Hanford Waste Vitrification System (HWVS)"

The fundamental concern, of the Department's management is the scope of the technical difficulties likely to be encountered in bringing on line not only the HWVP facility, but all the supporting systems required for continuous operation. Experience at Savannah River (for example the unexpected phenomenon of hydrogen evolution in feed preparation and other problems in bringing the plant on line) indicates a potential for similar unanticipated problems at Hanford. The prudence of initiating construction of the HWVP in April of 1992 is being questioned based on the increasing level of uncertainty about plant operations at DWPF and many program elements at Hanford.

Within this scope of concern, the technical assessment focused on the status of technology development and engineering practice. The foundation for this approach rests on the logical premise that only technology and man's ability to organize and use technology (engineering practice) are the source of technological difficulties. It is also clear that the HWVS must be assessed in the context of the Department's policy of compliance with all environment, safety, and health regulations and laws.

A capacity for independent engineering review of major projects was created within the Office of Environmental Restoration and Waste Management. Because there is reason to institutionalize this approach, an organization within the Department was selected to provide the broad scope of scientific and engineering expertise and continuity of management. The details of the organization and its structure, charter, and membership are contained in Appendix L. A limited number of subgroups were established with specific focuses (phenomenology, process engineering, facility engineering, regulatory requirements, and management and control) to examine all subsystems. Los Alamos National Laboratory was assigned the responsibility of organizing the resources and providing technical leadership to execute the task. Personnel from Sandia National Laboratory were involved to add the experience of a production-oriented organization in accomplishing these goals.

A technical assessment, even if directed toward technology development and engineering practice, can provide a broad response. To further focus the effort, a basic question was proposed: "Is it prudent for the Department to begin construction of the Hanford Waste Vitrification Project in April 1992 if there is not reasonable assurance that the Plant will operate in an efficient and cost-effective manner?" Further criteria were presented for a successful project: "Could high-level radioactive waste from all the double-shell tanks be processed on a reasonably continuous basis and would the result be a waste-form that is formally acknowledged as acceptable for disposal in the repository?"

Two conditions arise immediately from the definition of the basic question and the further criteria: if the Vitrification Plant is to run continuously, the entire system must be developed and running; and if the waste is to be formally acceptable, the details necessary for the licensing arguments must be considered and their development must be underway. These implied conditions helped define and focus the line of inquiry for the review process.

The plan for the execution of the technical assessment is presented in Appendix N.

III. GENERAL TECHNICAL ASSESSMENT

The General Technical Assessment provides the findings basis for Sec. I, the Executive Summary. Technical Assessment factors taken from Sec. I are repeated here (in bold italic and quotation marks) followed by the supporting findings. The supporting findings are drawn from the analyses of the five review subgroups. Findings that appear similar are the result of similar concerns raised by different subgroups. Similar findings were included because they were judged to include significant differences in viewpoint. Detailed analyses and the rational behind the findings are contained in the Appendices C through G Subgroup Assessments.

III.A ***"Significant disruption in the initial and subsequent waste feed for the vitrification plant will occur as a result of two factors."***

FINDING

Pretreatment facility modifications to achieve full regulatory compliance will be expensive and lengthy with no assurance of a successful outcome.

There appear to be no insurmountable technical problems. However, there are a number of serious concerns and problem areas whose solution (a) will require considerable financial and technical investment to rectify and (b) may incur great start-up and operational difficulties and substantial additional expense during maintenance of the HWVS facilities. The only potentially insurmountable problem in the HWVS is the necessary regulatory approval to use B-Plant for pretreatment.

The planning and engineering feasibility studies for retrofit of B-Plant for pretreatment appear technically well thought out. Several retrofit plans have been developed in differing levels of detail to address increasingly stringent regulation and permitting scenarios; however, these will require significant further development to serve the waste vitrification process in a timely and cost-effective manner.

The probability of B-Plant satisfying the current criteria for TRUEX radiochemical processing operations is questionable and must be resolved. The methodology presented for modifications to B-Plant appears to be in the conceptual stage. Long-term pretreatment requirements might be better met in a new facility.

A comprehensive evaluation of B Plant I&C System upgrades has not been conducted. Minor equipment upgrades do not address long-term commitments to the facility.

FINDING

There are no significant regulatory compliance issues that, at present, should stop or seriously delay the HWVP. There are, however, several key issues that could impact the HWVS if not they are not resolved in a timely manner. For both HWVP and the larger HWVS, effective resolution of compliance issues will be key factors in program success.

This finding by the Regulatory Subgroup considers issues raised by the existing Tri-Party Agreement (TPA). It is recognized that these issues were raised by the Office of Environmental Restoration and Waste Management with respect to meeting Department of Energy (DOE) regulations, and subsequently were incorporated into the Agreement.

The TPA is the predominant vehicle for resolving DOE's cleanup and compliance obligations in and around Hanford necessary to protect the public health, welfare, and environment. The TPA establishes schedules for achieving compliance with requirements for hazardous (including mixed/hazardous) waste management facilities and provides the framework for cleanup of Hanford over the next 30 years. It is a dynamic, negotiation-based regulatory compliance decision vehicle. Thus, changes are slow, even if they are well founded. The pace at which the crucial HWVS regulatory decisions are likely to be made and the uncertainty of the results in negotiating changes in the TPA do not appear to support the ambitious HWVS schedule.

TPA issues of particular concern are Seismic qualification of the planned pretreatment facility (B-Plant); double containment of B-Plant process cells, sumps, and transfer lines; integrity of the B-Plant piping to accomplish the new mission; and waste tank content characterization needed to help determine the pretreatment options for continuous HWVP feed.

Securing authorization to operate B-Plant under the provisions of the Resource Conservation and Recovery Act (RCRA) is by no means certain. For the near-term TRUEX demonstration, interim status of B-Plant appears to be a reasonable assumption and one the State supports. However, considerable work will be required to demonstrate that the Plant can meet RCRA requirements for operations over the long time-line envisioned for the Project. Adequate characterization of tank wastes for hazardous constituents has not been sufficiently completed to comply with RCRA Underground Storage Tank (UST) requirements. The data generated from this characterization will be used in establishing the pretreatment processes needed for the expected range of wastes.

FINDING

Development and demonstration of pretreatment technologies to reduce glass volume and concomitant cost for processing the waste from the remaining eight tanks will require a focused and strengthened program, an accelerated schedule, and significant resources.

The TRUEX process, a specific (Trade name) solvent extraction process, or an unidentified alternative process for removal of transuranics (TRU) from high-level waste (HLW) is essential for economic vitrification of post-NCAW. The TRUEX technology proposed for the pretreatment of NCRW, CC waste, and PFP waste has undergone limited development. Extensive laboratory study and pilot plant development will be required to demonstrate TRUEX technology. This is a high-risk concept with considerable potential for failure.

The TRUEX process holds great promise for reducing the volume of glass and its cost of production. It has been a baseline element in the pretreatment process since the mid-1980s. However, the development pace for this process, a process that has a high probability of not working, has not been consistent with significant cost reduction that it can provide. This process is still at the laboratory bench scale, and pilot plant operation are not scheduled until the fall of 1997. Other solvent extraction processes have not been considered. Alternative pretreatment processing technologies, to be available in case the solvent extraction methods fail, have not been pursued. The TPA requires that vitrification of waste begin by the year 2000 and there is currently no backup strategy for handling the eight tanks if the TRUEX process does not work-all the eggs are currently in one basket.

Before the resources for the pretreatment process are committed, the total life-cycle cost analysis should be completed to show that the expenditure is justified by the benefits. This situation, by eliminating the facility for the ion exchange step of pretreatment for the first two tanks, is likely to delay the start of hot operations in the vitrification plant by several years.

An approach of blending selected waste feeds to provide continuity of HWVP feed and limit feed variations was not presented. Feed blending and limited pretreatment options are to be covered in the new baseline scheduled for issue in October 1991. Any decision to reduce feed variations by blending must await further characterization of the various tank wastes.

Delaying construction of HWVP affords additional opportunities to take advantage of technology and the engineering and operating experiences of the West Valley Demonstration Plant (WVDP) and the Savannah River DWPF. It also allows time for further development of retrieval and pretreatment systems technology needed for optimum systems integration and to assure continuity of operations.

The Process Engineering team was unable to identify any future technology that could reasonably reduce the cost of the project or improve the processing capability within a reasonable time frame.

III.B *"DWPF is the prototype for HWVP. The Department's plan was to derive technology, design, and operating experience from DWPF before the design for HWVP was frozen. There have been significant difficulties in bringing DWPF on line. Operating experience from DWPF will be advantageous to HWVP in understanding the nature of operating problems such as:"*

FINDING

Transfer of lessons learned at West Valley and Savannah River to HWVP does not appear to be a coherent or uniform process, and to date, maximum benefit has not been obtained. At the basic science level, the functional knowledge and understanding of the phenomena associated with the processes are being transferred. Experimental work and technology do not appear to be well coordinated [TNX vs Pacific Northwest Laboratory (PNL)] with the vitrification process development at West Valley. Currently, DWPF is going through significant difficulties with start-up of process operations and the facility and process control systems. The opportunity exists to profit by "lessons learned" from DWPF design and start-up processes. Communication to provide technology transfer between HWVP and DWPF occurs at regularly scheduled managerial level meetings and day-to-day through a single resident engineer. Realization of the technology transfer opportunities appears very limited considering the quantity of useful information and value of the findings being generated at DWPF.

It would appear prudent that a team of Westinghouse Hanford Company (WHC) people, who would be ultimately responsible for bringing the HWVP on line, should be an integral part of the team bringing DWPF on line. WHC management has acknowledged the importance of training; because Westinghouse is the M and O contractor at both sites, there appears to be no formal impediment to such a cooperative effort.

III.C *"Numerous HWVP conceptual design issues remain unaddressed. Research and process studies are being conducted in parallel with Title II design. Lessons learned from the DWPF design shortcomings have been and are currently being integrated into the facility design. There is an advantage to suspending Title II design of the HWVP until the issues are*

satisfactorily resolved, the studies completed, and other start-up and operational data are available."

FINDING

Continuity of feed to the vitrification plant following processing of the two tanks is not assured.

The process technology, design, and engineering of HWVP are ready to support construction; however, the technology and engineering of the upstream processes necessary to supply continuous feed for vitrification are not well developed, and there are some phenomena needing further study. Resolution of these issues is essential for proper and efficient operation of the waste treatment process.

Process technology and engineering appear adequate to allow retrieval, pretreatment, and vitrification of two DSTs NCAW. WHC estimates that two years will be required to process feed from the two NCAW tanks. If HWVP construction is initiated in FY 1992, there is a high probability that vitrification will be shut down for lack of feed after all NCAW is processed.

The technology and engineered systems required to retrieve and pretreat the high-shear-strength solid waste from the other eight double-shell HLW tanks (post-NCAW) have not been developed sufficiently to ensure continuous feed to vitrification. Technology development has been deferred because tank safety issues have received higher priority for both resources and funds. Technology and engineering requirements for recovery of waste from the 149 SSTs are in the conceptual stage.

FINDING

Many uncertainties related to physical and chemical phenomena must be addressed before reasonable assurance can be provided that the HWVS can be operated in a continuous and cost-effective manner. Hanford is aware of most of these uncertainties, and there is sufficient time in the current schedule (hot-startup around the year 2000) to address them, but the presence of a detailed plan identifying the need and strategy for resolving each uncertainty within the context of the HWVS is not apparent. A well-conceived, focused, and well-funded research and development program must be implemented to address these uncertainties.

Two significant observations with regard to assessing the risk of technical failure of the HWVP are (1) the risk of failure could be significantly reduced or at least much better defined if commitments to the current vitrification plant design could be delayed until hot operations were initiated at DWPF (and to a lesser extent WVDP) and (2) Hanford does not appear to be aggressively pursuing cost-effective pretreatment alternatives to the TRUEX process. Viable backups to TRUEX are necessary to ensure the success of the HWVP as pilot plant testing of TRUEX is not scheduled until at least 1997.

III.D *"Lack of understanding of double-shell tank waste characteristics. Chemical and physical characteristics of the waste need to be understood if processing problems are to be solved. The characterization program specifies 55 samples taken from 10 tanks; only 17 have been obtained to date. The sample program has been interrupted to support the safety program, and completion of sampling is expected in 1998."*

FINDING

Physical characterization - The physical characteristics of NCRW and PFP waste sludges (those with high shear strength) must be better understood before retrieval processes can be developed.

Chemical characterization - There are considerable uncertainties in the quantities and specification of various chemical constituents in the wastes (even the major constituents). Most of the information currently available is based on historical information and flow sheet calculations, which have large uncertainties. More information is needed to better define pretreatment and vitrification plant requirements. Development testing has shown that small changes in composition can have large effects on glass processing characteristics and product quality. Uncertainties in waste composition have forced HWVP to devote considerable resources to determining a glass composition "envelope" that results in acceptable processing and product quality characteristics. If the waste compositions were better known, these efforts could be better focused, and the probability of successfully vitrifying and qualifying the waste for disposal would be enhanced.

Minor constituents - The expected quantities of key minor constituents in the wastes (e.g., ^{129}I, noble metals) must be verified by direct analysis of waste samples. These constituents can have profound effects on pretreatment and vitrification plant requirements.

III.E *"Lack of a reasonable understanding of the total life-cycle cost of the proposed system and the effects of various alternatives for treating and processing the wastes on cost. Processing technology can significantly affect the total cost of the program, and 10s of billions of dollars can be involved. Costs and the framework in which they are estimated need to be understood before action can be prudently taken. Full understanding of program* *actions, costs, and risks should be achieved and accepted before major decisions to construct projects are made."*

FINDING

DOE-RL/WHC have not adequately analyzed the costs, financial requirements, and potential commitments related to the various program elements and uncertainties.

Technology uncertainties were not fully recognized in the initial HWVS definition, were under-budgeted, and have been under-resourced. Detailed Program schedule milestones have slipped and disconnects are emerging.

III.F *"The imperative to consider single-shell tank remediation now. Unavailability of B-Plant results in an immediate need to consider a new double-shell tank waste pretreatment facility. A new pretreatment plant is to be addressed with single-shell tank remediation decisions. Single-shell tank processing requirements far outweigh double-shell requirements. Therefore, the needs of single-shell tank remediation must be addressed before an alternative processing facility and technology are proposed."*

FINDING

The 149 SSTs hold approximately 45,000 m^3 of sludge and salts accommodating 170 MCi of radioactivity. The bulk of the radioactivity, 160 MCi (99%), is contained in 75 of the tanks. These 75 tanks also contain 92% of the 70 kCi of TRU activity.

Current thought is that the all SSTs will have to be processed. Although the distribution of the radioactivity in the tanks indicates that approximately half the tanks provide no significant threat, they still may require processing because they contain hazardous material and are likely to be regulated under RCRA. An as-low-as-reasonably-achievable (ALARA) analysis of the situation is necessary to understand the effects of the processing. It is not clear that all have to be treated as HLW. However, there is a requirement that the HWVP be capable of processing the waste from all the single-shell tanks if the decision is made.

If the full 45,000 m^3 of material has to be processed as HLW, it is estimated that 34,000 canisters of glass will be produced. It is possible to reduce this to 10,000 canisters through the TRUEX process or an alternative process of equal capability. The critical point is that although TRUEX is recognized as important to the processing of the DSTs, it will be far more meaningful in processing the SSTs. If TRUEX is not developed, it will take approximately 100 years to cleanup the SSTs at a rate of 320 canisters a year. The milestone of 2018 for this objective will be in doubt.

If the SSTs are processed, a significant number of new DSTs will have to be constructed. This results primarily from the chemistry of the solids in the tank. When removed from the SSTs, the salts will have to be dissolved. Saturated solutions of sodium salts are about 12 Molar, and the salts will have to be diluted to about 6 Molar to be processed. An amount of water equal to the initial volume must be added to achieve this required dilution.

III.G *"The HWVP and the HWVS are being managed as separate entities with little integration. Resources are allocated on two priority scales. A fully integrated management structure and program plan, with properly allocated resources, would be prudent before any major construction activities are undertaken. The continuation of the current method of allocating funds, with the HWVP receiving dedicated project funds and with the balance of the system development effort competing for program funds that are distributed on a site-wide priority basis will ensure a continually widening gap between the completion of the HWVP and the completion of the balance of the HWVS."*

FINDING

The project and system are managed as separate entities with little integration. Requisite HWVS/HWVP objectives, assumptions, plans, and detailed requirements are in fragmented documents or have not been formally documented and validated.

The lack of strong leadership and active integration is a serious handicap to the HWVS. Distinctive responsibility boundaries, both internal and external to WHC, are preventing the program from achieving success. Two Department of Energy-Richland Operations Office (DOE-RL) organizations, Operations, and Environmental Restoration and Projects, and one Westinghouse organization, WHC Division 85000, perceive ownership/responsibility for the HWVS, including the HWVP subsystem. Communication and coordination between the DOE-RL organizational owners is inadequate. Accountability is diffused. (The organizational structure and relationships are shown in Appendix B as Figs. B-1, B-2 and B-3).

DOE-RL and WHC are using a task-based "discovery" approach in place of proactive, integrated Program management. Available funds, rather than proactive, integrated Program planning, define the extent of tasks authorized, placing the Program at risk.

Funding fluctuations in each fiscal year make effective HWVS Program planning and management difficult and result in loss of program integration. Funding and technology issues also are controlled and resolved independently of each other

A comprehensive, integrated technology and engineering development plan for the HWVS does not exist. Characterization, retrieval, and pretreatment have not received as much attention, resources, or funds as the HWVP. Lack of a coherent plan to develop these subsystems in a coordinated manner has hindered efforts to develop an integrated overall plan for vitrification of DST wastes. In the absence of an integrated technology and engineering plan, the three owners are reacting independently to programmatic questions and concerns. Reactions driven by DOE-HQ questions include the Risk Assessment Study, the Redefinition Study, multiple pretreatment assessments, and the Red Team Review.

Process systems integration (waste retrieval, pretreatment, grout production, and vitrification) also is limited. Planning and scheduling for sequential operations (NCAW, NCRW, CC waste, and PFP waste) is incomplete. Process Instrumentation and Control Systems for the HWVS are separated into three areas of responsibilities: the waste tank farms, pretreatment (or B-Plant), and HWVP. A definitive, integrated, and coordinated effort has not been organized.

FINDING

HWVS engineering practice is inadequately defined and informally implemented.

HWVS engineering practices are defined inadequately in terms of procedures and are applied informally to work activities. The formal, consistent use of standard engineering practices, such as statistically developed experiments and specifications, analysis of data for statistical validity, engineering design of experiments, quality assurance (QA) reviews, and process tolerances/specification ratios, was not evident.

HWVS source documents [Record of Decision (ROD), TPA, DST Waste Disposal Integration Plan] have not been effectively converted into a technical requirements document hierarchy that drives the Program and the HWVP subsystem. The absence of a controlled requirements document hierarchy has resulted in numerous interpretations of program assumptions and requirements that are not always consistent or cost-effective. Technical assessment studies (the Burris Report, the Noordoff Study, the PNL technology development reports) are used directly as specifications and requirements documents without formal management review and endorsement.

An unarticulated requirement for zero technical risk is an element of on-going engineering efforts, is consuming resources, and is probably unachievable in light of historical funding practices.

FINDING

Additional management skills and processes are needed to assess the current HWVS technical uncertainties

Technical performance metrics are not sufficiently defined or used to assess system development progress. A formal, management-controlled, well-understood and executed technical assessment and decision process is not evident. As a result, it is not evident that management is bringing technical uncertainties and development efforts to closure. Schedule preparation appears to be managements' primary decision-making process.

Technical assessments and decisions can be made at the working level without management review and approval and without system effect considerations. Systematic processes for design verification and validation by the operating contractor must be incorporated. Success of the system depends on future engineering decisions that are uncertain and project commitment by the architect/engineer (A/E) and contract vendors.

Management lacks a proactive process for identifying and addressing emerging regulatory issues.

IV. RELATIONSHIP OF ASSESSMENT TO ACTIONS AND DECISIONS

The technical assessment, although focused on issues of technology development and engineering practice, has identified a number of broader concerns that have varied levels of effect on the technical aspects of the HWVS. This section will outline and address a variety of topics, including the effects of considerations outside the HWVS, the effects of timing on requirements for the HWVS, significant issues related to the HWVP Subsystems, and issues related to management and control. The purpose is to help the reader understand the significance of the technical and regulatory effects on the HWVS.

IV.A Effects of Considerations Outside of HWVS on the System

The HWVS was defined at the beginning of the review and is shown in Fig. 1, Sec. II. Table 1 provides a summary of the content of the 10 DSTs containing the high-level radioactive waste. It should be noted that the level of confidence of the numerical values decreases from the NCAW tanks to the CC tanks. After the review process, the picture of the HWVS was revised to reflect a more complex picture of its structure and operation. Figure 2 shows the Review Team's current understanding of the system. This figure contains additional data that the Review Team believes prudent to address which provide a more thorough picture of some strategies which could facilitate the system's operation. In the following subsection, seven different items are addressed, and they are specifically cross-referenced to Fig. 2.

IV.A.1 Addition of waste to tanks from processing N-Reactor fuel/pumping of SSTs

The DSTs could receive additional waste from two different sources (see A on Fig. 2). One source is the possible processing of irradiated fuel from N-Reactor; approximately 2100 MTU remain to be processed in the PUREX Plant. This fuel, which is approximately 15 years out of the reactor, will produce approximately 1.2 million gal. of additional waste to be added to the NCAW, NCRW, and PFP tanks. The waste to be affected most will be the NCAW, which will see a 42 percent increase in volume. The NCAW is estimated to provide approximately 2 years of feed (including the waste from the N-Reactor fuel processing) for the vitrification plant.

It is important that this waste be transferred to the tanks before the existing feed is processed (year 2001).

If not, it is possible that the campaign to vitrify the NCAW waste will come to a close before the newer waste arrives. If the waste will not be generated on an appropriate schedule to allow a continuous and complete glass-making cam

Table 1

Summary Characteristics of Double-Shell Tanks with High-Level Radioactive Waste

Waste Type/Tank	Supernate	Solids
NCAW 2 Tanks 101 AZ 102 AZ	2000 kgal liquid 3100 Mt salt liquid[6] 26.5 MCi in liquid[6]	3400 Mt total mass solids[1A] 400 Mt mass sludge[2] 3100 Mt mass salt[3] 81.7 MCi in sludge[4] 2.5 MCi in salt[5]
NCRW 2 Tanks 103 AW 105 AW	700 kgal liquid[7] 200 Mt salt in liquid[7] 91 Ci in liquid[7]	1700 Mt total mass solids[1] 800 Mt mass sludge[2] 900 Mt mass salt[3] 2.4 MCi in sludge[4] 91 Ci in salt[5]
PFP 1 Tank 102 SY	500 kgal liquid[7] 200 Mt salt in liquid[7] 7700 Ci in liquid[7]	900 Mt total mass solids[1] 300 Mt mass sludge[2] 600 Mt mass salt[3] 0.2 MCi in sludge[4] 0.3 MCi in salt[5]
CC 5 Tanks 101 AY 101 SY 102 AN 103 SY 107 AN	3400 kgal liquid[8] ? Mt salt in liquid[8] ? MCi in liquid[9]	20400 Mt total mass solids[1] 1100 Mt mass sludge[2] 19300 Mt mass salt[3] 18.0 MCi in sludge[4] 0.8 MCi in salt[5]

Mt = metric tonne MCi = million curries

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1 Total mass of solids in settled solids layer, dissolved and undissolved, on a dry basis.

1A Total mass of solids in supernate and solids layer, dissolved and undissolved, on a dry basis.

2 Total mass of washed sludge to HWVP on a dry basis. This mass is consistent with the "Sludge Washing Baseline Option A" in updated canister projection table (provided informally by P. E. LaMont to Dr. D. Vieth on August 5, 1991).

3 Total mass of water soluble salts expected to be fed to Grout after washing, on a dry basis.

4 Ci in washed sludge to HWVP. NCAW and CC sludge includes Cs recovered from supernate assuming 95% recovery.

5 Ci in supernate plus wash water to Grout.

6 Supernate and interstitial liquor.

7 The volumes and salt contents of NCRW and PFP supernates are current values only. Because they are LLW, they frequently have additional volumes of process liquids added and are routinely decanted and concentrated.

8 Liquid processed together with solids; content of liquid lumped with solids content.

9 Characterization of all Complexed Concentrate wastes tanks is not sufficient for determination of solt and radionuclide content of supernate.

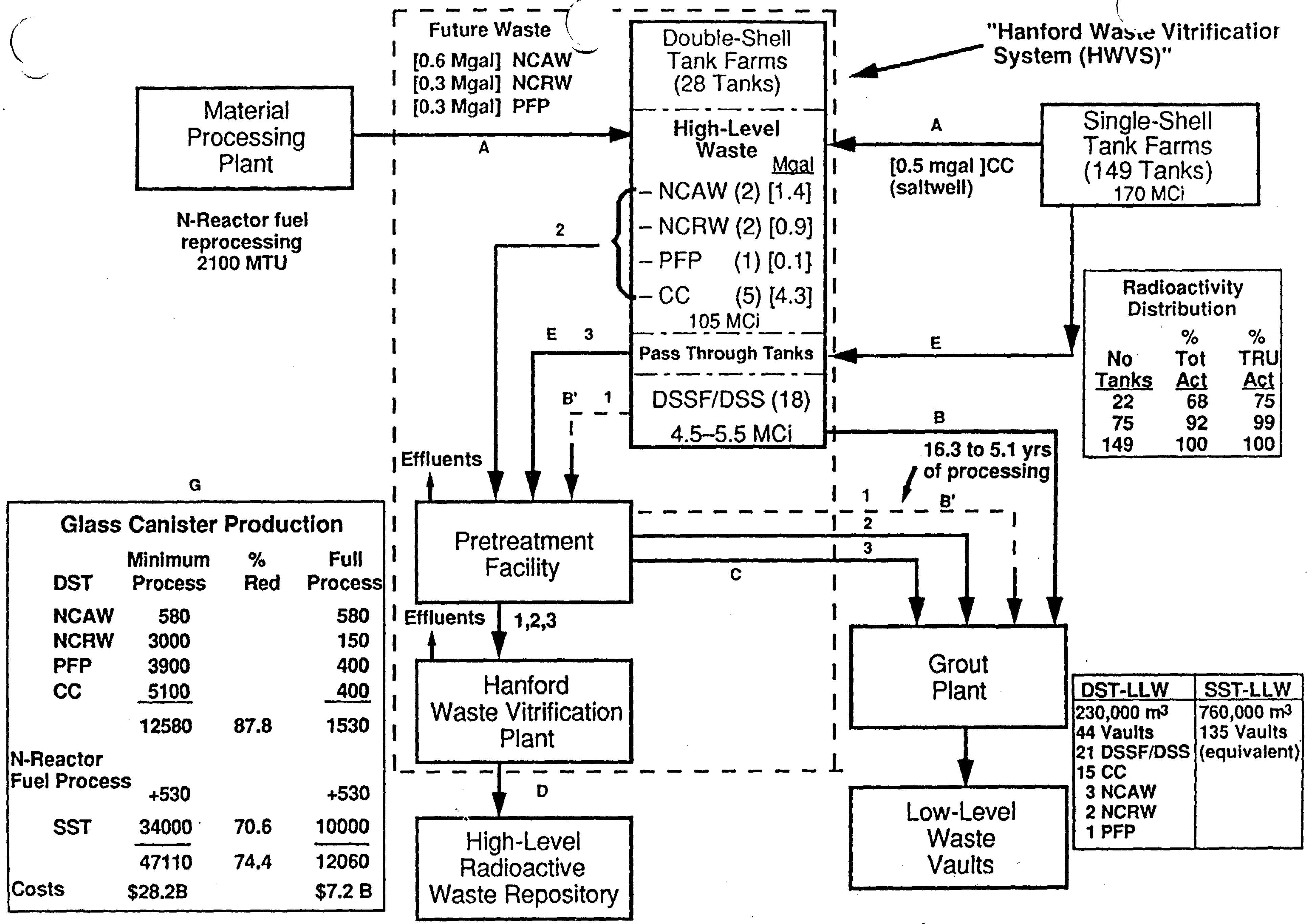

Figure 2: Revised Definition of "Hanford Waste Vitrification System (HWVS)"

paign, then it may be appropriate to postpone the start of the hot operation of the vitrification beyond December 1999.

The second source of waste being transferred to the DSTs generated by salt-well pumping of single-shell tanks. Approximately 0.5 million gal. of radioactive liquids will be transferred to the CC waste tanks. There appear to be no timing or other problems associated with this transfer.

Decision/Action Required: A decision regarding the processing of the 2100 MTU of N-Reactor fuel is required to allow sufficient time to include the waste in the NCAW tanks to be processed in the initial campaign.

IV.A.2 Requirements for radionuclide removal from DSSF/DSS waste

The 20 million gallons of Double-Shell Slurry Feed/Double-Shell Slurry (DSSF/DSS) contain between 4.5 and 5.5 MCi of Cs-137. The current plan is to send this waste directly to the waste grout plant (see B in Fig. 2). There is a question of whether this waste, because of its origin in the processing of reactor fuel, should be considered high-level radioactive waste (see discussion in Appendix J). This issue was raised by the States of Washington and Oregon in 1990. They petitioned the US Nuclear Regulatory Commission (NRC) to clarify its definition of high-level waste pursuant to their response on the proposed Department remediation strategy for Hanford. In its letter (Bernero to Rizzo, September 26, 1989) to the Department, the NRC indicated that they had already agreed that similar wastes at Savannah River and West Valley were not high-level radioactive waste. They also agreed that criteria used by DOE for classification of grout feed as low-level waste (LLW) are appropriate.

If this position is reversed and the Department has to process this waste further through a pretreatment ion exchange system (see B' in Fig. 2), it will have significant cost and schedule effects on the execution of the DST and SST remediation process. It is important to process this material early in the sequence to free DST space for processing the HLW and for SST waste that must be remediated in some manner. B-Plant is the planned site for ion exchange of this waste. If one ion exchange column is used, it is estimated to take 16.5 years to process the waste at a cost of $650 million; with three ion exchange columns in parallel, the time could be reduced to 5.1 years at a cost of $360 million. It also is assumed that the column would remove 99.5% of the Cs. This effort would add another 60 to 100 additional canisters of glass HLW.

The decision on this issue rests with the NRC, which is currently in a rule-making process. The comment period on the issue closed in March, and the evaluation is continuing. A position on this issue is not expected from the NRC until the latter part of calendar year 1991.

Decision/Action Required: If B-Plant is not accepted as a suitable facility for processing radioactive waste and if the DSSF/DSS waste is required to be be processed, then it will be necessary to identify the facility for ion exchange columns to remove the Cs from the waste. Analysis of the effect of the unavailability of the DSTs to support the processing of the HLW and to provide emergency storage for the SSTs also will be required .

IV.A.3 Requirements for processing grout for LLW

There is need to ensure that the plan for processing the low-level radioactive waste into grout is tied coherently to the HWVS and that the criteria for this operation are clearly understood (see C in Fig. 2). Because the Department has no quantitative criteria for LLW, the Department must build its justification for the LLW disposal on the criteria established by NRC for the disposal of commercial radioactive waste (see Appendix J). Because the waste contains hazardous materials regulated under the RCRA, the grout production is regulated by the State Department of Ecology. For a grout campaign to proceed, the results of the TCLP (EPA leach test for toxic material) and the compressive strength of the grout must be acceptable. The factor that will govern the acceptability of the LLW form is its leach resistance. This has resulted in an upper ambient temperature limit on the grout, and this will reduce the amount of radionuclides allowed in the grout. The new criterion does not appear to be a problem because the radionuclide concentration is significantly below the limit (see Table J-1 in Appendix J).

It is possible that conditions not related to disposal of radioactivity in LLW grout could affect the process and subsequently affect the operation of pretreatment and the vitrification plant. Examples of conditions include the compressive strength of grout or the leach rate of the hazardous waste constituents.

Decision/Action Required: Better definition of operational plans for converting the LLW from the pretreatment facilities to grout and interim storage requirements to support processing operations is needed. The technical characteristic specification of the grout to be sent to the LLW vaults needs to be better defined.

IV.A.4 Acceptability of glass composition for disposal in the repository

The primary output of the HWVS is glass high-level radioactive waste that is to be sent to the repository (see D in Fig. 2). For this operation to be considered successful, the waste actually must be disposed of in the repository. In this enterprise, the roles of two other agencies must be recognized - the Office of Civilian Radioactive Waste Management (OCRWM) and the NRC. In this effort, OCRWM plays the role of the licensee and the NRC is the regulator.

As the licensee, OCRWM has established waste acceptance criteria for the material they will handle. They believe that if the waste-form meets these basic criteria, they can build the engineered barrier system to satisfy the performance criteria the NRC will use to license the OCRWM to receive and dispose of waste. The OCRWM position is that there is no relationship between the repository performance criteria and the waste acceptance preliminary specifications. The NRC currently disagrees with this position because there is little in the way of technical analysis to show that an engineered barriers system can perform in a manner to satisfy the performance requirement given the release rate criteria from its waste-form established by OCRWM.

The technical basis of this issue is discussed further in Appendix H.

Decision/Action Required: The Department needs to pursue with the NRC the identification of a method (Rulemaking or Licensing Topical Report) that would allow the technical issue of waste-form composition and its acceptability to be resolved before glass is produced.

IV.A.5 Impact of SSTs on HWVS

There are 28 DSTs that hold 6500 m^3 of sludge accommodating 110 MCi of radioactivity. Ten of these tanks contain the bulk (105 MCi) of the radioactivity. The 149 SSTs hold approximately 45,000 m^3 of sludge and salts accommodating 170 MCi of radioactivity (see E in Fig. 2). The bulk of the radioactivity, 160 MCi (94%), is contained in 75 of the tanks. These 75 tanks also contain 92% of the 70 kCi of TRU activity. Table 2 provides a summary of the situation with respect to the SSTs and their impact on the HLW and LLW generated.

Current thought is that the all SSTs will have to be processed. Although the distribution of the radioactivity in the tanks indicates that approximately half the tanks provide no significant threat, they still may require processing because some tanks contain hazardous material and are likely to be regulated under RCRA. An ALARA analysis of the situation is necessary to understand the effects of the processing. It is not clear that all have to be treated as high-level waste. However, there is a requirement that the HWVP be capable of processing the waste from all the SSTs if the decision is made.

If the full 45,000 m^3 of material has to be processed as HLW, it is estimated that 34,000 canisters of glass will be produced. It is possible to reduce this to 10,000 canisters using the TRUEX process or an alternative process of equal capability. The critical point is that although TRUEX is recognized as important to the processing of the DSTs, it will be far more meaningful in processing the SSTs. If TRUEX is not developed, it will take approximately 100 years to cleanup the SSTs, producing 34,000 canisters at a rate of approximately 320 canisters a year. Considering either processing scenario the milestone of 2018 for this objective will be in doubt.

If the SSTs are processed, a significant number of new DSTs will have to be constructed. A major factor in the need for increased tank space results primarily

Table 2
Single-Shell Tanks
Summary for Situation and Options

149 Tanks
170 MCi Total Radioactivity (*90-100 MCi from DST to Repository)
70 kCi TRU Activity
45,000 m^3 Sludge Volume (53,000 Mt)
140,000 m^3 Total Volume (liquid and solids)

High-Level Waste	Low-Level Waste
With Minimal Pretreatment	**With Minimal Pretreatment**
14,000 Mt of solids to glass (34,000 canisters) 170 MCi to glass	165,000 Mt of solids for disposal 2 MCi for disposal
With Full Pretreatment	**With Full Pretreatment**
4,000 Mt of solids to glass (10,000 canisters) 170 MCi to glass	287,000 Mt of solids for disposal 2 MCi for disposal

Distribution of Radioactivity with Single-Shell Tanks

	22 Tanks	75 Tanks	149 Tanks
Total Activity	120 MCi	160 MCi	170 MCi
% of Radioactivity	68	92	100
TRU Activity	52 kCi	69 kCi	70 kCi
% of Radioactivity	74	94	100
		16 Ci Np-237[1] 5000 Ci Tc-99	

[1]Difference between 149 and 75 tanks

from the chemistry of the solids in the tank. Once removed from the SSTs, the salts will have to be dissolved. Saturated solutions of sodium salts are about 12 Molar, and to process them, the salts will have to be diluted to about 6 Molar. An amount of water equal to the initial volume must be added to achieve this required dilution.

Decision/Action Required: The effect of the SST waste on the capacity of the HWVS needs to be examined and fully understood. If B-Plant is not acceptable for pretreatment of the DST waste, then the processing and facility requirements for the SSTs need to be considered now. The cost and time required for processing the single-shell tanks can dictate a different technology of configuration or facilities.

IV.A.6 Effect of cost on HWVS development strategy

The total cost, based on elementary analyses, of producing the glass HLW form is significant (see G in Fig. 2 and Tables 3 and 4). A canister of waste currently is estimated to cost $600,000. (See Table 3 for data on how this estimate was achieved.) For both the DSTs and SSTs, there can be a significant swing in the amount of glass and its costs depending on the assumptions and operational conditions. As noted in Table 3, it is possible to reduce the number of canisters of DST waste by 87%, but it requires that the TRUEX process or an equivalent be developed. It represents the difference between $8 billion and $1 billion in processing costs. As noted above, the TRUEX process will have its greatest economic effect on the SSTs. Data provided indicate that the TRUEX process will achieve a nominal reduction of 75%, but the dollar value is significantly different as shown in Table 4. For both the DSTs and SSTs, TRUEX can mean a difference between $28 billion and $7 billion in processing and disposal costs.

Care must be taken in using these financial estimates because the volume of waste to be sent to the repository is increased significantly over the basis used to allocate costs. The figures in Tables 3 and 4 are based on the estimate that a total of 16,000 glass canisters would be provided, or approximately 15% of the repository volume. With the glass from the DSTs, on the high side, this would increase the number by 12,000 or a total of 26,500 cans produced, a 75% increase. If TRUEX does not work, and if both types of tanks are processed, then an increase of 45,000 cannisters, or 180%, would be experienced. In either case, the total basis for the cost figure would have to be reestablished. However, the point remains that the TRUEX process can have a significant effect on costs.

Decision/Action Required: Total life-cycle costs need to be developed for the various technical and operational options. Current cost analyses were not sufficient to provide a good basis for discriminating between options. Although

Table 3
Summary of Alternative Approaches to DST Pretreatment of HLW Glass Production

	Canisters of Glass								Costs
	NCAW	NCRW	PFP	CC-E	CC-W	Σ*	ΣΣ	%Red[1]	$ B[2]
Minimum Process Baseline	580	3,000	3,900	1,400	3,700	--	12,580		7.55
TRUEX Process Baseline	580	150	400	500		--	1,630	87.0	0.98
Option 1	580	*	3,900	*	3,700	2,200	10,380	17.5	6.23
Option 2	580	*	*	*	3,700	5,800	10,080	19.9	6.05
Option 3	580	*	*	1,400	3,700	2,200	7,880	37.4	4.73
Option 4	580	*	*	*	3,700	3,100	7,380	41.3	4.43

Option 1 = Blending NCRW, and CC-East (after Sludge Wash and Ion Exchange)
Option 2 = Blending NCRW, PFP and CC-East (after Sludge Wash and Ion Exchange)
Option 3 = Blending NCRW and PFP (after Leaching to Remove Chrome)
Option 4 = Blending NCRW, PFP and CC-East (after Leaching to Remove Chrome)

[1] % Reduction of canisters is based on difference between proposed option and minimum process baseline

[2] Cost is estimated by multiplying the cost percanister by the total number of canisters
Cost percanister is $600,000 ($250,000 for production; $350,000 for repository disposal fee)

Table 4
Glass Canister Production Quantities and Costs

DST	Minimum Process	% Red.	Full Process
NCAW	580		580
NCRW	3000		150
PFP	3900		400
CC	5100		400
	12580	88	1530
N-Reactor Fuel Process	(+530)		(+530)
SST	34000	71	10000
	47110	74	12060
Costs	$ 28.2 B		$ 7.2 B

TRUEX appears to have significant cost advantages, other waste processing options, (with modest production cost penalties) could allow for more timely conversion of waste into glass.

IV.B Effects of Timing on Requirements for HWVS

IV.B.1 Tri-Party Agreement

Timeliness of actions are critical to the successful operation of the HWVS. A number of factors have significant impact on the requirements for and implementation of the HWVS. This section examines a number of these factors and presents an analysis of their implications. Issues that will be covered are the Tri-Party Agreement, availability of information and technical data, processes for pretreatment, facilities for pretreatment and additional tanks to support process operation.

The TPA is the document that has codified the agreements of the Department, the Environmental Protection Agency, and the State of Washington with regard to the technical actions and timing necessary to remediate conditions at Hanford. It represents the best judgment and expectations at the time, based on then-current information and understanding, of the individuals who negotiated the Agreement. The negotiations required that the individuals involved make long-term judgments about solutions to technical issues as well as the political milieu (funding available to execute technical programs necessary for success) that would be in vogue at the time. These judgments resulted in proposed time frames and operational milestones that appear to be interpreted as accurate predictions as opposed to best estimates. The milestones also represent commitments to complete remediation actions, but they are only valid within the effectiveness with which technology and engineering practice can be developed.

Today, with respect to the HWVS and HWVP, it is not clear that estimates of time required to complete certain tasks and the assumptions that supported them are consistent with reality. For example, the perspective that all DSTs could be processed continuously beginning by 2000 and produce 1500 canisters of glass is not one that reflects current reality. This is based on the baseline assumption that B-Plant would be suitable and available for the pretreatment of all DSTs. The possibility that B-Plant may be unacceptable because of regulatory concerns puts the "by 2000" requirement to initiate hot processing of waste in serious doubt. The expectation that 1500 canisters of glass would be produced was based on the assumption that the TRUEX process could be made compatible with the DST waste and that all the operational difficulties with the solvent extraction process could be resolved in that time frame. TRUEX has been tested only on a laboratory scale (only gram-size samples) and must be demonstrated on a pilot plant scale with real Hanford waste to be a valid industrial-scale process and that operation is not scheduled until 1997. It is also believed that the problems with processing the waste containing noble metals in the melter would occur without significant setbacks. This is not assured at this time and remains a technical concern. This is expected to be a concern for the NCAW tanks, which have high noble metal content.

In the case of technology development and demonstration for situations where accidents and failures are unacceptable, if schedule becomes the dominant driving force at the expense of having time available to resolve technical/ operational issues, then the federal government can expect significant additional expense in correcting problems generated by providing systems or initiating operations before technical issues have been adequately resolved.

An observation made in the review about the Defense Waste Remediation (DWR) Program (which encompasses the HWVS) is that it is schedule-driven. The genesis of this situation could not be isolated; it appeared to have several causative factors. The pressure to fulfill the requirements of the TPA can be viewed as a factor contributing to this programmatic shortcoming.

IV.B.2 Availability of information and technical data

Under the current programmatic approach, it is unlikely that the data necessary for the successful execution of pretreatment process development will be available on the required schedule. There are several reasons for this concern. The first is that there appears to be a limited number of personnel devoted to the chemical process development effort. Second, there is an informality in this development area that is inconsistent with its significance and value. Basic principles of project management and project control would be useful. The process development effort that produces the various alternative flow diagrams, mass balances, and energy balances does not utilize any of the baseline and configuration control methodology to keep adequate records and a current baseline. It is argued that flow diagrams are in a preconceptual stage and data are insufficient to warrant baseline and change control. On the other hand, the systematic documentation of the lack of data for such a critical part of the operation is a way to drive home the need for the resources to obtain the data. Such details allow for ready evaluation of the status of the process development. Unless the formality of this operation is improved, the timeliness with which data will be available and useful on a systematic and authoritative basis is speculative at best.

IV.B.3 Processes for pretreatment

The processes for pretreatment are the linchpins necessary to maintain the vitrification of HLW in the reasonable cost range. If this point is recognized for its importance in the HWVS, then significantly more emphasis needs to be placed on the planning of programming activities and evaluating results within the concept of program objective. Currently, the development of options or alternatives is not well defined or structured.

The program appears to be affected by two poles. The first pole is the promise of TRUEX to significantly reduce the number of canisters of glass. Because of this promise and confidence in the TRUEX process, it appears that work on alternative approaches has not been pursued with appropriate emphasis. If the development work on TRUEX fails, it is not obvious what alternative pretreatment process would be used or even available. The significance of this point with respect to process cost, as well as political and regulatory consequences, needs to be more thoroughly appreciated. In view of the commitments of the Department in the TPA this is not an issue that can be ignored. The second pole is represented by the staff of the vitrification plant who believe that they can process any waste stream into a glass and have it be acceptable for the repository. This is a somewhat cavalier perspective in view of the costs that are involved.

If processes for pretreatment are to be conducted in a realistic perspective, better planning will have to be done, alternatives will have to be properly defined and examined, and a more disciplined approach to the program/project management/cost commitments will have to be imposed on this area.

IV.B.4 Facilities for pretreatment

For the pretreatment processes to be effective, four types of basic facilities will be required.

IV.B.4.a A process development facility that can handle the actual high-level radioactive waste

IV.B.4.b A facility for settling and decanting the waste

IV.B.4.c A production processing facility

IV.B.4.d An evaporator to reduce the liquid volume before the waste enters the vitrification plant.

From the timing perspective, there will be difficulties in the area of facilities. The process development is proposed to occur in the Waste Encapsulation and Storage Facility (WESF), a newer facility built on the end of the B-Plant. Renovation of this facility is required; however, at current funding profiles, the pilot plant is not scheduled for operation until September 1997. The pilot plant is expected to complete its operation by October 1997. There is not reasonable time for the design and installation of the process equipment in the production process facility that is necessary if vitrification plant is to operate continuously in 2002 with this development schedule.

The AR Vault has been proposed for use as the settle/decant portion of the preparation of the waste in the tanks on the way to the pretreatment facility. AR

Vault is of the same vintage as the B-Plant, and the Department and the State of Washington are concerned about its seismic and secondary containment qualifications. It is possible this facility will not be acceptable as part of the production facility complex.

As a baseline facility for the operation of the vitrification plant, the B-Plant was to be used as the production facility for the pretreatment processes. It is an excellent facility from the concept of flexibility in handling the uncertainties associated with the processing of the HLW. The canyon concept, along with the sheer size of the facility, make it well suited for the pretreatment process facility.

However, there are questions about the suitability of the facility. The Department and the State of Washington have raised three issues: (1) the qualification of the facility with regard to the requirement for double containment when processing hazardous materials, (2) the seismic qualifications of the facility, and (3) the capability of the piping to withstand the corrosive character of the processing solutions. It has been indicated that any one condition, by itself, might not be a cause for significant opposition to the use of the plant for production operations, but all three taken together make it almost impossible for State officials to support the proposal to use the facility. A Part B RCRA permit is required to operate the facility, and the State is not likely to grant the permit. The State appears to be willing to support the use of the facility as a development facility that has a short operational period (1-2 months) in which high-level waste will be processed. The State's position will have a significant effect on the timing of the availability of facilities for the pretreatment processing. There also will be significant schedule effects if the DSSF/DSS wastes have to be processed for removal of the Cs.

It is likely that the B-Plant will have difficulties satisfying the Department's requirements for non-reactor nuclear facilities. Seismic criteria in the Department Order 6430.1A probably cannot be met. With application of Order 6430.1A to B-Plant, the Department is applying a standard with 30 years of recent development to a facility that is 45 years old. If the Department wants this facility to be the production facility, it will have to waive its seismic requirements related to QA for construction practices.

The current Department policy is to tighten standards with regard to operations of nuclear facilities. Defense Programs, as the prototype for the Department, has significantly stiffened its requirements for compliance with Department Orders, especially Level 1 Orders related to environment, safety, health, QA, and safeguards and security. The level of detail in the review of compliance requirements has significantly increased, but the review process for B-Plant's operation have not been comparable to these in the Defense Programs (i.e., Rocky Flats or Savannah River). It is highly likely that the safety standards for a nuclear facility would prevent it from operating if a similar review were to be conducted. The issue for the Department here is the uniformity in the application of requirements for operation of nuclear facility.

The Department, in response to issues raised by the Defense Nuclear Facilities Safety Board and others, is taking major steps to strengthen its policy with regard to standards related to environment, safety, and health. The Secretary, responding to an inquiry from Congressman Skaggs, stated that the Department has decided to address the issue of utilization of plants designed to standards of previous decades. The approach will be to initiate reviews at each of its facilities to determine whether there is sufficient basis to permit continued safe operation. The Department reviews are performed by a number of different and independent groups, depending on the facility involved. The program executed patterned after the NRC's Systematic Evaluation Program developed evaluate whether and how to apply new standards to older nuclear facilities.

The Department wants to be sure that the facilities it operates meets national standards and its own Orders. It is expected that a list of 93 Level 1 Orders will be identified and the Department will review the contractor's compliance with respect to these orders. B-Plant and the AR Vault will have to be examined in the light of this review philosophy.

The strategy for developing the pretreatment facilities will need to be reconsidered and will have an effect on the pretreatment process development efforts. The most important point to consider is whether the waste in the SSTs are going to be processed. If they are, then the new pretreatment facility will have to be capable of functioning for a minimum of 30 years; if not, then other means of processing the waste, with greater HLW glass production requirements, may be more advantageous in the context of meeting schedule requirements.

The evaporator also will be an important facility for the pretreatment processing. Currently, a similar evaporator in Area 200 that serves several processing facilities is shut down because it does not meet emission control requirements. These are not issues that can significantly delay pretreatment; however, they do have to be recognized now, and actions must taken to keep them off the critical path.

IV.B.5 Additional tanks for support process operation

If the HWVS is to operate efficiently, significant storage space for waste-in-process will be required. As an example, in processing the NCAW tanks, tank space to perform simple mechanical separation in the settle/decant-sludge washing step will be required. Initially, this was to be done in B-Plant, but the limitation of the tank capacity to 8,000 gallons significantly diminished the throughput rate. The use of the AR Vault with its tandem tanks of 50,000 gallons each improved the throughput rate. If the AR Vault is eliminated because of regulatory concerns, the availability of tank space for pretreatment processing can become a schedule-controlling factor.

A tank for NCAW post-pretreatment storage is also a concern. Tank 102 AY currently is identified for the function, but it contains a heel that is suspected to be high in chloride content, a content that can adversely affect subsequent processing steps. The composition of this tank is to be determined through sampling. At that time, the decision regarding the nature of the pretreatment processing will be made. The chloride constituent, if present, can be removed by the simple process of sludge washing.

If B-Plant is not available for pretreatment processing and there is a need to maintain the proposed processing schedules, in-tank processing of some type will be required. Additional tanks will have to be constructed for this requirement. The characteristics for the tanks that perform this function should resemble those of process tanks. Their design will have to be modified to allow for ready removal of the material in the tanks; ready removal of all material from the current storage tanks is not a characteristic of the storage tank design. The material of construction for these tanks may have to be different than plain carbon steel depending on the chemical nature of the in-tank processing. Processes, such as simple sludge washing, can be accomplished in carbon steel tanks. If in-tank processing is going to involve more aggressive process chemistry, the material will have to be more chemically resistant. The selection of materials of construction for the tanks will be dependent on the nature of the alternatives to the TRUEX process.

Processing waste requires attention to two different sets of considerations, the needs for processing the supernates and the needs for processing the solids (salts and sludges) in the tanks. For example, the NCRW has a supernate that has no significant level of radioactivity and can be disposed of as LLW. Because it is in equilibrium with the sodium salts in the sludge, it is about 12 Molar in sodium concentration. To convert the supernate into grout, the sodium concentration in the solution has to be reduced to 6 Molar or possibly lower. This can be accomplished only by dilution which means that the volume of liquid has to be doubled. If 1 million gal. of supernate is removed from the storage tank to allow the solids to be processed separately, it must be stored in an empty million-gallon tank. If the chemical concentration is to be reduced to a half, then the volume must be doubled, and a second million-gallon tank is required.

For the solids in the NCRW tank, the solids will have to be dissolved and removed from the sludge. One kilogram of sodium nitrate will produce 0.5 gallons of 6 Molar solution. This solution will have to be stored on an interim basis until it can be converted to grout and disposed of as an LLW. Sufficient tank space will be required to allow parallel operations; if parallel operations are not allowed and sequential processing is required, the schedule could be severely affected.

The DSS/DSSF tanks are supposed to be the first tanks processed. The importance of this operation is to provide empty DSTs for the purpose of in-process storage of waste solutions. The demand for and availability of tank storage space does not appear to be well developed or documented. Because this requirement can have significant effect on the processing schedules, this aspect will require more detailed development.

IV.C Significant Issues Related to the HWVS

Section 2 examined a number of issues that will affect the timing of the full operation of the HWVS. This section examines a number of technical issues related to the various subsystems of the HWVS.

IV.C.1 Tanks

If the potential phenomena likely (1) to occur in subsequent processing and (2) to be the basis for process chemistry are to be fully understood and anticipated, then the chemical and physical characteristics of the waste need to be known. A DST is 75 feet in diameter, and the area that it defines is approximately 0.1 acre. The tanks contain solids that cover the bottom up to 30 feet deep. In view of the history of the waste's placement in the tanks, it is not likely that it is uniform over this areal expanse. It would be prudent to employ a statistically defined sampling strategy is developed to ensure that the information on composition is, although not totally complete, representative of what is present.

The characterization program that is being developed is strongly driven by tank-safety issues. From the perspective of providing information important to chemical processing of the waste, the waste characterization does not appear to be well developed. In the review it was difficult to understand which data resulting from the characterization program was important to the pretreatment process development. In conducting a characterization program, two basic types of information can be obtained The first is the information that the process engineers "know" they need to design the subsequent processing. This data set, with the supporting logic for the requested data, should be reasonably well defined. For the Hanford tanks, this does not appear to be the case. The second type of information is the speculative data that might provide insights into conditions or situations that were not previously expected (data to support discovery). Unexpected conditions can be revealed by any one of numerous data sets; the selection of which data to collect is based on an intuitive sense of what might be present.

The characterization program at Hanford appears to be one of measuring many parameters, but it is not clear that they have been able to subdivide the data proposed for collection into the two categories noted above. If this cannot be done, then the implication is that the process chemistry is being divorced from the realities of the situation, and the potential for failure in process development is noteworthy.

IV.C.2 Pretreatment

The current program for processing the high-level radioactive waste at Hanford is based totally on the availability of the TRUEX process. This is evident in the study of the 14 alternatives, half of which include and depend on the TRUEX process. This is a particularly interesting perspective in view of the recognized difficulties in matching the complex chemistry of the DST wastes to the complexities of this solvent extraction process.

TRUEX is a solvent extraction process to remove TRU contamination from solids in the waste tanks. It holds great promise for reducing the amount of material that will have to be converted into glass. However, TRUEX has many problems that must be solved before there can be any hope that it will be a satisfactory and reliable production process.

The chemistry of the high-level waste in the tanks, in its initial form, is at best complex. Highly aggressive acid solutions will have to be to added to get most of the sludge into solution so that it is possible to separate it from the TRU radionuclides that are mixed with it. For example, concentrated hydrofluoric acid and aluminum fluoride have to be added to the NCRW to keep the Zr in solution, and oxalic acid must be added to keep the Fe in solution. An initially messy chemistry will get even more complicated in order to keep all components that must be removed by the process in solution. This fact will require close control on feed stock chemistry and the conditions of the process. The chemistry of the system is one in which upsets can occur easily.

As currently planned, the TRUEX process will use centrifugal contactors for the solvent extraction process. This means that the incoming solution will have to be virtually free of particulates. This requirement will emphasize the filtration process to keep particulates out. Filters must be capable of withstanding the highly acid and corrosive environment of the process chemistry and must not clog. Particulates that enter the centrifugal contactors can cause havoc in the process operation, especially if they end up at the interface of the organic solvent/aqueous phase. There are currently problems with "interfacial crud" that results from modest precipitation of components in the aqueous phase. Interfacial crud inhibits the solvent extraction.

A second problem critical to successful operation of the centrifugal contactor is the disengagement time for the separation of the organic and aqueous phases. For centrifugal contactors to work efficiently, this separation must occur rapidly in comparison to the residence time that the solution is in the contactor. If it does not, the TRU component that is to be removed will stay in the aqueous phase and head for the LLW stream. This contamination can elevate the LLW to TRU waste, and the separation will have been totally ineffective. This disengagement time can be completely upset if the organic phase is finely dispersed or if an emulsion is produced.

If a pretreatment plant is to operate efficiently, it will be essential to detect the upsets in chemistry. In a highly radioactive system, this will all have to be done by remote means. This will place great emphasis on the instrumentation to detect the upsets.

Another effect of the chemistry instability is the potential for precipitation on a significant scale. If this occurs, the openings in the centrifugal contactor may become clogged or restricted with solid material, thereby reducing the efficiency or shutting down the process. The solution is to remove the contactors from the process line and clean them. This will have to be done remotely, and because the equipment is small and intricate and has close tolerance, the cleaning operation will be difficult and time consuming.

Centrifugal contactors are precision machines, and their operation can be easily upset by changes in mechanical conditions. Such things as bearing wear and seal deterioration resulting from severe environmental conditions can quickly put these machines out of operation. It may be possible to get complex and sensitive process chemistry to be sufficiently stable to use this approach but have the chemistry of the process cause such a high equipment attrition rate that it cannot be a viable production process.

The success of the solvent extraction process will depend strongly on the characteristics of the organic solvent. For the TRUEX process, CMPO has been selected as the solvent. It has extremely strong affinity for +3, +4, and +6 ionic species of the actinides (U, Np, Pu, and Am). In effect, from a process efficiency perspective, it is possible that the solvent may have an affinity for actinides that is too great; that is, it will be difficult to strip the actinides from the solvent.

There are uncertainties about the durability of such a process. The development of this process has been done on small sample sizes (2- to 5-g size) in a laboratory setting. Sample conditions have been elementary in nature; the complications of a large quantity of impurities have not been experienced. In the real waste, there will be a significant variety of impurities in the process streams, and their effect on process efficiency is unknown. Organic impurities in the waste tanks can be particularly troublesome. All waste tanks have some organics; some situations are mostly small quantities dissolved in the aqueous solution. It is not known how these impurities will interact with the organic extractant. This is one other reason that a pilot plant operating with real waste is critical. Only after such a scale-up will it be possible to determine if the system will really work. A major drawback is the fact that the pilot plant will not operate until 1997, and then it will operate for less than 2 months. The pilot plant is to process waste from the various tanks in this short time - a time frame that is likely to be inadequate.

A critical study for the pilot plant is determining the degree to which the solvent can be cleaned up and recycled. This may be the most critical test in the pilot plant program. If the extractant cannot be cleaned up sufficiently and the solvent recycled, then the process cannot be considered viable as a production-level process.

Alternate processes must be examined, and serious effort must be devoted to their development. TRUEX is a promising but tenuous process in the context of the Hanford wastes that have to be processed. If it cannot be made to work, the Department will be expected to have an alternative to back it up. A number of elementary processes involving blending, sludge washing, ion exchange, and preferential leaching have received cursory examination. Preliminary evaluations of four rudimentary processes are included in Table 3. Examination of the column designated % Red will provide some picture of their effectiveness. Only one has an effectiveness as high as 48% of the TRUEX process. The advantage is that they can work; the disadvantage is they have high processing costs. In those proposals, difficulties that are present are not immediately obvious. For example, in-tank sludge dissolution for NCRW will be difficult. The hydrofluoric acid solution is likely to be too aggressive for a carbon-steel tank or even a stainless-steel tank. If this is to be pursued, a tank constructed from Hastalloy C may be required. This will not be an easy project, nor will it be an inexpensive process vessel.

Other Department facilities (Los Alamos National Laboratory and Rocky Flats) have problems with TRU in the waste streams and need to clean them up. Their waste streams are generally simpler in terms of chemistry. Neither of these organizations, which have looked at TRUEX in some detail, believe that the TRUEX process will provide the solutions to their problems, and they are examining alternatives to the TRUEX process.

Beyond examination and discussion, it does not appear that there is an organized and serious effort to identify alternative chemical processing techniques to reduce the volume of waste to be converted into glass. If TRUEX does not work, the Department needs a good alternative process to offer as a real approach for pretreating the waste. Under the current program strategy, and even the new ones being developed, it appears that alternatives will not be considered until it has been demonstrated that TRUEX will not work. If TRUEX fails, this strategy may require postponement of operation of the vitrification facility until research on alternatives could be initiated and run its development course.

The significance of the failure to develop a pretreatment process with the efficiency of TRUEX needs to be fully recognized. If the process works, the volume of DST waste alone (converted to glass) can be reduced by a factor of eight. This represents a differential of approximately $7 M based on the current simplistic cost analysis. If the pretreatment process development program fails to provide a reasonable alternative, the Department is committed to make the waste into glass, and it is technically possible to accomplish this task. The question becomes "At what cost and who pays?" In a period of limited resources for the Department, other programs, through budgetary limitations, will have to share in funding the processing costs. The price tag gets even larger if the decision is made to process the SSTs.

IV.C.3 HWVP

In the context of a subsystem, the HWVP is relatively simple. (The HWVS subsystems are shown in Fig. 1, Sec. II). The HWVP contains only a waste feed preparation subsystem, a melter subsystem, an offgas treatment subsystem, and a process control subsystem. It is complicated by the fact that all will be involved with remotely processing highly radioactive materials. This condition places a great premium on doing everything correctly the first and every subsequent time. The emphasis here is for the individuals involved to be knowledgeable of and attentive to the job each is doing in operating such a facility. Attention to conduct of operations will be essential in start-up, nominal steady-state, and off-normal/emergency situations.

The DWPF, the model for the HWVP, was considered to be a straight-forward system to build and operate. Experience has shown that it has been more difficult to handle than expected, and significant delays have occurred in bringing it on line. Similar learning curve experiences will be encountered by the staff that operates the HWVP. The Department's own concept was that DWPF would provide "lessons learned" for the HWVP. Although this is occurring for basic science and facility design issues, it does not appear to be happening for the operational aspect of the facility. The facility currently is undergoing through cold check-out and soon will start through hot start-up. If the Department wants to take maximum advantage of the situation, the crew that is expected to put the HWVP on line should be an integral part of the crew that is bringing the DWPF on line - bringing the DWPF on line is a once-in-a-lifetime opportunity. The actual experiencing of and recovering from errors and problems at DWPF, from an operational perspective, should not be lost to those that will do it later as part of their occupation.

From the Department's perspective as the owner of both facilities, facilities (operated by the same corporation for the Department), the transfer of the information and experience should be both desirable and readily possible, if for nothing more than using the operational manuals and understanding their shortcomings so that better manuals can be prepared for HWVP. The experience could be important and add real value to the program.

A narrowed perspective on the specification of the waste feed has developed along with the development of the HWVP. Based on information presented in the review, it appears that only waste feed material data affecting the glass composition are considered important. The Vitrification Plant feed-stock specification is given only in terms of oxides that will affect the characteristics of the solid glass.

With the preoccupation on waste feed materials that will affect glass, there appears to be little or no interest in the remaining chemical constituents which could affect other aspects of plant operation. These chemical constituents, will be important because they will be involved in reactions in the waste preparation and melting processes. In waste preparation, they can have an effect on phenomena such as the formating reaction and can produce foaming effects or alter oxidation/reduction reactions in the adjustment tanks. In the melter, they can affect the oxidation/reduction reaction, and their decomposition can affect the offgas system.

The vitrification plant's efficiency will be measured in large part by the amount of time that it is on line producing glass. The glass chemistry is the most critical aspect of the production operations. However, if off-normal constituents in the waste feed represent an operational challenge and have the ability to cause the plant to become nonfunctional, then productivity can be lost. It is of most concern that a situation may be created in an area of high-cost operations that will have to be corrected - situation that could have been avoided by proper attention to the right feed characteristics. A plant for which the operations are interrupted by a large number of small items can be affected to a greater degree than a plant that has one or two major problems. The concatenation of many small items can be more serious because of the harassment character of the effect which could lead eventually to ignoring of serious problems.

APPENDIX A

HANFORD WASTE VITRIFICATION SYSTEM[1] DEFINITION

The Hanford Waste Vitrification Project (HWVP) is a project that is specifically organized and structured to design, construct and operate a facility for the purpose of converting liquid high-level radioactive waste stored in the double-shell tanks at Hanford into a borosilicate glass solid waste form that is suitable for permanent disposal in a deep geologic repository license for the disposal of high-level radioactive waste. The HWVP must also be able to convert the radioactive waste in the single shell tanks at Hanford into an accept able glass waste form if a decision to do so is made at some point in the future. While there has been a high degree of focus on this facility, it is but one of a number of subsystems in a larger system that must function in a coherent fashion if the overall objective of solidifying and disposing of the various radioactive wastes is to be achieved. (The HWVP is an organizational element in the Westinghouse Double Shell Tank Defense Waste Remediation Program).

If the view is accepted that the HWVP is a part of a larger system, then the system must be properly and adequately defined. Figure A-1 is the initial representation of the system with the other attendant operational units to which it is connected. Identified as the Hanford Waste Vitrification System (HWVS), it contains the primary subsystems that must be developed and technically controlled for the proper and continuous production of an acceptable high-level radioactive glass waste form.

The diagram shows that the HWVS consists of three major subsystems, the tanks that contain the liquid waste, the pretreatment processes and facility necessary to prepare the waste for the vitrification process, and the vitrification plant itself. The high-level radioactive waste is contained in 10 of the 28[2] double-shell tanks; they can be further subdivided into 4 different classes of waste based on previous process histories. The subdivisions include the Neutralized Current Acid Waste (NCAW), Neutralized Cladding Removal Waste (NCRW), the Plutonium Finishing Plant waste (PFP), and the Complexant Concentrate waste (CC). The waste in the tanks is generally present in three forms; two are solid phases and one is a liquid phase. The solid phases consist of sludges and salts. Sludges are

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[1]The HWVS is a construct created to facilitate the Independent Engineering Review of the vitrification plant and the infrastructure required to support the production of glass. This "system" has not been an officially defined part of the DOE-RL or WHC programmatic effort.

[2]The remaining 18 tanks contain wastes that are currently classified as mixed low-level radioactive waste and they will be handled as such.

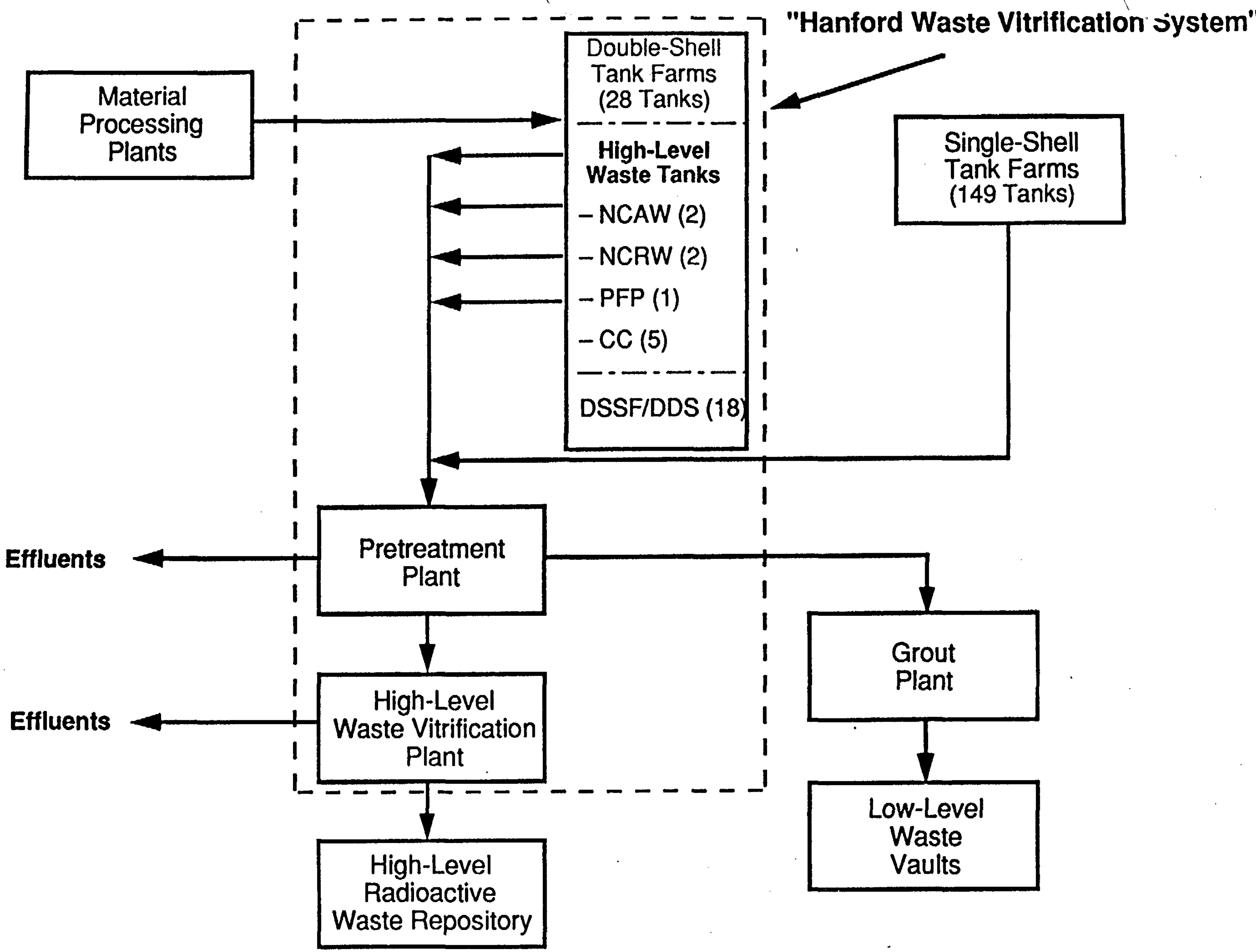

Figure A-1: Initial definition of "Hanford Waste Vitrification System (HWVS)"

chemical compounds resulting from the separations operations that are highly insoluble in water. In chemical processing, as soon as the compounds form they precipitate as a solid and special efforts are required to get them to redissolve in the water. The salts that are present are highly soluble and would dissolve in water; however, because the amount of water was reduced in order to reduce the volume of liquid waste, there is insufficient water to maintain all the salt present in solution and the excess precipitated as solids. The salts and sludges are mixed on the bottom of the tanks, but if water is added, the salts will readily dissolve and stay in the liquid; the sludges will stay in solid form. The bulk of the radioactive materials that constitute the high-level waste is in the sludge and this is the primary solid phase that must be converted to glass. The salts generally do not contain significant quantities of radioactive materials. Table A-1 is a summary of the material and radioactivity content in the double shell tanks. The objective of the pretreatment process is to remove the radioactive fission products and the TRU radionuclides from the sludges and salts that constitute the bulk of the waste materials. Figure A-2, shows the mass balance for sludges and salts in the NCRW waste.

The liquid phase, referred to as the supernate, is the third form of waste in the tank. Except for cesium, which is highly soluble in water, the liquid does not contain large quantities of radioactive materials. It does, however, contain significant quantities of salt. The major process objective is to remove the cesium from the supernate so that the vast quantities of salts do not have to be converted into glass. Table A-1 provides data on the dissolved salt content of the supernates. It also provides a good picture of which liquid can be considered low-level waste.

There is significant economic incentive to separate the two. Concentrated sludge slurries with cesium in the water will cost about $1000 per gallon to convert to glass for disposal as high-level radioactive waste. Salt slurry which is relatively free of radioactive contamination will cost about $15 per gallon to convert to grout for permanent disposal as low-level radioactive waste. A 1-million gallon tank of liquid will produce 1.4 million gallons of solid grout.

Figure A-1 also shows streams flowing into and out of the HWVS. One stream comes from the materials production facility where additional fuel from N-Reactor, which has been cooling for 15 years, remains to be processed; however, several factors affect the decision to reprocess, and the decision is currently being held in abeyance. If the deci sion is made to reprocess the fuel, about a million gallons of additional liquid waste (depending on the particular process chosen) will be sent to the double shell tanks and partitioned between the NCAW (about 0.6 million gal.) and NCRW (about 0.3 million gal. assuming Zirflex) waste tanks.

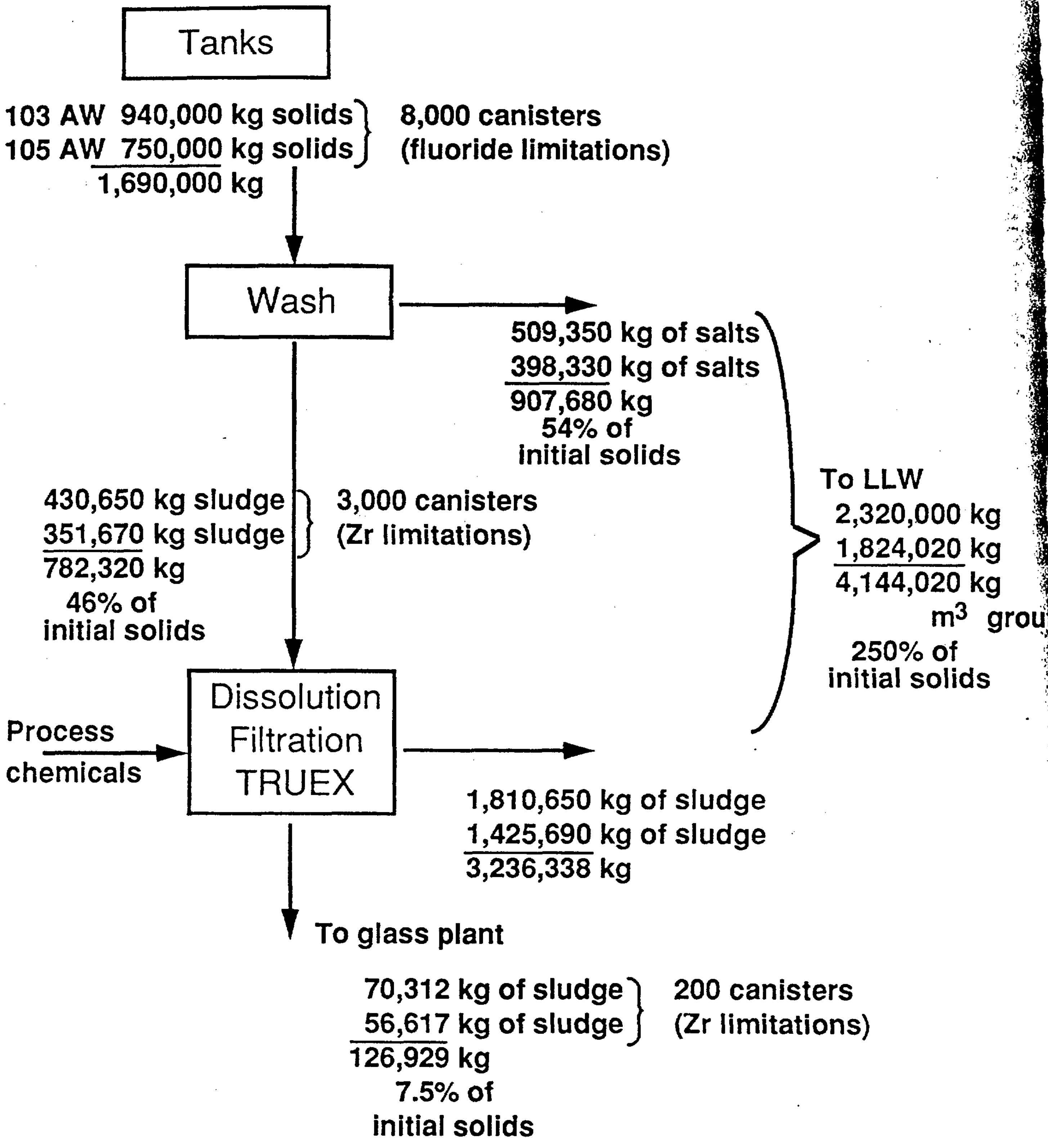

Figure A-2: Mass Balance for NCRW Solids

At this time additional liquid waste is being pumped from the "salt wells" in the single shell tanks and transferred to the double shell tanks. Some will be concentrated and become DSSF. The dilute complex waste that is transferred from SST to DST is estimated to be equivalent to 0.5 million gallons of CC waste after concentration.

The tank's contents are important to the continuity of feed for the vitrification plant from two perspectives. First, it is expected that material in the tanks will be processed as batches. This means that the chemistry of each tank will influence the subsequent processing steps. In certain cases, even within a group of tanks, there can be sufficient variation in chemical characteristics that each tank will have to be treated as a unique situation. Before processes can be designed the physical and chemical nature of the sludge, salt and supernate of each tank must be known and understood. Samples must be obtained and chemical and physical measurements made. For example, the shear strength of the sludge in the NCRW tanks is more than twice the shear strength of the sludge in the NCAW tanks. If the caked material in the bottom of the tank is to be processed, then it must be physically disrupted, mobilized into a slurry of dispersed particles and pumped out of the tank. The technical approach for the NCRW tanks may be different than that for the NCAW tanks.

Pretreatment is a technically and economically important step in the preparation of the feed for the vitrification plant. It is economically important to reduce the amount of material converted to glass. Nonradioactive process chemicals must be separated from the bulk of the radioactive materials, decontaminated and sent to the low-level waste disposal site (See mass balance in Figure A-2) thereby minimizing the amount of high cost glass that would be produced.

Significant investments will be required to develop the various pretreatment process technologies to reduce the volume of waste to be converted to glass. The TRUEX process is one pretreatment process currently under development; it is important because of the significant effect it has on high-level waste glass volume reduction. The TRUEX process is a solvent extraction process specifically developed to remove small amounts of transuranic (TRU) radionuclides from the bulk of the sludge after it has been dissolved in nitric acid and clarified. While the TRUEX process is capable of removing the TRU radionuclides, the process is sensitive to the chemistry of the acidic waste feed solutions to which fluoride must be added to effect dissolution. The acid fluoride waste feed solutions are highly corrosive and can change the nature of the feed, thereby affecting the operability of the process equipment (filters, centrifugal contractors, piping, etc). The waste feed solutions are known to be unstable and upsets in chemistry can significantly change their nature, thereby affecting the separations capability and the operability of the process.

The TRUEX process uses an organic solvent (CMPO) to extract the TRU radionuclides from the waste stream. The chemical is currently a research compound and is produced in small quantities (batches of 100 lbs.). It is not a product that is used in any significant chemical operation, and it is not clear that the industrial infrastructure is available to support this process. For the TRUEX process to be viable, the solvent (CMPO) must be cleaned and recycled in the operation. This has been demonstrated on a laboratory scale but a pilot plant confirmation of an efficient clean-up process and the solvent extraction process with real Hanford waste is essential before this process can be considered useful.

A drawback of this process is the inability to remove the Strontium (Sr) from the sludge. Consequently, all Sr in the sludge processed with TRUEX will be left for disposal as low-level waste. The CC waste stream containing between 1 to 8 MCi of Sr-90 that will go to the low level waste site will be a concern.

The largest mass of material to exit the pretreatment process will go to low-level waste. With the NCRW, for example, for every 100 kg of sludge that enters the pretreatment process, only 15 kg will go to the vitrification plant, but 410 kg of solution will exit in the low level radioactive waste stream. More solids exit than enter as waste because the waste stream includes the process chemicals added to promote chemical separations.

The low level radioactive waste stream must pass certain tests before it can be accepted as such. It must first be clear that it is not high level waste as defined in 10 CFR Part 50, Appendix F. Next, it must be determined that it is not TRU contaminated waste (it must have a TRU radionuclide content less that 100 nCi/gm of waste.). Next, it must be compared with the allowed levels of radionuclides for Class C waste in commercially operated disposal sites. While NRC has no jurisdiction over low level waste managed by the Department as part of the Defense Waste Program, the Department is using a standard, considered acceptable by society, to demonstrate that the levels of radioactivity are far below those considered to be an acceptable upper limit. A detailed discussion of the situation with the low-level radioactive waste is presented in Appendix K.

The continuous operation of the low-level waste disposal operation is critical to the continuous operation of the vitrification plant. If the grout production operation stops, the vitrification plant, to continue operations, will need additional storage for the output of the pretreatment process. Lack of temporary storage tanks would mean that the production of low-level waste and the pretreatment process would also stop. Continuous operation of the low-level grout operation is important to vitrification plant operation even though there is no tie to the technical aspect or quality of the glass production operation. The operational relationship is determined only by the need to match mass flow requirements.

The Hanford Waste Vitrification Project is the plant that is being developed to produce the borosilicate glass waste form. This subsystem itself is composed of several major subsystems for processing the waste which include the waste feed treatment subsystem, the melter subsystem, the offgas treatment subsystem and the process control subsystem.

Glass is recognized as a robust and tolerant material with which to create a solid waste form for disposal of high level radioactive waste. The two aspects that must be considered with respect to glass, are the quality of the product and the efficiency of plant operation. They are both tied to control of feedstock.

The waste feed preparation subsystem is comprised of a set of large tanks used to receive the sludge-slurry from the pretreatment processing facility and prepares it for delivery to the melter. The primary activities in this subsystem is the chemical modification of the chemical and physical characteristics of the slurry to facilitate its transfer to the melter and its processing in the melter. The sludges that are sent to the plant contain nitrites, nitrates, carbonates, sulfates, phosphates, fluorides etc and the main chemical changes occur by adding formic acid or hydrazine to reduce the quantities of nitrites and nitrates in the feed. The formic acid also changes the physical characteristic making it easier to pump the slurry into the melter. Another primary function of the preparation process is the evaporation of the water in the slurry. In this process, more than half of the water in the feed must be evaporated before it goes to the melter.

This portion of the plant may be the most critical since it is here that the characteristics of the waste necessary to allow efficient melter and plant operation must be established and confirmed before further processing is approved. Chemical analysis of the waste feed will be the important measurement in the waste vitrification process. It will be important to know the constituents in the feed such as impurities that can affect the offgas system or the quantities of impurities that affect the oxidation/reduction reactions in the glass melting process. The chemical balance will also affect the rate at which the glass mixture melts and therefor the production rate of the plant. It will also be important to understand the concentration of such waste elements as the noble metals since the will affect the long term lifetime of the melter.

The melter, the next subsystem, is a ceramic lined furnace that will be heated with an electric current passing through the glass. This type of furnace has been used in the production of commercial glasses for many years. The situation in the vitrification plant is different in that a commercial furnace melts only selected chemically stable materials of controlled purity; generally there is no chemical decomposition taking place in the furnace at the same time the melting is occurring and the feed is free of moisture. In the waste vitrification plant, the feed can be highly variable in terms of chemical composition and will contain materials that do not necessarily facilitate the production of a high quality glass. As noted earlier, the feed will contain chemical constituents with nitrates, nitrites, carbonates that decompose when heated and give off large volumes of gases (CO_2, NO_X, etc). The feed is expected to be 50% water that will be converted to vapor in the furnace. Some of the radionuclides will have significant vapor pressures at the temperatures (1150 °C) at which the furnace operates and such radionuclides as (Tc-99, I-129/135, Cs-137) will leave the furnace via the offgas system where they will be trapped.

The performance of the melting process will be strongly dependent on the chemical composition of the feed stock. While the chemistry of the glass will be important, the composition of the waste can affect the efficiency of plant operations and will be equally important for this reason. The analytical chemistry part of the process control system will be extremely important to the efficiency of plant operation.

The third major subsystem in the plant will be the offgas system necessary to assure that hazardous materials and radioactivity released in the melting operations do not leave the plant. For every 100 kg/hr of glass produced many kgs/hr of gaseous materials will be liberated in the melter and will have to be processed by the offgas subsystem. A major factor for the offgas sub-system will be the molten particulate produced in the melter that will be entrained in the high velocity offgas stream and carried into the gas clean-up subsystem. There is sufficient quantity of such particulates to clog the offgas sub-system with out proper attention to the details of operations. The mass of particulates in the offgas stream will be dependent on the oxidation/reduction reactions in the melting process and the amount of gases released in the melting operations. The offgas subsystems utilize technology that is well established.

A critical subsystem in the vitrification plant will be the computer based process control subsystem that will control all aspects of facility and process operations. The plant has many interlocked systems that must work in proper sequence and many are required to have fast reaction times in case of accident conditions in the plant. For the plant to function properly, measurement and sensor technology will be important to provide the on-line signals to a computer monitored and controlled system. A major draw back in such systems is the sensitivity to electronic noise generated by portable radio transmission, lightening, poor grounding conditions etc. To eliminate such problems, transmission of data and control signals by optical cable is being required.

When the glass has been produced it will be sent to a repository for the disposal of high level radioactive waste. Such repositories, operated by the Department, are required to be licensed by the NRC. The NRC has established its licensing requirements for the repository and its subsystems. The requirement are contained the 10 CFR Part 60. The regulations have established waste-form design requirements under Part 60.135. There are also performance requirements but they are tied to the performance requirements set for the engineered barrier system. The engineered barrier system is to be composed of multiple barriers and the performance of each barrier is to be defined in the context of achieving the overall performance of the subsystem. This requires that the release rate from the waste-form must be specified and validated as a basis for licensing. If the waste form is to be acceptable, the basis for the allocation and the validation of the performance characteristics must be accomplished.

If the schedule for the operation of the HWVS is actually achieved and it begins its campaigns by 2000 and processes all the waste in 5 - 7 years, all the waste will be produced before the licensing review of the repository begins. This means that the release rate characteristics of the waste form will be set before there is a formal determination that they are acceptable. This juxtaposition of timing places great need to achieve a formal acceptance of the waste form far before the vitrification plant begins operations. If this is not achieved, then the operation of the plant occurs at great risk to the government.

APPENDIX B

HANFORD WASTE VITRIFICATION SYSTEM MANAGEMENT

The Hanford Waste Vitrification System (HWVS) is managed through the Richland Field Office (RL) and Westinghouse Hanford Company (WHC). Figure B-1 shows the organizational structure within the Richland Field Office that is responsible for managing the HWVS.

Within the Richland Field Office, the management has been bifurcated along subsystem lines. The front end of the system, the program to conduct the characterization of the tanks and development of the retrieval technology is managed by the Technology Development Division under the Deputy Manager for Operations. The approach used to manage this effort is typical of traditional program management within the department. There does not appear to be requirements to follow the methodology for project management and control as required in Department Order 4700.1. The Waste Management Division in FY91 is responsible for managing $500 M of program activities of which $20 M is allocated to the remediation of double-shell tanks and development of pretreatment technology. The Division has 1 technical staff member (equivalent) devoted to this effort.

The third subsystem in the HWVS is the Hanford Waste Vitrification Project (HWVP). This project is currently designated as a Major System Acquisition and is managed as a project following the requirements specified in Departmental Order 4700.1. The Vitrification Project Office under the Deputy Manager for Environmental Restoration and Projects is responsible for managing the project, This Project is the singular focus of this Office. In FY91, the financial resources managed by this Office was $58 M. The Office has 14 technical staff members devoted to this task.

Within WHC, the HWVS is managed by the Defense Waste Remediation Division. This Division reports to the Vice President for Restoration and Remediation. Figures B-2 and B-3 provide the outline of the organizational structure within WHC. The Division has five major suborganizations that are responsible for operations of B-Plant; Defense Waste Remediation Program concerning program planning, integration and HWVP facility operations; Waste Pretreatment Engineering and Projects; Hanford Waste Vitrification Plant; and the Grout Facilities for processing and disposal of low-level radioactive waste. The current organizational structure provides coverage for all subsystems within the HWVS plus one system outside of the HWVS, the grout processing and development facility. It should be clarified that, while they have responsibility for developing a program for characterizing the tanks and retrieving the waste,

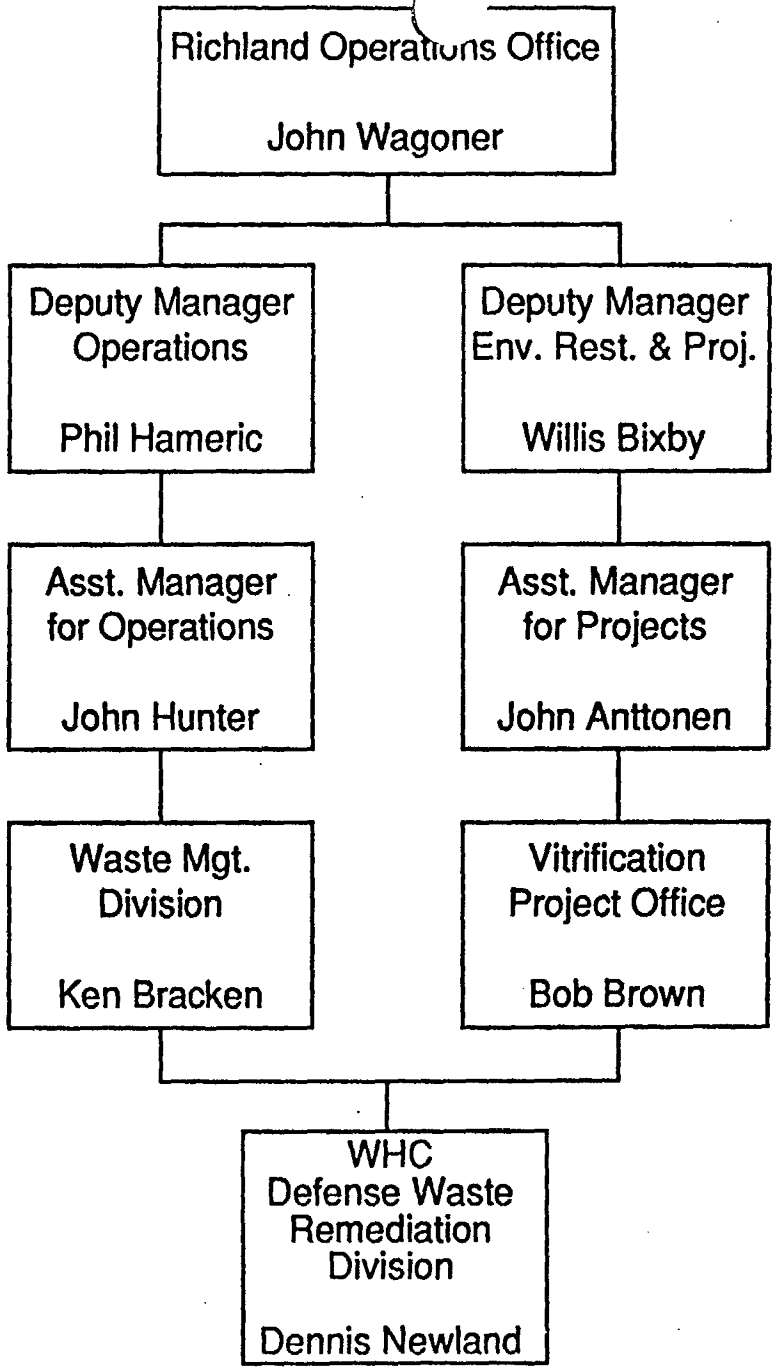

Figure B-1. Richland Field Office Organizational Structure for Management of the "Hanford Waste Vitrification System (HWVS)"

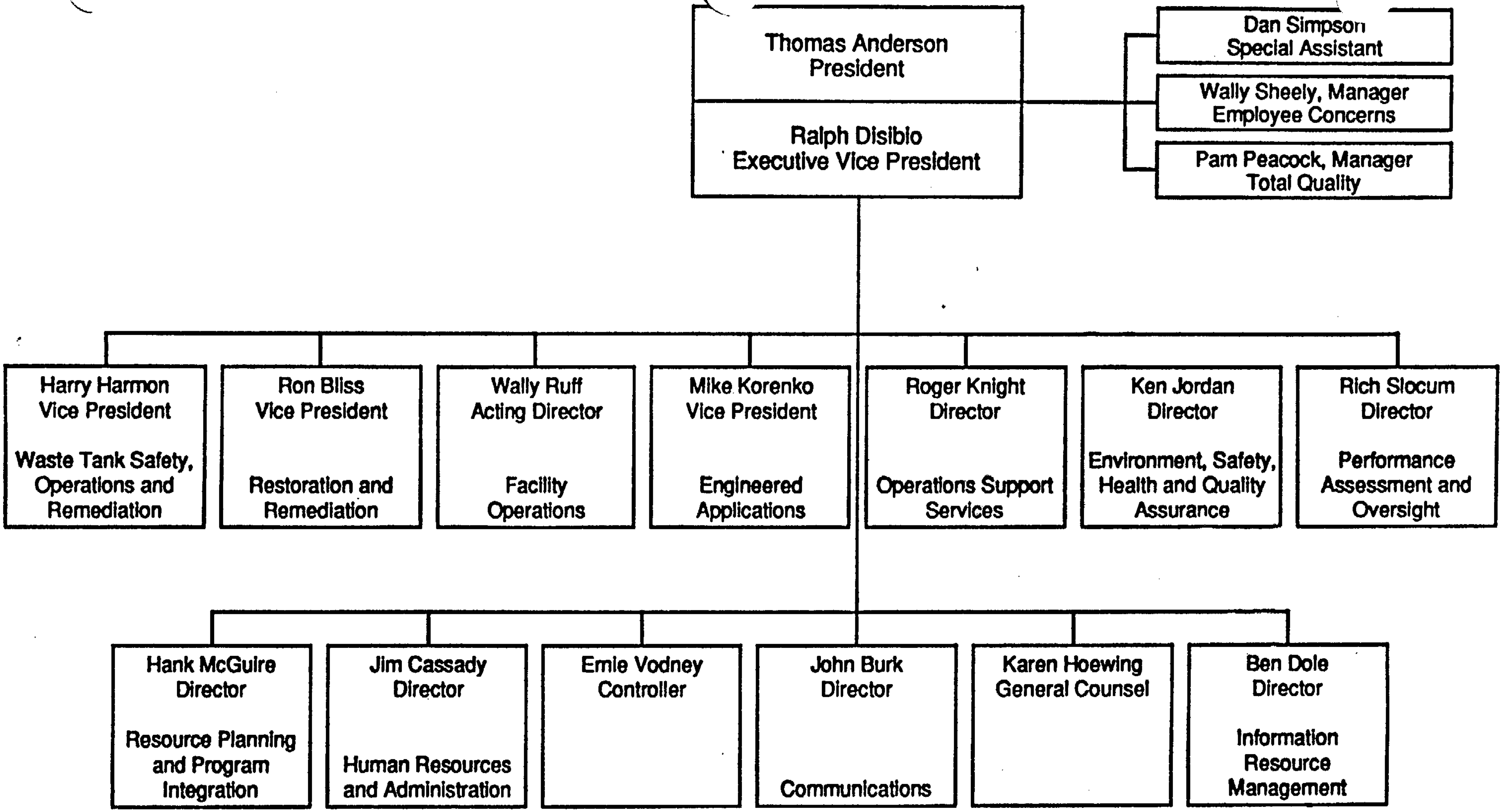

Figure B-2. General Organizational Structure of Westinghouse Hanford Corporation

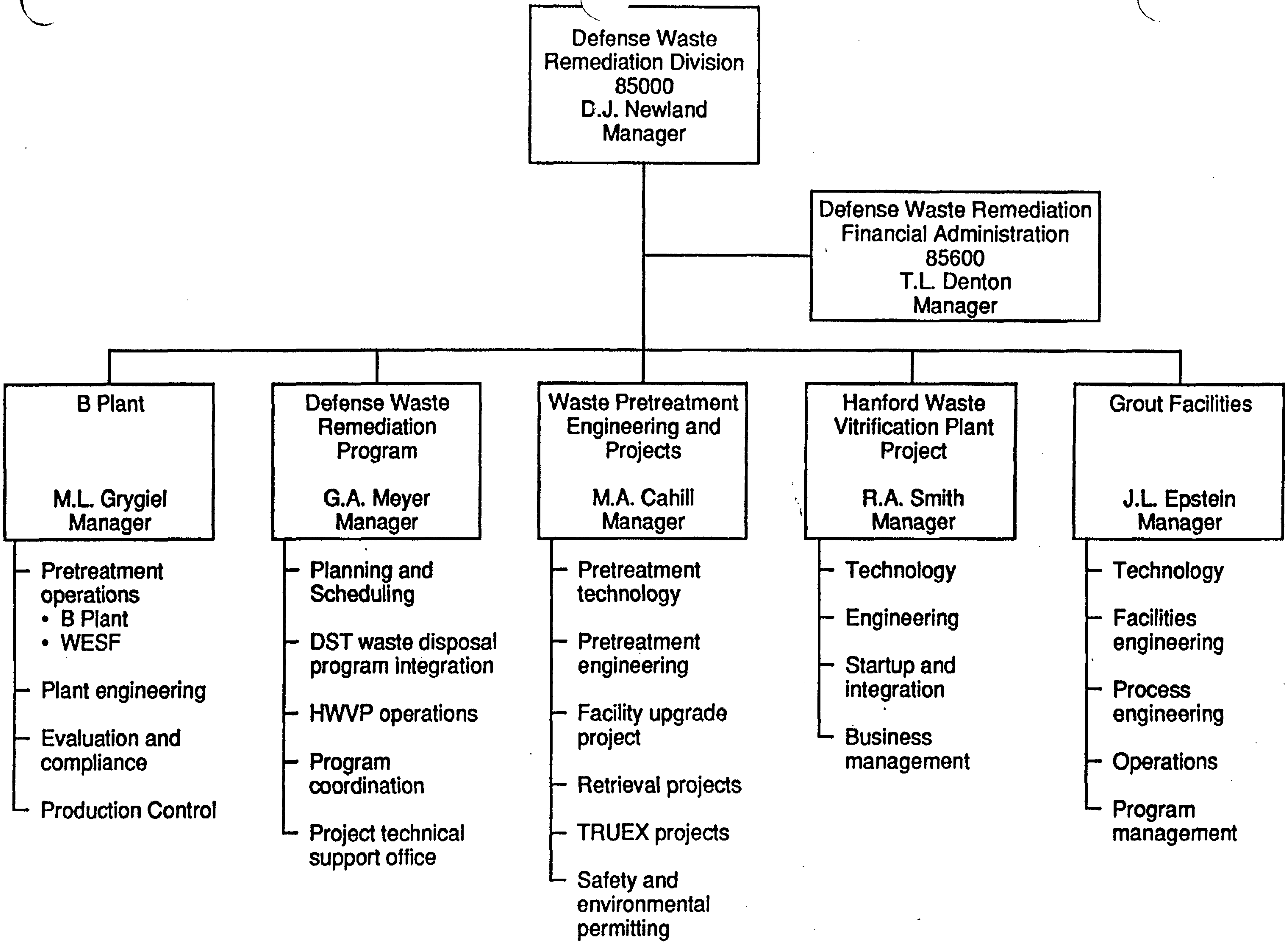

Figure B-3. Organizational Structure of the Westinghouse Defense Waste Remediation Division the actual control and operations of the tank farm is under the Vice President for Waste Tank Safety Operations and Remediation.

In FY91, the financial resources allocated to this Division were $97.5 M, of which $18.6 M was for the HWVP, $36.8 M for B-Plant and supporting facilities and programs, $28.1 M for grout plant development and operations, $11.7 M for waste retrieval and pretreatment technology development. This organization has no programmatic responsibilities other than HWVS development and operations. Table B-1 below outlines the number of staff and their organizational distribution.

Table B-1

Defense Waste Remediation Division Personnel Distribution

B-Plant	
-Planning and Control	34
-Operations	84
-Engineering	41
Defense Waste Remediation Programs	36
Waste Pretreatment Engineering and Projects	44
Hanford Waste Vitrification Plant	68
Grout Facility	49
Financial Administration	8
Total	366

The Hanford site is transitioning from contractor directed activities with Department oversight to Department managed activities implemented by contractor work assignment. In response to a Headquarters directive, DOE-RL will begin assuming site management responsibility using the Site Management System (SMS) in late summer of 1991. Using SMS, DOE-RL will manage site activities, programs, and projects through annually issued, fairly detailed contractor work breakdown structure. DOE-RL will provide programmatic direction, assessment, and decisions. The contractor will carry out activities to the WBS and report progress and issue to RL.

APPENDIX C

Phenomenology Subgroup Assessment

C.1 Summary of Findings

The Phenomenology Subgroup examined the principal physical and chemical phenomena associated with retrieving high-level wastes from the double-shell tanks, pretreating the waste, and vitrifying the waste. The significant findings of the subgroup are:

- Many uncertainties related to physical and chemical phenomena must be addressed before reasonable assurance can be provided that the vitrification plant can be operated in a continuous, cost-effective manner. A well-conceived, well-funded and focused research and development program is needed to properly address these uncertainties.

- The risk of failure associated with HWVP could be significantly reduced or at least much better defined if commitments to the current vitrification plant design could be delayed until hot operations were initiated at DWPF (and to a lesser extent WVDP).

- Hanford does not appear to be aggressively pursuing cost-effective pretreatment alternatives to the TRUEX process. Viable alternatives to the TRUEX process are necessary to ensure the "success" of the HWVP, especially since pilot plant testing of TRUEX is not scheduled until at least 1997.

More discussion on these points is provided in the following paragraphs.

A major obstacle in arriving at the subgroup's findings was the lack of a set of quantitative objectives for the HWVP (within the context of the Hanford Waste Vitrification System). Without such a set of objectives, it was impossible to define the basis for success or failure of the project, which made it difficult to assess whether a given technical uncertainty or set of uncertainties could cause the project to "fail." The following items were assumed to constitute success of the project (1) startup of hot operations in December 1999, (2) continuous operation of the vitrification plant at an availability approaching the design availability (70%), (3) production of a waste glass that is acceptable for repository disposal, and (4) development of post-NCAW waste pretreatment schemes that significantly reduce the glass production requirement relative to the requirement projected if only sludge washing, filtration, and ion-exchange are employed. It was understood that HWVP construction would initially involve land-clearing and site preparation followed by construction of the canister storage facility. Thus, construction of the vitrification plant would not be initiated until after considerable additional technical information is available. It was also assumed that modifications suggested by research and development programs could be incorporated into the design up until initiation of vitrification plant construction and, in some cases, even after initiation of construction, although there would certainly be a cost and schedule penalty.

The subgroup believes that there is sufficient time in the current schedule (hot startup around the year 2000, and processing of NCAW waste first) to address the technical uncertainties identified in this assessment. While Hanford is aware of most of these uncertainties, the presence of a detailed plan identifying the need and strategy for resolving the uncertainties within the context of the HWVS is not apparent. Plans exist for resolving uncertainties in certain portions of the HWVS (e.g., the HWVP Applied Technology Plan addresses information needs associated with the vitrification plant), but a system-wide plan for resolving uncertainties apparently does not exist. A well-funded research and development program with priorities based on the degree of importance of each uncertainty to the entire system as well as the state of knowledge each uncertainty is needed.

Although there are significant differences between the DWPF and HWVP in waste streams, pretreatment, feed preparation, and some vitrification plant features, the DWPF should provide a robust, long-term, full-scale test of the vitrification technology to be used in the HWVP. Many lessons learned from DWPF have already been incorporated into the HWVP design, and there continue to be fruitful technical information exchanges at the research and development level. It would be desirable to be able to continue to incorporate lessons learned from DWPF into the HWVP design at least through initiation of hot operations at DWPF. Initiation of construction of the HWVP in 1992 may preclude or at least increase the costs associated with the incorporation of future DWPF lessons learned into the HWVP. The technical risks associated with the HWVP could also be better defined after the initiation of hot operations at DWPF.

The subgroup did <u>not</u> assume that the success of the HWVP depends on the success of the "baseline" pretreatment strategy, which involves the implementation of the TRUEX process. However, the success of the project does depend on the development and implementation of pretreatment processes that achieve cost-effective partitioning of post-NCAW waste constituents. The degree of partitioning necessary has not been defined, but it will ultimately be determined by a combination of technical limitations, regulatory requirements, and cost/benefit tradeoffs. Hanford has not given adequate attention to these issues or to developing viable alternatives to the TRUEX process. Because of the reliance being placed on TRUEX to provide cost-effective partitioning of waste constituents, the subgroup devoted considerable attention to this process and identified a number of uncertainties that must be addressed before the process can be considered viable. However, this attention to TRUEX should not be construed as an endorsement of the process, nor should it dilute the higher-level concern that no viable alternatives to TRUEX have been identified or pursued by Hanford.

Discussion of the specific technical uncertainties that the subgroup believes will require considerably more attention before reasonable assurance can be provided that the HWVP will "succeed" is offered in Section II. Consistent with the organization of other portions of this report, the uncertainties are divided into four categories: (1) double-shell tanks, (2) pretreatment, (3) vitrification plant, and (4) general. The discussion of each uncertainty includes a description of the phenomenon and its relevance, a brief description of the Hanford approach to addressing the uncertainty (if an approach exists), subgroup recommendations for addressing the uncertainty (if different from the Hanford approach or if Hanford does not have a well-defined approach), and an assessment of the potential impact of the uncertainty if it is not addressed. Section III provides a brief discussion of technical alternatives to the HWVP "reference strategy", which the subgroup was asked to address. A list of the physical and chemical phenomena considered by the subgroup is provided in Section IV.

C.2 Discussion of Findings

C.2.A Double-Shell Tanks

C.2.A.1 Mobilization of High Shear Strength Sludge (post-NCAW Wastes)

The mobilization of relatively high shear strength sludges will be required for the retrieval and pretreatment of NCRW and PFP wastes. Hydraulic methods of mobilization appear to be desirable so that the wastes can be pumped to downstream treatment locations. A key aspect of mobilization is the use of hydraulic energy to break up the sludge without damaging the tank or its internals, and without causing excessive heating of the waste, which can exacerbate erosion/corrosion problems both in the tanks and downstream of the tanks. These phenomena are being addressed for NCAW retrieval, but test programs to develop retrieval techniques for post-NCAW sludges are only in the conceptual stage. Given the options available (number of mixing pumps, pump capacity, gradual lowering of pumps into sludge, liquid addition, etc.) there is a high probability that workable hydraulic retrieval processes can be developed on a timely basis for the double-shell tanks. If single-shell tanks are included in the HWVP processing campaign, retrieval technology may be a more critical issue. The subgroup did not address the retrieval of single-shell tank wastes.

C.2.A.2 Gas Release During Mobilization

Gases trapped within sludges are expected to be released as a result of agitation during the retrieval process. The gases so released may be explosive or flammable, and could represent an explosion/flammability hazard during retrieval. The trapping of gases and their subsequent release as a result of slurry motion has been well documented for Tank 101-SY (containing CC waste). The so-called slurry gas in Tank 101-SY is roughly an equimolar mixture of H_2, N_2O, and N_2 which is within the flammable range. Neither the composition nor the volume of gas trapped in sludges (other than in 101-SY) is well known, and thus the significance of this phenomenon can not be presently assessed. This phenomenon is not currently being addressed by Hanford, and although it is not an urgent problem (post-NCAW wastes will not be retrieved during this decade), it should be accounted for in the development of retrieval technology.

C.2.B Pretreatment

C.2.B.1 Deagglomeration of Solids During Sludge Washing/Settling/Decantation

When the sludges in the double-shell tanks are mobilized, sludge particles may deagglomerate as a result of energy input from the mobilization process (shear forces from mixer pumps). Additional deagglomeration may occur during washing when soluble sludge constituents are dissolved. Deagglomeration may significantly affect the time required for the washed sludge to settle and therefore reduce processing rates. If in-tank sludge washing is used (currently being considered as an alternative to using AR Vault), slow settling rates may pose a significant problem because of the long settling times involved. Options for dealing with slow settling rates include centrifugation, the use of flocculating agents, and the installation of filters to prevent the transfer of suspended sludge particles along with the wash solution. Each of these options comes with possible penalties: additional equipment and facility space for centrifugation, impact on waste loading in glass for flocculating agents, and plugging problems for filters. Although deagglomeration should not pose an insurmountable problem, studies should be conducted with actual waste sludge to determine settling rates under various conditions, partitioning of waste constituents between liquid and settled solids as a function of time, and operating conditions that optimize these parameters.

C.2.B.2 Partitioning of Waste Constituents in Simple Pretreatments and Sludge Dissolution

The partitioning of waste constituents (both radionuclides and other chemicals) after simple pretreatments such as settling/decantation and sludge washing need to be better defined in order to verify current expectations for feed compositions to subsequent pretreatment, the vitrification plant, and/or the grout facility. The processes for dissolving post-NCAW sludges also need to be better defined to establish the types and quantities of chemicals necessary and to determine the amount of undissolved sludge and the disposition of important radionuclides and other chemicals that could affect subsequent processes. Although no major problems are anticipated with simple pretreatments and sludge dissolution, significant uncertainties in waste partitioning exist that could substantially impact the glass production requirement and/or the need for additional pretreatment processes.

C.2.B.3 Hydrazine Addition

In the conceptual flowsheets for preparing post-NCAW waste sludges for the TRUEX process, hydrazine is added to the dissolved sludge to decompose NO_2^- prior to feeding to the solvent extraction process. Although hydrazine is effective in accomplishing the decomposition, it is a moderately volatile, highly toxic, and highly reactive reducing agent that poses significant safety (toxicity and explosion) hazards. Screening studies and experimental work to define an alternative chemical or to select an alternative process that eliminates the need for hydrazine should be pursued. The concern is that safety considerations could ultimately preclude the use of hydrazine in a highly radioactive process, and if there are no alternatives, the cost and schedule of the project could be significantly affected. Alternative strategies should be pursued in parallel to the implementation of the hydrazine process in case unanticipated difficulties arise.

C.2.B.4 Instability of TRUEX Feed.

Because the centrifugal contactors being proposed for the TRUEX solvent extraction process are not capable of handling significant quantities of solids, satisfactory operation of TRUEX is contingent on providing a stable, single-phase feed to the process. The phenomenon of precipitate formation during feed storage has been observed in the experimental NCRW program. Additional development work is needed to ensure that a stable feed can be supplied to the solvent extraction process. Alternatively, solvent extraction equipment that is better capable of handling solids could be identified and developed. Work on understanding conditions that stabilize the feed is ongoing, but there appears to be no effort to identify alternatives to the centrifugal contactors.

C.2.B.5 Interfacial Phenomena in TRUEX Process

Two phenomena observed when processing post-NCAW wastes in bench-scale TRUEX experiments are the formation of "crud" at the liquid-liquid interface and extended disengaging times for the aqueous and organic phases (these phenomena may be related). Centrifugal contactors do not readily accommodate these phenomena, so conditions that minimize their occurrence should be identified. The long disengaging times for the organic/aqueous phases can be shortened by adding a chelating agent, but additional experimental work is needed to determine the optimal amount of chelating agent and to ensure that the chelating agent does not adversely affect the vitrification or grout processes. WHC appears to be addressing these problems, but, again, the apparent lack of an effort to identify alternatives to the centrifugal contactors is a concern.

C.2.B.6 TRUEX Corrosion Concerns

The aqueous solutions to be fed to the TRUEX process will be highly acidic and, in the case of NCRW, will contain high levels of fluorides. The corrosive nature of these solutions will require the use of expensive corrosion resistant materials for process piping and vessels and possibly for ancillary ventilation and confinement equipment. Although WHC is addressing the problem of corrosion of primary process piping and vessels, there is a concern that corrosion of ancillary equipment is not being given adequate attention. Experience at other DOE installations with highly acidic, halide-containing solutions suggests that corrosion of ancillary equipment can be a serious problem.

C.2.B.7 Cleanup of Organic Extractant in the TRUEX Process

The organic extractant in the TRUEX process (CMPO dissolved in TBP) must be cleaned up prior to reuse in the extraction process to remove radioactivity and degradation products. Although solvent washing technology is well-established for processes such as PUREX, the ability to clean up the extractant for extended reuse in TRUEX applications has not been demonstrated at any significant scale. If the solvent cannot be efficiently washed and reused, it may be necessary to purchase large quantities of makeup CMPO and dispose of large quantities of spent solvent by processes such as incineration. These actions may pose both economic and permitting problems. The solvent washing operation should be demonstrated at the pilot plant scale to properly address these uncertainties.

C.2.B.8 Possible Unavailability of CMPO

Although not strictly a physical or chemical phenomenon, the subgroup is concerned about the future availability of the extractant used in TRUEX process (CMPO). CMPO is a speciality chemical that is not presently available in commercial quantities. The current cost of this chemical in 100 pounds lots is about \$2.00/gram, although the cost is expected to decrease to about \$1.00/gram in 1000 pounds lots. There are two companies that have produced or have an interest in producing CMPO. One firm uses the Grignard reaction to produce the CMPO, while the other firm proposes to use a non-Grignard route. If the TRUEX process is chosen for removing TRU components from post-NCAW wastes, WHC must initiate a program to work with chemical suppliers to ensure that the projected quantity of CMPO will be available. WHC expects to need about 2000 to 3000 pounds of CMPO for startup with a makeup equal to about 2000 pounds per year. These quantities translate to a cost of about 1.5 million dollars for startup and about 1 million dollars per year for makeup.

C.2.B.9 Complexant Concentrate (CC) Organic Destruction

The large amount of organics (primarily complexants) present in the CC waste must be destroyed prior to introduction to the TRUEX process and the vitrification plant. Potential problems in the vitrification plant include larger quantities of offgas from the melter, changes in melter redox potential, sooting of the melter and offgas system, and the formation of solids in the SRAT and SME that could foul heat transfer surfaces and thereby reduce plant production. The possible adverse effects of the organics in the TRUEX process include the production f multiple phases, changes in distribution coefficients, reduction in phase separation times, and problems with solvent cleanup.

Current plans are to add hydrogen peroxide to decompose the organic complexants, although other alternatives (e.g., supercritical water oxidation, electrochemical oxidation) have been identified. WHC is currently considering organic destruction either before or after the TRUEX process (although most alternatives appear to be before TRUEX). The subgroup believes that destruction after TRUEX is not advisable because of the potential problems mentioned above. Also, it is possible that destruction of organics prior to TRUEX could result in adequate partitioning of TRU constituents to the sludge so that TRUEX would not be necessary. More experimental work is necessary to establish the degree of organic destruction that can be accomplished with various alternatives, the degree of TRU partitioning between sludge and supernate associated with various levels of organic destruction, the feasibility of safe and reliable operation of destruction processes at full-scale, and the potential effects of residual organics on the TRUEX process and/or the vitrification plant and grout processes.

C.2.B.10 Foaming during Acidification of Complexant Concentrate

During acidification of samples of complexant concentrate waste (to dissolve the sludge), excessive foaming has been observed, which may adversely affect pretreatment processing times. Foaming can be controlled by the addition of anti-foaming agents, but the effects of these agents on subsequent TRUEX solvent extraction and on the vitrification and/or grout processes have not been established. WHC is investigating schemes to avoid the use of anti-foaming agents, such as the addition of waste to acid rather than vice-versa. This problem appears to be receiving sufficient attention from WHC, and because CC waste is the last waste scheduled to be processed through HWVP, the subgroup feels that this problem will be adequately addressed before it becomes a critical concern.

C.2.C Vitrification Plant

C.2.C.1 H_2 Generation from Noble-Metal-Catalyzed Formic Acid Decomposition

H_2 evolution occurs primarily during formic acid addition to the slurry receipt and adjustment tank (SRAT) for treatment of melter feed. Noble metals present in the waste (predominantly NCAW) are believed to be responsible for the H_2 generation problem; catalyzed decomposition of formic acid by noble metals is a well-documented phenomenon. Many reactions (neutralization, redox, decomposition, production of other gases, and organic/oxidizer reactions) occur simultaneously during this step, which significantly complicates the fundamental understanding of the basic chemistry involved.

WHC/PNL believe that plant operation without a thorough understanding of the H_2 generation phenomenon is possible if the exhaust ventilation system for the feed preparation tanks can be appropriately designed and sized to prevent buildup of H_2 gas to concentrations exceeding the lower explosive limit. This approach will require supporting information from experimental efforts to understand the fundamental nature of H_2 gas evolution and to establish sufficiently conservative design criteria. Significant technical work is needed to investigate the mechanism(s), identify the problem constituents (e.g., specific noble metals), and determine the important variables affecting the rate and quantity of H_2 generation.

PNL has extensive processing studies planned, and SRL/DWPF has a task force in place to address these issues, so this problem appears to be receiving adequate attention. However, if experimental results suggest that the problem cannot be eliminated by design features, additional work may be required to investigate alternative methods to avoid H_2 generation, including such possibilities as poisoning the catalytic reaction or developing an alternative process chemistry (formic acid substitution). Such work may have a significant impact on HWVP cost and schedule. Experimental work involving actual radioactive waste should be emphasized, as it is well known that trace amounts of materials can significantly affect catalytic reactions.

C.2.C.2 Energy Release of Formating Reactions

The reaction of formic acid with nitrate ion is exothermic, with an enthalpy of about -50 kcal/mol. It is important that measures be taken to prevent unreacted formic acid from accumulating in the SRAT to levels where a thermal runaway could cause an overpressure. The primary concern is with long induction periods after acid addition is initiated. It is anticipated that any potential problems with this phenomenon will be identified during full-scale feed preparation system testing at PNL (in FY 1992) or during DWPF facility startup. Also, past experience in nuclear applications has suggested that this phenomenon should not be a problem provided that the formic acid is added in a controlled manner and the reaction mixture is well-agitated. Nevertheless, development efforts should identify the conditions under which runaway reactions could occur and the possible magnitude of the consequences, and the plant design should account for the reaction energy that could be produced under off-normal conditions (e.g., inadvertent rapid addition of formic acid or loss of SRAT agitation).

C.2.C.3 Undesirable Material Buildup in the Recycle Stream

Cesium and various water insoluble condensibles that are collected in the vitrification plant offgas systems will be recycled to the SME and ultimately fed back to the melter. The zeolite used to remove the cesium, a filter precoat of diatomaceous earth, and various decontamination solutions used in the HWVP (typically nitric acid, sodium hydroxide, potassium permanganate, oxalic acid, and EDTA) will also be added to the recycle stream. Water soluble materials, including approximately 5% of the cesium, will be transferred to the tank farm for eventual disposal in grout.

The recycle system is a concern because it provides a potential mechanism for the accumulation of undesirable constituents in the melter feed. To pose a problem, a constituent would have to be very volatile in the melter (essentially a decontamination factor of 1), be collected in the offgas system, and be water insoluble or collect on the zeolite. Although the subgroup has identified no such problem constituents (other than mercury if it is present in significant quantities), the recycle concept needs to be demonstrated experimentally to verify that it is viable (it is not apparent that HWVP has actually recycled any material collected in offgas systems in their experimental melter runs).

Although the qualification point for feed to the melter is in the SME, it was the opinion of some subgroup members that the addition of any feed to the melter that did not come through the feed preparation tanks prior to the SME (e.g., decontamination solutions) could present a problem with qualification of the glass. Such material could also alter the redox state of the glass if it is not accounted for during the feed formating step.

C.2.C.4 Scale Buildup on or Erosion of Heat Transfer Surfaces

Scale buildup on or erosion of heat transfer surfaces in the SRAT and SME (where evaporation is performed) can be markedly affected by the presence of small amounts of impurities (such as organics) in the feed solutions. Heat transfer coils can be replaced or cleaned, but test programs should ensure that simulated feed solutions contain all of the components expected to be present in the radioactive feed so that the rate of degradation of heat transfer performance and the frequency of coil changeout or cleaning can be estimated. Although not considered a critical issue, if these phenomenon are not addressed, there may be surprises in the amount of plant downtime required for coil changeout or other mitigative actions.

C.2.C.5 Noble Metals Accumulation in Melter

The accumulation of electrically conductive noble metals (e.g., RuO_2, Pd, Rh, and Ag) on the floor of continuous melters can cause various problems, including power control disruption, glass exit drain plugging, refractory erosion and electrical short circuiting of the melter. International experience (Japan, United Kingdom, and Germany) with this problem has shown that noble metals accumulation can significantly impair melter performance. The DWPF (and HWVP) melter design does not directly accommodate features to prevent impaired melter performance due to noble metals accumulation. Plant operation is possible using the current design, but HWVP operating efficiency may be limited by a decreased glass production rate or premature melter failure. Temporary melter idling conditions may also cause increased noble metal agglomeration and settling.

Several key areas of concern remain which require development efforts. First, an analytical technique must be developed to verify the existence and the concentration of the various noble metals in all of the wastes, as the noble metal contents specified to date are the result of flowsheet estimations (only NCAW is expected to contain significant quantities of noble metals). Second, prototypic melter runs for extended time periods (several weeks) involving noble-metal-containing feeds must be conducted in order to better understand the mechanisms and the potential magnitude of the problems associated with particle agglomeration, settling, and pool or nugget formation. These tests should be run with appropriate instrumentation and post-test examination for determining noble metals mass balance and disposition. The information must be generated in a manner that is consistent with full-scale operation. If full-scale conditions are not approximated, the extrapolation of current models to full-scale operations via computer simulation may be inappropriate for predicting noble metals impacts on melter life. PNL and SRL have ongoing cooperative efforts to address these problems, so the issue of noble metals accumulation appears to be receiving adequate attention at the present time.

C.2.C.6 Crystalline Phase Formation in Melter

Crystalline phases in the melter can increase glass viscosity and, in a worst case scenario, accumulate in a sludge layer on the floor of the melter, clogging the glass exit drain to the pour spout. The entrainment of crystalline phases in the final glass product is also a concern, as this phenomenon may result in a glass that is ultimately determined to be unacceptable for repository disposal. Spinels, silicates, and insoluble oxides in the glass matrix (e.g. ZrO_2) are the main crystalline phases of concern. Although a liquidus temperature specification is intended to eliminate or minimize crystallization in the borosilicate glass, composition and temperature variations and/or the presence of heterogeneous nucleating agents within the melter could locally affect crystalline phase formation. These characteristics indicate that crystallization is a kinetically limited, thermodynamically favored process. Because heterogeneous nucleation plays an important role in crystal formation and growth, minor insoluble constituents in the borosilicate glass (e.g., RuO_2 and Cr_2O_3) can dramatically increase glass viscosity by nucleating crystal growth.

The development of techniques to detect and monitor crystalline phase accumulation in the melter should be considered, as this would provide an advance warning capability for crystallization problems that might arise during long-term melter operation. Development of models to predict the liquidus behavior and the tendency for crystalline phase formation in the glass will be needed in conjunction with the development of physical property models in the Composition Variability Study (CVS). These efforts will be difficult considering the complex phase equilibria involved in the borosilicate glass system, and they are further complicated by the need for representative simulants of possible heterogeneous nucleating agents within the system. The potential impacts of not addressing crystalline phase formation are reduced melter life, which translates to reduced plant availability, and the production of glass that may ultimately be deemed unacceptable for repository disposal. Unlike the noble metals problem, which is expected to occur for only one waste type (NCAW), crystalline phase formation could be a problem for all waste types. Although this phenomenon has been receiving attention for several years and is currently being addressed in the CVS, some issues, such as the need for nucleating agent simulants and techniques to monitor crystal phase formation in the melter, appear to be receiving little attention from WHC/PNL.

C.2.C.7 Glass Redox Chemistry

The redox state of the glass in the melter affects the tendency of the glass to foam, the tendency for conductive phases to form in the glass, and recent work suggests that it may affect the properties of the glass product (i.e., durability). The redox state is determined by the synergism of the following variables: gases above the melt, transition metals in the melter feed, and organic compounds in the feed. The glass redox state is typically quantified using a colorimetric technique to determine the Fe^{+2}/Fe (Tot) ratio. The current specification calls for the Fe^{+2}/Fe (Tot) ratio to be greater than 0.005 (to prevent glass foaming), but less than 0.3 (to prevent conductive selenide, sulfide, or metallic phase formation).

Adjustments to the quantities of formic acid introduced during feed preparation should be based on concentrations of components that participate in oxidation/reduction reactions. Verification of the glass redox state prior to slurry transfer to the melter feed tank should be a routine procedure. Development work is needed to characterize the offset between the predicted glass redox state (based on the melter feed chemistry) and the actual redox state of the glass product. Also, the colorimetric technique used to measure the Fe^{+2}/Fe (Tot) ratio is prone to large measurement errors. Development work is needed to identify and correct the problems associated with this measurement technique, or perhaps to develop an alternative method. Work is also needed to determine the exact role of the glass redox state in influencing glass properties, especially durability. WHC/PNL recognize these problems and appear to be addressing them within budgetary constraints. The potential impacts of not addressing these issues are a significant reduction in the operating efficiency of the plant and a reduction in the durability of the glass product.

C.2.C.8 Effect of Organic Compounds in the Melter Feed

The total organic content and the specific organic species present in the melter feed can have a profound effect on the redox state of the glass. The decomposition products of these particular species may also pose problems in the melter offgas system. The decomposition of organic species must be controlled such that accumulation of combustible gases (e.g., H_2 and CO) or soot in the melter plenum/offgas system is minimized. The accumulation of soot or tarry substances can plug offgas lines or result in the carburization or sulfidization of melter plenum components.

Although organics in the melter feed are not deemed a serious problem with respect to plant operation, very little experimental data has been presented to address the concerns of the subgroup. Simulated waste feeds have contained only simple oxalates as organic species. Complexant concentrate waste, with its high organic content, is of particular concern with respect to vitrification, especially if organic destruction processes are only partially effective. Development work is needed to identify the specific organic species present in the various pretreated wastes and investigate their effect on glass production and offgas treatment. Plant operation is possible utilizing the current total organic carbon specification for the melter feed, but this specification may have to be adjusted in the future to account for specific organic species that are determined to be problem constituents. WHC/PNL do not appear to be addressing this issue in any detail at the present time, as they do not know the exact composition of the wastes or the effect that pretreatment will have on the organic content of the wastes.

C.2.C.9 Devitrification of the Glass Product

The fundamental phenomena involved in devitrification of the glass product are similar to those involved in crystalline phase formation in the melter. These phenomena involve the heterogeneous nucleation of thermodynamically stable secondary phases on melt/glass insolubles. Time-Temperature-Transformation (TTT) models to predict devitrification (or crystallization) kinetics in the glass product are required as reportable information per the Waste Acceptance Preliminary Specifications (WAPS). This issue is not expected to seriously affect plant operation, but it may play an important role in determining the acceptance of the glass product for repository disposal.

Supplemental information relating devitrification to changes in the durability of the glass product should be developed to verify that no detrimental effects are noted. SRL studies to date have shown that changes in glass durability as a result of devitrification or microcracking are insignificant with respect to the annual release rates for radioactive constituents contained in borosilicate glasses. Significant efforts are in progress at PNL to address this issue over the expected HWVP glass compositional range. Because of the size of the glass composition envelope (i.e., high compositional variability of the four waste types), these studies will require an enormous amount of work, including sample preparation, standard preparation, and analytical support (X-ray diffraction and leachate analysis). Samples must also include representative quantities of all possible heterogeneous nucleating agents present in the different wastes. The project should allocate sufficient time, budget, and priority to complete this work so as not to delay the overall HWVP Waste Form Qualification Plan.

C.2.C.10 <u>Modeling of Glass Property/Composition Relationships</u>

There appear to be two different schools of thought regarding the modeling of glass property/composition relationships. These models are important because they will be used to choose an optimized glass formulation, and to predict glass properties within the melter (e.g., viscosity, liquidus, and electrical resistivity) and in the glass product (durability and devitrification). A "first principles approach," which relates glass properties to composition via structural (non-bridging oxygen) or thermodynamic (free energy of hydration) considerations, has been used at SRL. HWVP is utilizing a statistically designed mixture experiment (Composition Variability Study) to generate empirical relationships between glass properties and composition. While the SRL approach has generated linear models relating glass properties and composition, the HWVP approach has the capability to incorporate second order (interactive) terms into the empirical glass property/composition models.

An important property of the glass product is the radionuclide release rate defined in terms of a standard leach resistance test (Section 1.3 of WAPS). The ability of the SRL and/or HWVP models to predict the durability of the product glass is thus critical to guarantee waste form acceptance by the federal repository. Recent results at PNL indicate considerable lack of fit in attempts to linearly correlate leach data for CVS glasses (either PCT or MCC-1 Test) with the calculated free energies of hydration predicted by the SRL model (based on glass composition). Significant technical work is needed to generate an empirical model that appropriately fits the CVS data and to further investigate the discrepancies with the SRL model. In order to present a convincing argument to the WAPS Technical Review Group (NRC), a logical explanation for the differences between the two durability models must be found, or it must be shown that the two models are compatible with each other. Because both DWPF and HWVP are producing borosilicate glass waste forms, it is important that all aspects of Waste Form Qualification at the two sites be consistent with each other. Potential consequences of inconsistencies include delays in approval of the Waste Form Qualification Plan(s) and delays in acceptance of the waste form for repository disposal. WHC/PNL appear to be addressing this problem in a conscientious manner.

C.2.C.11 <u>Cold Cap Behavior</u>

The introduction of feed slurry onto the molten glass surface in the melter creates a region that has been called the cold cap. Within this region, a number of important and complex phenomena occur, including the evaporation of water, calcination of feed materials, oxidation/reduction reactions, gas generation due to decomposition, and conversion of feed oxides to glass. Establishing the mechanisms associated with these phenomena is important to understanding production rates, crystalline phase formation, phase separation, and overall processibility of the melter feed. Models based on heat transfer, mass transfer, reaction kinetics and empirical data have been attempted in the past. While these models have been useful in describing certain aspects of cold cap behavior, none has successfully provided an overall understanding of the phenomena.

Plant design, construction, and start up should not be delayed due to the lack of understanding of cold cap behavior. However, without this information, optimal operation of the Plant cannot be achieved. Empirical data obtained during development testing has shown that cold cap characteristics are directly related to production rate, and in extreme cases, cold cap disruptions or abnormalities could interrupt operations. Establishing an understanding of the phenomena occurring in the cold cap would increase operating efficiency, and reduce the probability of siltations developing during operations that may require plant shutdown. WHC/PNL do not appear to be giving much attention to understanding these phenomena at the present time.

C.2.C.12 Steam Explosion in Melter

Steam explosions are physical phenomena that can occur when cool liquid is mixed with a hot liquid. Steam explosions in the melter need to be considered because aqueous solutions (feed slurry, feed line flush water or cooling water) can contact molten glass or molten salts. Based on the results of a number of studies, steam explosions in the melter are judged to be of low probability and limited consequences, and therefore they should not serve as a basis for delaying HWVP construction. However, the subgroup is concerned that HWVP personnel have not conducted an analysis of their own and appear to be relying completely on analyses carried out at Savannah River and by others. This approach may put HWVP personnel in an awkward position when the issue of steam explosions is inevitably raised during safety and readiness reviews. HWVP should give careful consideration to this possibility and weigh the potential consequences against the effort required to develop an analysis or to write a position paper defending the applicability of other analyses to HWVP.

C.2.C.13 I-129 Evolution from Melter

Iodine-129 is potentially a significant dose contributor, and if a large fraction of this radionuclide were a stack emission at HWVP, it is unlikely that the plant would be permitted to operate. At the present time, both the ^{129}I inventory in the tanks and its pathway through the vitrification plant are not well known. Based on the current HWVP design, it is possible that most of the iodine entering the melter will be emitted from the ventilation stack. Therefore, if a significant fraction of the iodine goes to the melter, an ^{129}I emission problem may exist.

Technology is currently available to analyze ^{129}I concentrations in all process streams, and if implemented in conjunction with pretreatment testing on real waste to determine ^{129}I partitioning to the grout and vitrification plants, the need for iodine trapping equipment in the offgas system could be determined. Space will be included in the vitrification building for iodine trapping equipment, should it be required. Silver zeolites, which have long been used to trap iodine in separation plants and in power reactors, have been designated as a potential absorbent for ^{129}I. However, the halogens in the HWVP offgas stream may interfere with the usual sorption process. The problem is that fluorine and chlorine in the offgas are more reactive than iodine and would displace it from sorption sites. Therefore, new iodine trapping technology may have to be developed.

Iodine-129 evolution is judged to be a phenomenon that could delay plant startup only if: (1) early measurements of ^{129}I in waste samples and in pretreatment tests were not made to establish its concentration in melter feed, (2) much more ^{129}I was fed to the melter than anticipated, and (3) an offgas trapping method was not developed on a timely schedule. WHC/PNL appear to be addressing the potential need for ^{129}I trapping equipment, but the significant challenges associated with developing the trapping technology will probably not be given much attention until after a determination of need is made.

C.2.C.14 <u>Tc-99 Volatility in Melter Offgas System</u>

Technetium-99 is potentially a significant radiation dose contributor that must be efficiently trapped by the offgas system. It is a transition metal that can exist in a number of oxidation states with different volatilities, with TcO_2 generally being the least volatile. If the redox potential of the melter feed is not sufficiently reducing to eliminate TcO_4^- in the feed, significant volatilization of ^{99}Tc from the cold cap will occur. Also, if the waste is acidified in the feed formating step faster than the TcO_4^- can be reduced to TcO_2, boil-off of $HTcO_4$ is expected. German work with radioactive vitrification under highly oxidizing conditions has indicated 40-60% volatilization of ^{99}Tc in the melter, although essentially all of this material was trapped in the offgas system and recycled to the melter. No volatilization occurred during formaldehyde denitration of acidified feed.

The significance of ^{99}Tc volatility for HWVP can not be quantified at present due to the very limited data base available. ^{99}Tc behavior during feed preparation and melter operation needs to be characterized at an early stage of hot operations, so that its impact on offgas cleanup can be quantified.

C.2.C.15 <u>Aerosol Particle Deposition in Melter Exhaust Line</u>

Aerosol particle deposition from flowing gas streams is an unwanted phenomenon that can be minimized but not wholly prevented. Melters at Hanford, Savannah River, and West Valley have experienced offgas line plugging as a result of deposition of particles entrained into or formed within the offgas line. The observed deposition is a net result of a depositional flux to the wall and subsequent re-entrainment of incident particles. The current HWVP approach to addressing this problem is intended to maximize the re-entrainment rate, and thereby minimize the net buildup of deposits. This approach makes use of a "film cooler", which introduces cool air along the offgas line walls near the inlet. The cool air lowers the temperature of the aerosols to below their "molten sticky" temperature so that they do not adhere to the surface even if they contact it. Care must be taken to avoid cooling to a temperature where water vapor can condense, leading to "moist sticky" particles. The HWVP line also avoids sharp bends to minimize deposition, and a minimum velocity of 50 ft/sec is specified.

While the approach described above represents the current state of technology, deposits are almost certain to form as a result of the presence of a small fraction of sticky particles. Freshly formed particles, caused by rapid cooling, are likely to be super-cooled liquids or of such small size that they will act as an adhesive to retain larger particles. It is unlikely that 50 ft/sec is a threshold velocity that will prevent particle retention. Particle deposition in the melter offgas line is likely to cause periodic plant shutdowns, but the frequency of plugging events is judged to be low. Therefore, this phenomenon would not be grounds for delaying the construction of HWVP.

C.2.C.16 Solids Accumulation in Submerged Bed Scrubber

The submerged bed scrubber (SBS) will capture a large fraction of aerosol particles emitted from the melter. The captured particles will be dispersed in the SBS scrubbing liquid, and could possibly alter its rheology. If scrubbing liquid were to become too viscous, it could lead to impaired scrubbing efficiency, plugging of the drain line from the SBS, or fouling of heat transfer surfaces. At present, the buildup of solids in the SBS is expected to be limited by suspending and purging the solids during a sparging and flush operation using liquid from both the high efficiency mist eliminator (HEME) and the slurry mix evaporator condensate tank (SMECT). Present knowledge does not allow one to assess the significance of this phenomenon, and future experimental work will be required.

The need for additional work on SBS solids buildup has been recognized by WHC/PNL. The information gained from scheduled tests is expected to resolve this potential problem. This issue should not negatively impact HWVP startup or operation because viable backup technologies (e.g., educator venturi scrubber) exist and could be used in the unlikely event that solids buildup caused insurmountable difficulties in the SBS.

C.2.C.17 Corrosion of Melter Plenum/Offgas System Components

The melter plenum and offgas system are exposed to a highly corrosive environment due to the presence of halides, sulfates, and nitrates in the melter feed. Even though Inconel 690 was determined to be the most corrosion resistant alloy tested for these applications, molten salt accumulation can result in appreciable corrosion. Breakaway corrosion of Inconel 690 components was observed in the PAMELA melter with a feed containing appreciable sulfate and fluoride levels. Melter feed limits for these corrosive materials were based upon their solubility in the glass, not melter plenum/offgas system component corrosion. The temperature in the melter plenum also plays an important role in contributing to Inconel 690 corrosion. For example, Inconel 690 corrosion via a sulfidization mechanism is more thermodynamically favored at lower temperatures (less than 750°C).

Decreased plant efficiency could result if significant melter plenum/offgas system corrosion causes a premature component failure (prior to meeting the 2 year design life). Further studies are required related to the effects of halides, nitrates, and sulfates on Inconel 690 corrosion. The effect of corrosion on the structural integrity of Inconel 690 components, especially the lid heater elements, should also be addressed, as the design life of these components was based only on creep resistance data. It is not clear that these potential problems are being addressed by WHC/PNL.

C.2.D <u>General</u>

C.2.D.1 <u>Sampling and Characterization of Double-Shell Tank Wastes</u>

To date, only 17 core samples of Hanford double-shell tank wastes have been taken, and of these, characterization has been completed on only 10 cores. Increased sampling and characterization of double-shell tank wastes is needed to address a number of issues critical to the successful startup and operation of the vitrification plant. These issues include:

- Tank safety - It will not be possible to retrieve or pretreat waste until tank safety issues are resolved.

- Physical characterization - Physical characteristics of NCRW and PFP waste sludges (those with high shear strength) must be better understood before retrieval processes can be developed.

- Chemical characterization - There are considerable uncertainties in the quantities and speciation of various chemical constituents in the wastes (even the major constituents). Some of the information currently available is based on historical information and flowsheet calculations, which have large uncertainties. More information is needed to better define pretreatment and vitrification plant requirements. Development testing has shown that small changes in composition can have large impacts on glass processing characteristics and product quality. Uncertainties in waste composition have forced HWVP to devote considerable resources to determining a glass composition "envelope" that results in acceptable processing and product quality characteristics. If the waste compositions were better known, these efforts could be better focused, and the probability of successfully vitrifying and qualifying the waste for disposal would be enhanced.

- Verification of historical data - Analysis of waste samples can provide verification of composition estimates based on historical data and flowsheet calculations, thus allowing an assessment of the confidence that can be placed in these estimates (which typically form the basis for "reference" flowsheet information and glass compositions).

- Minor constituents - The expected quantities of key minor constituents in the wastes (e.g., iodine-129, noble metals) must be verified by direct analysis of waste samples. These constituents can have profound effects on pretreatment and vitrification plant requirements.

- Samples for development work - Many more waste samples must be taken to support pretreatment development efforts. These efforts have been hampered in part by a lack of real waste with which to work.

- Surprises - Surprises in the quantities or speciation of chemical constituents may have profound effects on pretreatment and vitrification plant requirements. Sampling and analysis is the only way to avoid or at least minimize the number and impacts of such surprises.

It would be desirable to homogenize tank contents prior to sampling so that samples that are more representative of what will actually be pumped out of the tanks can be obtained. Significant uncertainties in waste compositions are likely to persist until homogenization is achieved. The current strategy is to take core samples, which are of limited value because of the inherent spatial variability in the sludge composition. However, core sampling is the only option at this time because Hanford is not yet ready to install mixer pumps or other waste mobilization devices into the tanks. Indeed, additional core sampling information is needed to support tank safety and mobilization/retrieval efforts. Hanford should place high priority on this and other work necessary to obtain samples of homogenized tank contents.

The subgroup was concerned about the apparent lack of a waste characterization plan. WHC has identified a "requirement" to obtain about 55 samples from the double-shell tanks (which includes the 17 already taken), but a satisfactory explanation of the basis for this requirement was not provided. WHC should place priority on developing a characterization plan that clearly identifies the characterization needs of each programmatic element of the Hanford Waste Vitrification System (HWVS) and ties the number of samples required from each tank to these needs.

One of the reasons that double-shell tank waste characterization efforts at Hanford have lagged is that there has been insufficient sampling and analytical capability and insufficient funding to support the various competing characterization programs (tank safety, double-shell tanks, and single-shell tanks). WHC plans to significantly increase sampling and analytical capabilities in the 200 and 300 areas over the next few years. Additional sampling trucks will be procured, and analytical facilities in 200 area will be expanded so that by 1994 they are capable of handling four to five times the current annual capacity of samples. WHC should continue to pursue this aggressive program of expanding characterization capabilities.

C.2.D.2 Grout/Low Level Waste Specifications

Although not strictly a physical or chemical phenomenon, the subgroup is concerned about the specifications for the low-level waste to be sent to the grout facility. The specifications for this waste are based on DOE Orders, agreements with the State of Washington, and design considerations. There is currently no commitment to the requirements of 10 CFR 61, although this issue is now being negotiated by the States of Washington and Oregon and the NRC. Performance assessment considerations may also eventually affect grout feed specifications.

The only radioactivity limit that the grout must currently meet is the 100 nCi/gm TRU limit required by DOE Order 5820.2A. However, Hanford believes that the grout will also meet the applicable 10 CFR 61 low-level waste limits, should they be imposed. The grout will contain listed hazardous wastes (EPA land disposal requirements), so the permit negotiated with the State of Washington will require that samples of grout pass the EPA TCLP (toxicity characteristic leaching procedure) leach test, which could limit the quantity of heavy metals and organics that can be present in the feed. Long-term performance assessment considerations may limit the amount of ^{129}I, ^{99}Tc, and nitrate/nitrite that can be present in the feed.

In order to meet landfill subsidence requirements, the grout must have a minimum compressive strength of 38 psi, which may limit the concentration of materials such as sodium in the feed. The design basis temperature of the grout is 90°C at the vault wall. Tests are now being conducted to determine the maximum allowable grout temperature in the vault that meets the wall temperature limit and is consistent with the compressive strength limit of 38 psi. Temperature considerations could limit the amount of Cs and Sr that can be present in the grout.

The subgroup is concerned that specifications imposed by regulations are subject to change and could ultimately result in the inability to proceed with the grout campaign as currently planned, which would cause delays in the HWVP vitrification campaign. The subgroup is also concerned that the philosophy for removal of radionuclides from the low-level wastes going to the grout facility is inconsistent with practices at Savannah River and West Valley. The solutions going to the cement disposal facilities at these sites are treated to provide a decontamination factor for Cs of about 4000 to 50,000 while the Hanford feed is only decontaminated by a factor of 20. The result is that the feed solutions to the

Hanford grout facility will have a maximum of approximately 300 μCi/gm of Cs while the equivalent solutions at Savannah River and West Valley will have a maximum of about 0.1 μCi/gm Cs. It is not apparent that Hanford is applying the principal of ALARA to waste disposal, and if this becomes an issue in the future, it could adversely affect both the grout and vitrification campaigns.

C.2.D.3 <u>Definition of Objectives.</u>

Although not strictly a physical or chemical phenomenon, the subgroup is concerned that the double-shell tank waste remediation effort at Hanford suffers from ill-defined and shifting objectives. The objectives are often stated in extremely vague terms, such as "minimize HLW volume" or "minimize overall costs", which makes it difficult to define quantitative success or failure criteria for the HWVS. These vague objectives have undoubtedly contributed to the management problems associated with the remediation effort (see Management and Control Subgroup assessment).

Because each double-shell tank waste type has different characteristics, the subgroup believes that quantitative objectives should be defined for each waste. In addition to providing management with greater focus, this approach would allow the various authoritative agencies (DOE, NRC, State of Washington) to review and approve the strategy for each waste type independently.

The subgroup has developed the following objectives for the pretreatment and disposal of Hanford double-shell tank wastes based on a variety of WHC and PNL sources. These objectives are provided only as examples, as there were different numbers stated in different reports and presentations. A 20% contingency was added to get the high values for the numbers of canisters and grout vaults.

<u>NCAW</u> pretreatment objectives:

- Partition 99.9% of TRU into glass or 0.19 MCi into glass, 0.0002 MCi into grout.
- Partition 95 % of non-TRU into glass or 39.9 MCi into glass and 2.1 MCi into grout.

<u>NCAW</u> disposal objectives:

- Canister target at 480, with no more than 580.
- Grout vault number target at 3 (14,000 m^3), with no more than 3.6.

<u>NCRW</u> pretreatment objectives:

- Partition 95% of TRU into glass or 0.012 MCi into glass, 0.00065 MCi into grout.
- Partition 0 % of non-TRU into glass or 0 MCi into glass and 0.02 MCi into grout.

NCRW disposal objectives when using simple pretreatment schemes such as sludge washing, Zr dissolution, and/or selective TRU leaching:

- Canister target at 300-600, with no more than 720.
- Grout vault number target at 1 (5,100 m^3), with no more than 1.2.

NCRW disposal objectives when using the TRUEX process:

- Canister target at 150-230, with no more than 276.
- Grout vault number target at 2 (9,800 m^3), with no more than 2.4.

PFP pretreatment objectives:

- Partition 95% of TRU into glass or 0.013 MCi into glass, 0.0007 MCi into grout.
- Partition 0% of non-TRU into glass or 0.000 MCi into glass and 0.0004 MCi into grout.

PFP disposal objectives when using simple pretreatment schemes such as sludge washing and Cr/PO_4 leaching:

- Canister target at 400 (980?), with no more than 480.
- Grout vault number target at 0.14 (720 m^3), with no more than 0.17.

PFP disposal objectives when using the TRUEX process:

- Canister target at 100 (440?), with no more than 120.
- Grout vault number target at 0.42 (2,100 m^3), with no more than 0.50.

CC pretreatment objectives:

- Partition 95% of TRU into glass or 0.016 MCi into glass, 0.00085 MCi into grout.
- Partition 95 % of non-TRU into glass or 13.3 MCi into glass and 0.7 MCi into grout.

CC disposal objectives when using organic destruction and sludge washing only:

- Canister target at 870, with no more than 1044.
- Grout vault number target at 15 (68,000 m^3), with no more than 18.

CC disposal objectives when using the TRUEX process:

- Canister target at 150, may be as high as 580, with no more than 700.
- Grout vault number target at 14 (74,000 m^3), with no more than 17.

Once quantitative objectives such as these are established and accepted, WHC can better plan and organize their resources to conduct remediation. In defining the objectives, consideration should be given to technical feasibility, regulatory requirements, and cost/benefit analyses.

C.2.D.4 Radiation Effects and the Use of Nonradioactive Simulants

Radiation is expected to have three principal effects in aqueous high-level waste systems: radiolysis of water to form H_2 and O_2, radiation-induced corrosion (resulting from the radiolytic formation of corrosive species), and the Wigner effect (where atoms are knocked out of crystals by particles emitted by radiation). The Wigner effect can exacerbate corrosion problems by disrupting passive films on materials. Other radiation effects include heating as a result of radiation absorption, and enhancement of chemical reactions involving free radicals (bond-breaking reactions are typically not stimulated, as the usual radiation wavelengths are different from the vibrational frequencies of most chemical bonds).

On the basis of considerable worldwide experience over the past 45 years with the processing of highly radioactive solutions, it is unlikely that radiation effects will significantly impact the startup and operation of the vitrification plant. However, there is always the possibility that surprises will be encountered when development efforts for unproven radioactive processes are based on nonradioactive simulants. Hanford should strive to conduct as much development work as possible with real waste in order to avoid such surprises. Real waste will not only have representative radiation fields, but it will also have chemical and physical characteristics that are more representative than simulated waste. DWPF and WVDP operations should provide valuable experience with the vitrification of real wastes prior to HWVP startup, although the ability to accommodate major surprises by design changes in the HWVP may be costly and, in some cases, not possible.

Another potential effect of radiation is a reduction in the durability of the glass product. Radiation effects on durability have not been investigated to any great extent, so more work in this area is warranted.

C.3 Alternative Technologies

C.3.A Stirred Melter

The stirred melter concept has been introduced as a possible alternative for the DWPF melter design. The design was originally developed and tested by Owens-Illinois for glass industry application. Subsequent development and testing of the design has been done by Associated Technical Consultants (ATC) in cooperation with Glasstech, Inc. The mechanical stirring action provided in this design blends the feed material with the molten glass. This action increases the heat transfer rate, thereby increasing production rate for a given size melter. The melter residence time required to generate a homogeneous product is also reduced by the mixing action. A limited duration test conducted in 1989 by ATC in cooperation with SRL showed that simulated melter feed could be processed at a rate four times faster than the HWVP design criteria in a melter of similar size to the DWPF/HWVP melter. This increased production rate can be translated into a reduced size requirement for the melter; a stirred melter having approximately half the linear dimensions could produce glass at the same rate as the DWPF/HWVP melter design. A melter production rate higher than the current design basis would not benefit the plant because the feed preparation and offgas systems would be incapable of supporting the higher rate without significant design modifications (probably involving facility enlargement).

It has been suggested that the increased production rate provided by the stirred melter would allow for more efficient use of cell space within the vitrification plant when compared to the current DWPF/HWVP melter design. A potential advantage of the smaller stirred melter is that it may allow for redundant glass processing capability (parallel melter trains) in the HWVP canyon without an increase in facility size. Another potential advantage is the reduction in the amount of waste generated by the decommissioning of melters that have exceeded their design life.

However, stirred melter technology has not been demonstrated sufficiently to draw conclusions as to its applicability to HLW vitrification. Disadvantages of the stirred melter include accelerated refractory corrosion rates, increased downtime for replacing corroded parts (e.g., paddles, electrodes), increased release of volatiles to the offgas system, a more complicated remote design, the need to establish the quality of the waste form, and possible increased cell contamination due to more frequent equipment changeouts. Technology development and demonstration efforts would be required to establish the reliability, adaptability to a remote environment, glass product quality, and offgas characteristics of the system. This information could then be used to evaluate the consequences of changing the melter design on the the rest of the plant systems. The impact of the stirred melter on the entire process must be assessed before making any decisions on a design change. Technology development and demonstration efforts to support this decision would require significant funding and probably a minimum of 5 years of concentrated effort.

C.3.B Alternatives to the TRUEX Process

The TRUEX process has been demonstrated only at the bench scale, and it may have difficulty in adapting to all of the different post-NCAW wastes, as has already been shown in limited testing with NCRW sludge. Alternative processes should receive the R&D resources that will allow a comparison with TRUEX. Possible alternatives to TRUEX include:

- Solvent extraction processes using solvents other than CMPO (for example, DHDECMP), which may offer advantages in terms of reduced process complexity, reduced chemical requirements, and reduced waste volume at a possible cost of less efficient TRU partitioning.

- Hollow fiber contactor separation processes.

- Chromatographic-type separation processes involving extractants that are fixed on resin beds.

- Simple dissolution-reprecipitation schemes that have advantages of reduced process complexity at a cost of less efficient TRU partitioning.

- Selective leaching processes. For example, limited tests on NCRW sludge showed that 60-80% of the TRU was removed from the sludge with simple leaching, resulting in a 100-150 nCi/gm sludge, whereas the target is 30-50 nCi/gm. These results are sufficiently close to the target that more thorough study is justified.

- Solubilization of constituents that limit waste loading in glass to remove them from the high-level waste sludge (for example, oxidation of Cr^{3+} in the PFP waste to higher oxidation states that are soluble in the supernate).

- Destruction of organics in the CC waste prior to pretreatment, which may provide sufficient partitioning of the TRU constituents to the sludge that TRUEX or an equivalent process is not needed (simpler schemes, such as sludge washing, could be used).

Combinations of these alternatives may also be viable.

It is important to recognize that unlike historical solvent extraction processes, such as PUREX, where purity and selectivity in extracting U and Pu are paramount, partitioning of TRU wastes for vitrification and grout disposal is a much less demanding task. Simple, cost-effective processes capable of meeting disposal objectives while minimizing additional production of wastes are needed for waste partitioning. Complex processes are inherently risky because of their potential for downtime, extensive maintenance, and excessive raw materials requirements and waste production. TRUEX will be a very complex process which when applied to the very complicated post-NCAW wastes may result in a continuing series of technical problems.

A redirection of the pretreatment R&D effort is needed to fully explore alternatives to TRUEX. Decisions to pursue alternatives should be based on technical feasibility and cost/benefit studies. Benefits associated with keeping TRU partitioning simple for the very complicated wastes that are to be processed at Hanford could be far-reaching.

C.3.C Alternative Waste Forms

The original mission of the HWVP was to solidify the NCAW from the processing of N-Reactor fuel in the Hanford Purex Plant. Based on the chemical and radionuclide content of this waste, a borosilicate glass similar to that developed for use at Savannah River and West Valley was chosen as the waste form. The HWVP mission was eventually expanded to include all high-level double-shell tank wastes at Hanford. Given the relatively mature level of understanding of borosilicate glass processing and product characteristics compared to other waste forms, the subgroup believes that the selection of borosilicate glass as the waste form for the double-shell tank wastes is valid. Borosilicate glass is also the only high-level waste form that the federal repository project and the NRC have considered for acceptability for geologic disposal.

Because of the large volume of single-shell tank wastes at Hanford, and the poorly characterized nature of these wastes, it may be appropriate to reopen the issue of alternative waste forms if a decision is made to retrieve and process these wastes. Alternative waste forms might be appropriate if the single shell tanks contain significant quantities of chemical constituents that cannot be readily processed into glass or easily removed by pretreatments. For example, the Idaho National Engineering Laboratory has opted for a ceramic waste form because their wastes contain high concentrations of aluminum, which cannot be readily processed into glass or washed out of the waste.

Any decision to proceed with alternative waste forms will have to be based on a myriad of considerations, including technical feasibility, development requirements and costs (for pretreatment, waste form production and low-level waste disposal), construction and production requirements and costs, regulatory requirements, and efforts associated with waste form qualification.

C.4 Phenomena Considered by the Subgroup

C.4.A Double-Shell Tanks:

- Generation of explosive mixtures
- Environmental releases
- Bumps
- Burps
- Nonuniformity of contents
- Slurry rheology
- Potential criticality
- Retrieval efficiency/heel removal
- Damage to tank and internals during retrieval
- Hydraulic removal
- Physical/chemical characterization
- Slurry transfer in lines
- Heat up during retrieval
- Corrosion inhibition/enhancement

- Inverse densification (where higher temperature solutions are more dense than lower temperature solutions)

C.4.B Pretreatment (HWVP):
- Environmental releases
- Gelation of waste
- Deagglomeration of sludge particles
- Generation of explosive gas mixtures
- Partitioning of waste constituents
- Corrosion (particularly by acidic halide solutions)
- Rheology
- Physical/chemical characterization
- Sedimentation
- TRUEX solvent recovery
- CMPO availability (TRUEX)
- TRUEX solids deposition
- TRUEX extraction coefficients
- TRUEX solvent degradation
- TRUEX interfacial phenomena
- Radiation effects
- Dissolution chemistry
- Organic destruction
- Foaming during sludge dissolution
- Selective leaching
- Waste generation/disposal
- Blending

C.4.C Pretreatment (Grout):
- Generation of explosive gas mixtures
- Heat buildup in grout
- Leaching of hazardous materials from grout
- Removal of radioactive chemicals (Cs, Sr, I, Tc) from grout feed
- Removal of organics
- Removal of Na+
- Grout compressive strength
- Grout radionuclide and chemical specifications
- Radiation exposure to personnel

C.4.D Vitrification

C.4.D.1 Feed preparation
- H2 evolution - catalysis by noble metals
- $HCOOH/NO_3^-$ reactions
- Scale buildup on SRAT/SME heat transfer surfaces
- Erosion of tank/agitator/cooling coils

- Zeolite segregation in SME
- Accumulation of constituents in recycle stream
- Radiation effects
- Redox control
- Frit formulation/glass optimization
- Analytical measurement uncertainty
- Sampling uncertainty
- Residue buildup in SRAT/SME

C.4.D.2 <u>Melter</u>

- Generation of explosive gases and soot formation
- Steam explosion
- Volatilization of hazardous materials
- Noble metals accumulation
- Phase separation (sulfates, fluorides, phosphates)
- Crystalline phase formation (spinels, etc.)
- Refractory and electrode corrosion
- Plenum materials and heater corrosion
- Plugging of glass outlets
- Cold cap behavior
- Melter idling
- Mixing/residence time behavior
- Foaming/sulfidization (redox)
- Radiation effects
- Brittle fracture of refractory (thermal shock)
- Dissolution kinetics
- Canister cooling/annealing (devitrification)
- Convective zones (dead zones)
- Glass durability
- Modeling of glass properties

C.4.D.3 <u>Offgas system</u>

- I-129 evolution
- Tc-99 evolution
- Particle deposition in offgas line
- Solids buildup in SBS
- DF in system components
- Corrosion
- Foam deposition
- Vapor deposition in offgas line
- Plugging of HEME
- Radiation effects
- Scale formation on SBS cooling coils
- NO_x formation and removal
- Explosive gas mixtures

- Surges in offgas flow rate

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APPENDIX D

PROCESS ENGINEERING SUBGROUP

D.1 Summary

The Process Engineering Subgroup has reviewed the status of the Hanford Waste Vitrification Project (HWVP) and concluded that the process technology, design and engineering for retrieval and pretreatment of Vitrification Plant feed are not adequately developed. As a result there is a high probability that, subsequent to processing of the initial two tanks containing neutralized current acid waste (NCAW) feed suitable for the Vitrification Plant will not be available. Programs for development and demonstration of post-NCAW retrieval and pretreatment must be completed if continuity of Vitrification Plant operation and the ability to process post-NCAW feeds are to be assured.

Post-NCAW retrieval and pretreatment have not received management attention, resources or budget support comparable to the Vitrification Plant. There is not a comprehensive, integrated technology and engineering development plan for the Hanford Waste Vitrification System (HWVS). Lack of a coherent plan to address issues in a coordinated manner has hindered development of an integrated overall plan for site remediation. The Westinghouse Hanford Company (WHC) is currently redefining the baseline plan for the HWVS. The new strategy is scheduled to be released in October 1991. The plan should be expanded to include processing of single-shell tank (SST) wastes as part of an integrated site remediation program since SST processing requirements are much greater than those of double-shell tanks.

The Process technology, design and engineering of the HWVP are ready to support site preparation beginning in fiscal year 1992 and subsequent construction to permit processing of two double-shell tanks containing NCAW in the year 2000. Design of the Vitrification plant is being conducted in a credible manner. Problems with the HWVP Vitrification Plant design uncovered by this subgroup are not abnormal for a project of this type and can be resolved within the current schedule if adequate attention is given to their solution. However, deferral of process equipment procurement until after hot start-up of the Savannah River Waste Processing Facility (DWPF) is completed would permit resolution of surprises uncovered during hot startup.

Following study of the HWVS baseline current at the time of this review, the following observations were made:

D.1.A The HWVS lacks coordination and integration at both the project management (DOE) and operating contractor (WHC) levels. Integration of waste retrieval, pretreatment, grout production and vitrification is limited. Planning and scheduling for sequential processing of NCAW, Neutralized Cladding Removal Waste (NCRW), Complexant Concentrate (CC) waste and Plutonium Finishing Plant (PFP) waste is complete only in a gross sense.

D.1.B Process technology and engineering for retrieval, pretreatment and vitrification of two DSTs containing NCAW are progressing satisfactorily. WHC estimates that two years will be required to process feed from the two NCAW tanks. The technology and systems required to retrieve high shear strength solids and pretreat the waste from the other eight double-shell high-level waste tanks (post-NCAW) have not been developed sufficiently to assure continuous feed to vitrification.

D.1.C Low-level waste (LLW) from the high-level waste (HLW) pretreatment process will be stored in DSTs prior to future disposal on grout. This waste and additional LLW stored in 18 DSTs may require additional treatment to satisfy ALARA requirements. There is also significant potential that regulatory agencies will promulgate more restrictive requirements for the radionuclide content of grout. Either of these occurrences could lead to a need for additional LLW treatment and storage facilities which in turn would adversely affect the vitrification process schedule.

D.1.D The TRUEX process, or an alternative process, for removal of transuranics (TRU) from high-level waste is believed to be important by WHC for economic vitrification of post-NCAW. The TRUEX technology proposed for the pretreatment of NCRW, CC and PFP has undergone limited development. Extensive laboratory study and pilot plant development using simulated and actual waste will be required to demonstrate TRUEX technology. This is a high-risk technology with considerable potential for failure.

D.1. E Delaying Vitrification Plant process design and equipment procurement affords additional opportunities to take advantage of technology, engineering and operating experiences of the West Valley Demonstration Project (WVDP) and the Savannah River Defense Waste Processing Facility (DWPF). It also allows time for further development of retrieval and pretreatment systems technology needed for systems integration and assured continuity of operations.

D.1.F The probability that B-Plant will satisfy current criteria for radiochemical processing operations appears low. This review team considered the methodology presented for B-Plant modification and maintenance to be in the conceptual stage. It is our opinion that a new facility would better meet long-term pretreatment requirements.

D.1.G An approach using blending of selected waste feeds to provide continuity of HWVP feed and reduce feed variability is being developed by WHC. Any decision to reduce feed variations and assure feed continuity by blending must await completion of the WHC study and further characterization of the various tank wastes.

The Process Engineering team has been-unable to identify any future technology that could reasonably be expected to reduce the cost of the HWVP.

D.2 <u>Waste Characterization</u>

Detailed chemical and physical properties of all the wastes to be processed are generally unavailable. Only 17 of a proposed 55 core samples have been taken from HLW tanks scheduled for processing. Sampling and analysis for these tanks will not be completed until 1998. Waste and product characterization is an area of specific concern. Small changes in waste composition could adversely affect the pretreatment process by increasing settling rates, solubilizing precipitated TRU elements etc. Organics, especially possible surfactants, are of concern. The major quantified grout product specification is for non-TRU wastes. Because these low (< 100 nCi/gm) TRU levels are difficult to monitor, they could easily be exceeded during process upsets, if decontamination factors are not firmly understood and controlled. Non-radioactive contaminants in the grout (e.g. nitrates, nitrites, Cd, Cr+6) may be a controlling factor as grout specifications are evolved.

Only 10 of 28 DSTs are currently defined as HLW requiring vitrification and therefore preprocessing. No sampling program is planned for 18 DSTs that are currently classed as containing LLW suitable for feed to grout. Sampling of sludges and supernates in these tanks is needed to establish physical and chemical characteristics and to verify that further processing will not be required. Changes in LLW specifications or unanticipated constituents in the remaining 18 tanks may mandate pretreatment and vitrification of additional material.

Characterization of all feed materials should be expedited to assure development of feed pretreatment systems appropriate to HWVS Requirements.

D.3 Waste Processing Strategy

In the judgement of WHC the apparent robustness of the waste vitrification process would allow the HWVP to be operated on untreated waste feed. This option is an ultimate, but expensive, fallback position should the development of pretreatment options prove impractical or inconsistent with the HWVP schedule.

Most of the volume of Hanford tank wastes consists of nonradioactive salts, chemical compounds and process wastes, mixed with relatively small quantities of highly-radioactive fission products, activation products and transuranic residues. If the high-level wastes are extracted from the mixture and vitrified as a separate class, then the non-radioactive residues can be disposed of by much less expensive means, thus providing an important incentive for waste pretreatment. Preliminary studies indicate that successful partitioning of typical Hanford DST wastes into high- and low-level fractions will reduce the volume of glass by approximately an order of magnitude. If the large volume of low-activity residues can be grouted the cost savings from partitioning may amount to tens of billions of dollars. Waste pretreatment, although not technically required, has therefore become an economic necessity.

Because millions of gallons of waste are involved, pretreatment processes must be simple, reliable and economical. Because several widely divergent waste compositions are involved, the pretreatment options must be generically effective, or customized for each class of waste. Regardless of the waste type and process selected, the resultant grout product must be formally acceptable for shallow land burial at minimal cost, or the enormous economic advantages of partitioning will be lost.

The selection of simple unit operations for the primary pretreatment sequence (washing, settling, decanting and filtration) is determined by the sheer volume of waste that must be processed. Partitioning the waste into a large-volume low-specific-activity non-TRU fraction that can be disposed of cheaply and a minor fraction containing the high-level and TRU wastes concentrated in an expensive refractory (glass) matrix, is an essential feature of the HWVP waste solidification process. What has not been quantitatively established for the HDWRP is the volumetric ratio of these two fractions, which is a sensitive function of the processes used, the additives required and the success of the pretreatment separations employed (i.e. their decontamination factors). For example, ALARA considerations would dictate that cesium-bearing NCAW supernates be processed to remove more than the currently targeted 90 to 95% of the Cs 137. However, additional processing will greatly increase the consumption of chemicals required to regenerate the ion exchange columns and increase the quantity of LLW which will require subsequent processing and disposal as grout.

Requirements for pretreatment simplicity, reliability, flexibility, cost effectiveness and acceptability of the grout product, constrain the choice of suitable pretreatment options. Resource limitations and emphasis on meeting the schedule demands of the vitrification plant have prevented extensive process development. The result has been that WHC has attempted to identify generic processes that, if they can be developed, have the best chance of falling into the acceptable parametric space previously discussed.

To provide feed to the HWVP and to demonstrate the minimal steps necessary to process Hanford tank wastes, Westinghouse has first chosen to process NCAW, the most tractable of the DST wastes. There will be nearly 2 M gal of NCAW, which is currently stored in two DSTs as reasonably mobile sludge, covered with approximately 1.5 M gal of supernate. The supernate contains most of the nonradioactive sodium salts from reprocessing, neutralization and tank passivation, and most of the soluble fission products, notably Cs-1 37.

Westinghouse proposes that these tanks be decanted and the slurry resuspended and pumped to a process vessel where repeated washings will remove the remaining soluble salts detrimental to the glass-making process (sodium salts, chromates carbonates, phosphates and sulfates). The washed slurry will be combined with the residues from the supernate pretreatment process (to be described) and fed to the HWVP where it will be vitrified into a high-level waste-transuranic waste (HLW-TRU) glass.

The supernatant liquids and washings will contain nearly all the soluble salts that would otherwise increase the quantity and decrease the quality of the HWVP glass product plus most of the major soluble radionuclide ingredient, Cs-137. The supernate will be filtered to remove any suspended solids (possible TRU) and passed through an ion-exchange resin column to remove the cesium. The clarified effluent from the column will be adjusted for concentration and acidity and fed to the grout plant, and cast into grout, provided it can meet regulatory standards for low-level nontransuranic waste (LLW). The cesium will periodically be eluted from the column, combined with the filtered solids and fed to the HWVP.

Two advantages of the HWVS design are assumed by WHC: the ability of the vitrification process to accept wide variation in feeds and production of LLWthat is acceptable feed to the grout plant. These advantages are interrelated, so that a deficiency in one must be compensated by the other.

The first presumed advantage is the inherent robustness of the vitrification process: its ability to handle a wide variety of wastes and still produce an acceptable glass product. This robustness and the belief that the glass product can be fully characterized by analysis and control of the HWVP feed composition, are important to the success of the HWVP. Pacific Northwest Laboratory (PNL) and Savannah River Laboratory (SRL) models developed to predict glass durability and processing behavior are not consistent. These problems are described in more detail in the Phenomenology report (Appendix D).

The second presumed advantage is that the HWVP pretreatment system will produce a low-level waste that is acceptable for direct burial as grout in a concrete vault surrounded with asphalt. This assumption is predicated on the acceptability of a waste composition that is still under negotiation.

Except for the 100 nCi/gm TRU limit, the allowable radioisotope content of the design basis grout product has not been adequately defined. Current assumed limits are not consistent with those at similar DOE (SRP for example) plants. Tighter regulatory restraints are possible since Washington and Oregon have petitioned the NRC for tighter standards. Stricter disposal standards and/or problems with poorly defined pretreatment systems could require significant modification to pretreatment systems or grout requirements.

The philosophy for limited removal of radionuclides from the solution going to the grout facility appears to conflict with the practice at Savannah River and West Valley. The solution going to the cement disposal facilities at Savannah River has a maximum allowable Cs-137 concentration of about 0.1 mCi/g while the Hanford limit is about 300 mCi/g of solution. It is not apparent that Hanford is applying the principal of ALARA to waste disposal.

On both presumed advantages, the Process Engineering Subgroup believes that the HWVP management has underestimated the amount of development work required and the need for integrating their studies of the three waste products: glass, grout and off-gas. All waste must be carried by these three- media, and each cannot always accommodate the deficiencies of the other if they are each independently optimized. WHC is also committed to a schedule that precludes easy incorporation into their program of valuable experience that will evolve from the concurrent operation with radioactive feed of the West Valley and Savannah River vitrification projects. The lessons learned from West Valley and DWPF could otherwise be applied to HWVP in a very positive way, and might reduce the need for expensive process redesign and development or prevent a common-mode failure.

WHC has devoted considerable effort to the definition of the vitrification plant flowsheet and the design of the HWVP, but pretreatment operations have received considerably less attention. The Process Engineering Subgroup assesses the post-NCAW pretreatment development as currently at a pre-conceptual design stage and of being incapable of satisfactory completion within the current HWVP schedule. The potential problem with the WHC processing strategy is that the technologies required may not be developed in time to allow processing of the more complex waste streams immediately after NCAW processing is completed or that the new technologies may not be appropriate for production of Vitrification Plant or Grout Plant feeds.

The technical base needed to support NCAW waste retrieval, pretreatment and vitrification are reasonably well developed. Engineering practicability for NCAW retrieval has been demonstrated at Savannah River while pretreatment capability has been demonstrated through previous operations in which cesium was removed from supernate by ion exchange in B-Plant.

Pretreatment flowsheets for the much less complex conversion of NCAW to suitable grout and melter feedstocks (the baseline process described above) are much better defined, and probably can be proven prior to HWVP final design and construction, but only if sufficient resources are devoted to them. Specific details of the NCAW and post-NCAW retrieval and pretreatment process are given in the following sections.

Development of advanced technology required for post-NCAW processing will require a major expenditure of time, manpower and dollars. Discussions with technical personnel from both WHC and PNL indicate that these personnel have the ability to undertake and resolve the technical problems. However, resource and funding priorities currently prevent resolution of these problems on a time scale that is consistent with the current HWVP schedule.

The technical base and demonstration of engineering practicability needed to support post-NCAW waste retrieval and pretreatment are not adequately developed. The development of technology required to support these operations has been deferred because of resource limitations. Wastes stored in tanks are not fully characterized. Variations in the physical properties of these materials could affect retrieval operations of require additional pre-processing. Variations in feed composition will require adjustment of pretreatment chemistry. These retrieval and pretreatment development operations could have major impacts on Vitrification Plant operations because of a possible lack of feed. Deferment of vitrification plant construction would allow resolution of these long-term problems and allow the HWVP design to incorporate lessons learned during DWPF and West Valley operation.

The present schedule for the HWVP does not adequately provide for the development or demonstration of pretreatment processes that might be necessary to produce an acceptable vitrification feed product. The "top-down" schedule necessary to support the HWVP startup date required by the Tri-Party Agreement has severely compressed the pretreatment and technology development schedules. The result is that the output from the pretreatment process development (including HWVP feed characterization) will not be available until HWVP construction is completed. Additionally, the pilot plant needed to demonstrate the complex pretreatment process under consideration (TRUEX) is scheduled for design before the process is developed and the plant is scheduled for construction before development is completed.

The present schedule-driven success-oriented program which does not provide adequate time for resolution of problems uncovered during development will very likely assure that effective pretreatment will be denied to the HWVP on the required schedule and that much more high-level waste will be generated, and at a higher cost, than necessary. The current Westinghouse program has attempted to mitigate the effects of these resource and scheduling conflicts, by beginning to consider a series of alternative pretreatment options. These alternatives are intended to provide some relief, while remaining within the nominal envelope of previous commitments.

D.4 Waste Retrieval

D.4.A NCAW Retrieval

Technology necessary to support retrieval of NCAW waste from the DSTs is well developed. The slurry mixing pumps planned for use are based on technology demonstrated at Savannah River, modified based on testing at PNL to adapt that technology to Hanford waste.

Testing is either complete or planned to predict NCAW sludge mobilization, uniformity of slurry, erosion/corrosion effects, jet forces on tank components, and slurry transfer requirements. Simulated waste used in testing is based on characterization data available from tank sludge samples.

WHC has conducted 1/12 scale tests on sludge mobilization using simulated sludge. These tests are being expanded to 1/4 scale in a new test facility. Static forces measured in tests on 1/6 scale models of tank components were extrapolated to full scale to determine what components need to be removed or strengthened in the double shell tanks. Analysis of dynamic forces is in progress.

Uncertainty in the effective cleaning radius of two pumps will be reduced by adding two more pumps. Corrosion/erosion test results indicate planned operations will be acceptable. Mixing pumps have been sized based on test results, and full-scale testing in one of the NCAW DSTs is planned. The major weakness in NCAW retrieval plans is the 1997 schedule date for full scale demonstration of the technology. This demonstration date will be too late to incorporate any major changes if hot startup and reliable operation are to commence in December 1999.

A major contamination problem at Savannah River from leakage of mixing pump-bearing cooling water has been recognized by Hanford and engineered out of their design. If deep viscous sludges in some tanks require incremental lowering of pump impellers as sludge is slurried, the current engineering solution may require modification.

Temperature increase resulting from sludge mobilization has been calculated and compared to requirements for tank safety for planned operations and a range of contingencies. Instrumentation to measure sludge mobilization and uniformity (vertically and radially) in the DST test is well thought out and either available or being developed. A system to remove, decontaminate and transport tank equipment and components has been developed.

The currently planned waste removal demonstration will recover only 90% of the in-tank solids. By adding the two extra pumps, WHC hopes to demonstrate an ability to recover a higher fraction of solids. It should be noted that the DST Environmental Impact Statement stipulates that recovery of 99.5% will be attained before tanks are decommissioned. There are currently no HWVS plans to meet this requirement.

There will be an interruption in feed to HWVP of two years following approximately two years of operation assuming availability, successful retrieval and subsequent pretreatment of NCAW. Other potential "NCAW-like" feeds have been identified that could extend the initial campaign to approximately 8 years. One candidate is 106 C, a single-shell tank that will require completely different and more difficult retrieval technology. Hydraulic slurry mixing in single shell tanks is judged to be an unacceptable risk because of the large amount of water that must be added to dissolve the salt and slurry the sludge, and possible damage caused by impingement of the high pressure jets on fragile tank walls. Use of DST retrieval technology in potentially leaking or corroded SSTs increases the potential for material loss through solubilization and leakage. Follow-on feed from SSTs is limited by unavailability of appropriate retrieval technology. The current schedule for HWVP operation contains a 2-year hiatus between vitrification of NCAW and post-NCAW wastes.

D.4.B Post-NCAW Retrieval

The other DST waste, i.e. NCRW, PFP, and CC (except for East area CC which is characterized as NCAW-like") will present different and more difficult retrieval problems. Higher shear strength (thicker) wastes (e.g. NCRW is about double the shear strength of NCAW) may require other technology. The extent of technology and engineering development required for these wastes is unknown, but programs similar to those being carried out for NCAW wastes will be required. Post-NCAW wastes are poorly characterized. Sample data may come too late to factor into current design and development programs. Sample data could hold surprises about physical characteristics or chemical composition that would require changes in retrieval or pretreatment technology.

D.4.C Waste Retrieval Instrumentation and Control Systems

Instrumentation and control systems used at the tank farms will be developed and designed independent of the HWVP by tank farm engineering organizations. Most new systems will be based on technology used currently to monitor wastes at the tank farms and from DWPF experiences at Savannah River.

Thermocouple trees presently installed in tanks will be removed and replaced with larger dry wells designed to withstand the large mechanical forces imposed by waste retrieval operations. The dry wells incorporate thermocouples and are designed to accept neutron and gamma probes to monitor sludge mobilization and continued particle suspension. Ultrasound is also being considered for density measurements and mapping to assist in evaluating mobilization tests.

Process control systems at the tank farm will be upgraded to include portable mixer pump controls, tank ventilation controls and closed circuit television. Systems for controlling motors, monitoring strain gages, pressure transducers, etc are commercially available. Integrating and fielding a system for use in the tank farm environment will be a significant effort. Mobilization technologies are being developed and evaluated for prototype systems; detailed design has not started for production systems. Funding issues are delaying demonstration and prototype testing which precludes detailed design of production systems.

).5 Pretreatment

D.5.A NCAW Partitioning

Pretreatment of NCAW is well defined and uses established technology. The primary uncertainty is with the extent of cesium removal required in processing supernate to allow grout disposal of LLW product. Some additional processing or system modification might be required to improve the efficiency of Cs removal.

The proposed pretreatment flowsheet for NCAW is as simple an operation as can be conceived on the scale required. Slurry sluicing, pumping, washing and decanting, filtration and ion exchange are common, well-developed engineering operations, which have been repeatedly demonstrated in radiological processing operations. A high level of confidence is assigned to the eventual success of NCAW pretreatment, but there are several important reservations concerning the ability to demonstrate this process and to bring it into full-scale continuous operation in time to provide washed feed to the HWVP.

Areas of specific concern are:

D.5.A.1 Process Selection - Process vessels need to be selected, designed, or built as required. Presently, in-tank washing, washing in 244 AR vault, in B-

Plant, and in a new special purpose pretreatment facility, are all under consideration. The process needs to be defined with sufficient precision so that design, construction and/or modification options can be implemented.

D.5.A.2 Sludge Washing - Full-scale, or appropriately-scaled, retrieval, washing, and decantation experiments should be undertaken to identify any operational difficulties and to establish the process decontamination factors for controlling components (e.g. TRU).

All DST wastes must remain in suspension long enough to be homogenized and transported as a pumpable slurry, without plugging, and yet settle sufficiently to be separated readily by decantation. This washing sequence has been successfully demonstrated elsewhere with wastes believed to be similar, and with simulated wastes on a laboratory scale. There is a legitimate question as to whether these experiments can be scaled, or whether simulations can reproduce the minor constituents that might affect these transport properties of NCAW. Difficulties in settling/separation rates can be mitigated by the addition of flocculating agents not currently provided, and whose effects on the succeeding processes have not been determined. Experiences at West Valley and Savannah River Site need to be combined with experiments with actual NCAW to resolve this question. A separation factor (solids suspended/solids precipitated) needs to be determined for NCAW under actual process conditions in order to define and size the polishing filters required and to assess the effects of resolubilization of TRU from tank residues, as well as the potential for post-decantation precipitation and hydrolysis of dissolved species. Characterization of all NCAW-like waste tanks is required unless the washing/decantation phenomena are sufficiently understood to develop a worst-case mitigation scenario, or sufficient tankage is made available to provide a well-mixed master blend of NCAW-like feed to the pretreatment process, as is being considered for the DWPF.

D.5.A.3 Ion exchange - The acceptability of the currently proposed 95% cesium recovery in B-Plant ion-exchange columns needs further study. WHC has indicated that although higher recoveries are achievable, a much greater volume of LLW and grout would be produced. In this respect, HWVP pretreatment does not compare favorably with that of WVDP and DWPF, where residual Cs contents are orders of magnitude lower.

The use of Cs-100 resin for Cesium-137 removal needs to be demonstrated on a more realistic scale. Radioactive solutions containing Cs-137 should be sorbed and eluted from these resin columns repeatedly until resin lifetime can be determined, their capacity vs age evaluated, their failure mode identified and a means for their disposal and replacement selected. Resin capacity and elution efficiency are essential to the success of the pretreatment process and must be demonstrated on a more realistic scale than that currently employed (10-5 scale).

D.5.B Post-NCAW Partitioning

The pretreatment processes for the post-NCAW wastes, although even more important to the success of the DST remediation program, are in the pre-conceptual design phase, are still under discussion, and are difficult to evaluate at this time. Nevertheless some general comments apply.

The post-NCAW wastes, NCRW, PFP and CC, in the aggregate constitute a much larger volume (especially when only solids are considered), are in a much less tractable form than the NCAW for both retrieval and pretreatment. For these reasons, this Subgroup endorses the WHC decision to defer post-NCAW processing until after the NCAW experience. However, deferring the development of processes for post-NCAW pretreatment can not be allowed, because these processes are extremely challenging and their development will be difficult, costly and time consuming.

The common denominator for the post-NCAW wastes is the need for removing a large quantity of non-radioactive and low-level wastes from co-precipitated or complexed TRU wastes so that the latter can be economically fixed in a reasonable quantity of vitrified glass. Because post-NCAW TRU wastes are found in the same phase form (solid or liquid) as the diluent LLW, simple phase separations (wash and decant as in NCAW) are not an effective separations process. Present thinking is to dissolve post-NCAW in nitric acid and to chemically process the acid solutions through an extensively modified variant of the Purex solvent extraction process, called TRUEX, to isolate the TRU elements. Although individual elements of the TRUEX process have been extensively evaluated, TRUEX has never been operated at the scale required nor with feed mixtures resembling the post-NCAW wastes. The success of TRUEX depends on the ability of a bidentate chelate known as CMPO, to compete successfully with the normal PUREX extractant, TBP and any other complexants present, in a series of extraction and stripping cycles. The essential ingredient, CMPO, is a complex chemical [octyl (phenyl) -N, N-diisobutyl-carbamoyle methylphosphine oxide] custom-made in small lots for experimental purposes. There is currently no industrial base for producing ton quantities.

Post-NCAW waste processing requirements are largely undefined. Feeds are uncharacterized and the pretreatment technology is undeveloped. Preliminary lab tests have been conducted on gram samples of NCRW to establish distribution coefficients and solids dissolution parameters for removal of TRU residues by TRUEX processing. CC and PFP process data are lacking. A previous review indicated that a thorough job had been done in identifying and planning work needed to complete development of the processes. However, we believe that development is in a very rudimentary stage and that successful implementation of the TRUEX process can not be assumed.

Dissolution of the aged TRU solids in the post-NCAW wastes is known to be difficult, and will almost certainly require a nitric-acid-fluoride mixture to effect satisfactory dissolution. This mixture is extremely corrosive to conventional process equipment and will require special high alloy materials such as "Hastelloy C" to be substituted for ordinary stainless steels.

The high zirconium and aluminium concentrations in post-NCAW wastes are notorious in their ability to hydrolyze, precipitate and form gelatinous sols and "interfacial crud". This can occur throughout processes of this nature, often on an unpredictable basis, producing process upsets. Aqueous and organic phases containing these components can be difficult to separate. Long disengagement times have already been noted for some post-NCAW wastes.

TRUEX flowsheets are in the preconceptual stage and have undergone major changes as preliminary laboratory data have been developed. Phosphates may be introduced from the stripping agent with an adverse effect on glass formulation. Aluminum-nitrate addition required to complex the fluoride may adversely effect grout quantities and chemistry. Much laboratory work must be doneto identify and resolve problems with TRUEX processing of the variable Hanford wastes. This laboratory work will require much time and effort and could possibly result in disqualification of the TRUEX process for pretreatment of some waste streams.

Complexant concentrate waste presents an additional challenge as decantation is not possible and the supernate and sludge need to be dissolved together. Because these wastes contain a significant quantity of residual organic complexant, it is currently believed that the organic content must be destroyed in order to produce an acceptable grout and to minimize complexant and complexant degradation products that might interfere with TRUEX.

The processes currently considered for organic destruction, hydrogen-peroxide and/or ozone oxidation, have proven only partially effective for destruction of organic residues. Processes that might be more effective, such as super-critical-water oxidation, have not been tested with CC. In addition, the Process Engineering Subgroup believes that scale-up of this technology will prove impractical.

Flowsheets and mass balances must be developed to allow evaluation of feasibility and practicality. Extensive pilot plant testing of flowsheets will be required to test and demonstrate concepts developed in the laboratory. Surprises that are expensive and require time-consuming system modifications can be expected. A conceptual design has been developed for TRUEX flowsheet testing in Cell 38 of B-Plant and cells B and C of WESF. Pilot test facilities will be available in 1997 at the earliest. Extensive process and equipment testing and modification can be anticipated prior to full-scale system implementation.

The solvent-extraction contactors tentatively chosen for TRUEX should be carefully evaluated under realistic operating conditions. Areas of concern include materials of construction and the suitability of centrifugal contactors for applications where long disengagement times and suspended particles can be encountered. Alternatives such as pulsed columns will require considerably more volumetric holdup, with increases in cell space and much greater headroom. Their impact on facility design would be considerable.

WHC proposes to upgrade the B-Plant to save both time and money on the construction of pretreatment facilities. We believe that the WHC estimates of cost and time savings over new facilities are overly optimistic. Upgrading of B-Plant to provide production-scale TRUEX processing will require extensive modifications. The ability of an upgraded B-Plant to meet DOE Order 6430-1A standards and requirements for nuclear facilities is questionable. Robotic systems and maintenance concepts that have not been demonstrated in a remote canyon environment are proposed. Further definition of plant requirements and proposed B-Plant modification and maintenance technologies are needed.

The above examples should not be interpreted as a rejection of the process options being considered for the post-NCAW wastes. Rather they should serve as an example of the development work required when an unproven process is directed toward the solution of a complex separations problem. The WHC engineering staff is well aware of these difficulties and should be given the opportunity to address them effectively; the payoff from the successful implementation of a pretreatment process involving TRUEX is too great to deserve less. In the judgement of this Subgroup this would require a much larger effort then is currently planned, including the operation of both an extensive pilot plant development program and an extensive near-scale demonstration plant.

The extensive modification of aging facilities such as B-Plant, to accommodate NCAW and future- waste pretreatment processes, either as pilot or full-scale processes, does not appear to be consistent with a program that might extend well into the middle of the next century. Considerable thought should be given to the construction of a multiple-purpose waste remediation facility with sufficient flexibility to accommodate HWVS pretreatment needs. Additionally Hanford should attempt to provide or release additional tankage to permit waste feed blending in order to mitigate problems related to waste inhomogeneities, stratification and the need to customize the pretreatment of similar wastes with differing concentrations, as well as to provide storage for off specification grout feed.

D.5.C Pretreatment Process Instrumentation and Control System

Baseline configuration defines the use of B-Plant for waste pretreatment. This plant was constructed as part of the original Hanford facilities in the 1 940s. Upgrades to the plant and services have been incorporated over the years with many more proposed to extend its lifetime. Considerations for continued use of B-Plant included these upgrades.

The use of B-Plant from an instrument and control systems standpoint will require considerable evaluation with a cost benefit analysis. Product quality control, analytical chemical evaluations, environmental monitoring and HVAC operations must be considered to ensure conformance with regulatory requirements. Pretreatment process flow charts are incomplete and will require the instrument and control system to be flexible to support process revisions. Upgrades for instance, could include the use of electronic equipment which will then require proper power feeds, isolation and grounding. The B-Plant upgrades proposed so far are a limited change out of equipment which will support pilot demonstrations of HWVP processes; not a comprehensive upgrade that could support remediation operations for a considerable period of time. Funding for an instrument and control system in a new facility would not be very different than a comprehensive B-Plant upgrade.

One item shown by WHC during the facilities tour was a neutron coincidence counter demonstration project. The instrument is to monitor the Transuranic Extraction (TRUEX) process effluent stream (grout feed) for residual

TRU content. There are significant risks associated with reliance on this experimental instrument as a major process control indicator or regulatory compliance monitor if that is how it is to be used.

D.6. Vitrification

The HWVP has drawn a majority of its technology from the DWPF. Much has also been learned from the WVDP. More will be learned about operation of the HWVP as the DWPF and HWVP go through additional cold testing and hot startup.

D.6.A Feed Preparation

The HWVP uses formic acid to destroy nitrates present in the vitrification plant feed. There is a potential for the production of significant amounts of flammable hydrogen due to catalytic effects of noble metals present in the plant feed. It is apparent that instrumentation will be required to monitor for flammable gases and that modification of the process vessel ventilation system may be required to mitigate potentially explosive gas concentrations. More experimental work is required to quantify the extent of this reaction and the potential for excessive hydrogen evolution during normal or abnormal operation of the feed treatment system. We believe that this problem can be resolved by appropriate design but only after the magnitude of the problem is established.

The HWVP feed preparation process differs from that used at the DWPF. The DWPF feed treatment process includes acid hydrolysis to destroy organics used to precipitate cesium in the pretreatment process. The DWPF acid hydrolysis step evolves gases, primarily benzene which is both explosive and carcinogenic. The gases are condensed and double distilled in preparation for incineration.

The pretreatment processes envisioned by WHC should result in feed to vitrification that does not require organic destruction. Therefore, the vitrification feed treatment will be much less complex than DWPF if the required pretreatment organic destruction process is developed.

Concerns have also been expressed with respect to possible fouling of heat transfer surfaces in the feed treatment tanks. Coils are designed to allow removal and replacement. If fouling is a problem, cleaning or adjustment of feed chemistry may be required. The Process Engineering Subgroup believes that problems with the feed treatment system can be resolved if they prove to be real.

D.6.B Melter Technology

The HWVP will use the DWPF design for its first generation melter. This design should be a reasonable first unit pending results of testing to be conducted at PNL and hot operations to be conducted at the DWPF. Potential problems exist with noble metals buildup in the Hanford melter that do not exist to as great an extent at West Valley and Savannah River. Other possible problems have been identified with respect to organics in the melter feed and overly vigorous off-gassing. These issues have been addressed by the Phenomenology Subgroup and deemed not to be major problems or resolvable in the time available prior to HWVP startup.

Fluor Daniel, Inc. is developing a design to remotely replace the melter pour spout heaters should they prematurely fail. If the design development is successful, these improvements will be incorporated into later generation melters. There is also interest in a stirred melter which is believed to offer major capacity (throughput) advantages. The Process Engineering Subgroup believes that developments with the stirred melter should be followed by WHC. However, the stirred melter is a conceptual design. Further design development and demonstration can be expected to require at least five years. Melter capacity improvements may not be cost beneficial unless comparable improvements can be made in feed treatment and off-gas system capacities.

D.6.C Offgas System

The off-gas system uses a "cold film" offgas line and high transport velocities to reduce potential for particle deposition and plugging. The line is also provided with a reamer to clean the line periodically. A submerged-bed scrubber captures and removes entrained solids from the off-gas system. These designs are based upon technology developed for the WVDP system. Although we are unsure as to the effectiveness of this design, it does not appear to be impractical. Should rapid plugging of the melter off-gas system occur, the process vessel vent system can provide short-term backup.

If problems with the off-gas system appear unmanageable, a venturi scrubber, similar to those installed at the DWPF, should prove quite effective. Time would be required to rework the system but would not prove fatal to the operability of the vitrification plant.

The high efficiency mist eliminator and high-efficiency particulate air filters are conventional systems and should present no major technology problems.

D.6.D __Vitrification Plant Instrumentation and Control__

The HWVP includes an Integrated Management and Control System (IMACS) which will operate, control, and monitor waste stream processes and facility services. The system has five key components: (1) Management Information System (MIS), (2) Health Protection Computer System (HPCS), (3) Analytical Laboratory Computer System (ALCS), (4) Distributed Control System (DCS), and (5) Data Highway, or network. The three IMACS computer systems will be procured individually. Overall systems integration does not appear to be addressed.

The MIS primary function is to provide storage, analysis, reporting and archival of plant process, environmental, analytical, and product data. The system will also facilitate data communication between remaining IMACS computers and other Hanford site computers.

The ALCS will facilitate the collection, analysis, and storage of waste form qualification data. Capabilities will exist for sample tracking, automated data analytical instrumentation, and report generation.

A HPCS is incorporated to monitor and report information related to radiological environments. Some instrumentation will be required to provide data for both HPCS and process DCSs.

The Distributed Control System (DCS) will provide operational control of waste processing and facility services. Distributed control allows local field stations and controllers to operate processes with minimal influence from a central facility. WHC has requested maximum use of simple manual controls and independent logic controllers.

Redundant Data Highways or local area networks allow individual elements of the DCS to communicate necessary operational data and interlock information.

Electrical power and grounding statements require conformance to applicable National Electrical Code and National Fire Protection Association regulations.

Westinghouse expects "mature, standard, commercial, off-the shelf hardware, software, and firmware" where possible. Turn-key systems through startup are envisioned. FDI is preparing specifications for this software which will be issued as four separate bid packages. There is a major potential that the software provided may not be suitable for the HWVP as the vendors are unlikely to be familiar with requirements peculiar to the system. Software maintenance could also prove difficult if WHC personnel are not intimately involved in development of this complex package.

Process instrumentation detailed definition is the responsibility of the A/E. Fluor Daniel basically specifies that measurement and control devices must be suitable for the expected operating environment and compatible with process requirements.

D.6.E Maintenance

The space allocated for jumper and equipment lay-down in the HWVP has been increased over that for the DWPF. The HWVP also has provided additional space for handling and decontamination of failed equipment. There are also plans to build a separate facility at Hanford to handle site-wide contaminated equipment size reduction, decontamination and packaging needs. The current HWVP baseline design includes a Remote Equipment Decontamination Cell (REDC), a Contact Decontamination and Maintenance Cell (CDMC) and an Equipment Laydown Area (ELA). Solid wastes are brought to these areas for temporary storage, treatment as necessary and packaging for shipment to a separate waste treatment/volume reduction facility. The REDC has shielding windows for viewing, manipulators for maintenance/decontamination and other remote tools. The CDMC is designed to allow both remote and contact maintenance operations.

D.6.F Technical Liaison

The Savannah River DWPF is having significant technological and engineering problems with their startup. Delays in HWVP construction would enable Hanford to take advantage of more "lessons learned" at DWPF. To date, they have had a total of 58 scheduled formal technical and engineering exchanges with DWPF and/or WVDP. WHC and PNL have also kept abreast of the technology and engineering developments in Germany, France, England and Japan.

An HWVP resident, manager-level person has been assigned to DWPF for the past three years. In addition to taking advantage of the DWPF technology development, results of the exchanges are apparent when reviewing the HWVP designs; there are significant improvements when compared to the DWPF design. Examples are:

- HWVP plans five analytical laboratories versus two at DWPF. DWPF already plans an-out-year project for new analytical laboratories. To provide space for the additional laboratories, HWVP located the canister welder in the canister transfer tunnel.

- HWVP plans to rinse each glass waste canister with water in the transfer tunnel before placing the canister in the decontamination cell. This will significantly reduce the risk of contaminating canisters during removal from the cell.

- After observing the congested conditions in the DWPF operating and maintenance corridors, HWVP provided more space in the corridors which will greatly enhance operability and maintainability.

D.7 Other Issues

D.7.A Alternative Technologies

A limited investigation by the Process Engineering Subgroup of alternative technologies that might, in a reasonable time (< 10 years) reduce long-term costs or improve process capability has identified no candidates that might improve performance or costs. The long-term technologies (laser separation, transmutation, etc.) would require lengthy (> 20 years) and expensive, high-risk R&D programs.

Intermediate-term technologies have been proposed (molecular traps, crown ethers, membrane separations, alternative extractants, etc.). These technologies are at laboratory scale and will require continued research and pilot-scale demonstrations before they can be applied to the waste remediation problem. Although one or more of these alternatives might prove to be more effective than the TRUEX process, we have no basis upon which to select or recommend a preferred technology. Switching to one of these alternatives would involve additional HWVS delays and offer a potential for failure equivalent to or greater than that for the TRUEX process.

Nitrate anion exchange is a proven technology that can efficiently recover thorium, neptunium and plutonium. However, TRUEX-type technology is required to recover trivalent actinides with high efficiency. The TRUEX CMPO extractant has a high affinity for both actinides and some impurities making back extraction overly difficult. CMPO also has potential problems with formation of three phase systems that complicate operation of extraction equipment. As a result there is still a need for additional pilot-scale testing and development to verify the utility of the TRUEX process.

DHDECMP is an alternative extractant to CMPO. DHDECMP forms weaker complexes than CMPO allowing easier back extraction of actinides. Its lower cost and lack of a third-phase-problem may make it preferable to CMPO. A disadvantage of DHDECMP is its higher solubility (increased losses) and lower radiation stability. Both CMPO and DHDECMP have the disadvantage of extracting fission product lanthanides.

Crown ethers are a promising extractant as they can be made in forms that are highly selective for specific elements. They have been shown to be very effective for noble metals which are a problem in some Hanford wastes. Unfortunately, work on these compounds has been restricted primarily to University laboratories.

Substituted malonamides are a nonorganophosphorus with promise as extraction agents as they are low-cost and degrade to products that should not interfere with solvent extraction. Sorption of cesium and strontium or other radionuclides on zeolites which can be directly incorporated into glass could be considered. The Vitrification Plant utilizes this technique to purify aqueous recycle from the melter off-gas system.

Extraction chromatography and hollow fiber contactors with potential applicability to waste separations use extractants that are physically bound to a solid media to recover impurities. These systems have been developed in the laboratory and used commercially in non-radioactive systems. However, there applicability to Hanford wastes is unproven.

The above alternative technologies to TRUEX potentially could be used for waste pretreatment. All are worthy of further research because they could yield major cost savings. However, none have been developed to the extent that they could be applied to the HDWRP in a reasonable time frame. They are also high-risk technologies. For this reason, the Process Engineering Subgroup can identify no alternatives to the TRUEX-type waste pretreatment process that could be effected in a reasonable time frame.

Short term technologies are generally in the area of incremental modifications to process equipment and subsystems. Studies of alternative designs (French calciner melter) have shown no cost or performance improvements.

WHC is currently evaluating short-term pretreatment technologies to make additional feeds available to the HWVP. This work is directed at assuring a continuous feed supply for the HWVP so as to bridge the gap between the completion of the simple NCAW pretreatment operation and implementation of TRUEX processing and maintain continuity of HWVP operations.

The use of pulse columns instead of centrifugal extractors is an option that could be considered. Pulse columns offer greater capability to handle interfacial crud relative to the centrifugal extractors. Hanford also has more experience with pulse column operation whereas they have not used centrifugal contactors in a production-scale operation. If Hanford drops the B-Plant pretreatment option, which appears likely, for a PUREX Plant or new facility, the headroom constraints imposed by the smaller B-Plant cells disappears and the pulse column may become the preferred extraction unit.

WHC continues to study equipment and process variations (improved melter designs, off gas treatment, etc.) and has incorporated them into the HWVP as they are shown to be useable. More of these modifications will be added as further lessons are learned from the West Valley and Savannah River operations.

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APPENDIX E

FACILITIES SUBGROUP ASSESSMENT

E.1 Summary of Issues/Findings/Concerns

E.1.A Background

These subgroup investigations were limited to the seismic, civil/structural, architectural, mechanical and electrical features of the facilities which compose the HWVS shown in Figure 1, Chapter II. Assessment of the facilities reviewed are:

E.1.B Existing DST's and Piping

Inadequate funding has severely hampered waste retrieval development efforts. The absence of spare tanks has precluded conclusive full scale testing to verify pilot scale retrieval techniques.

E.1.C Existing B-Plant

Seismic qualification, without waivers, will be an expensive, drawn out procedure, with no assurance of a successful outcome. This uncertainty, combined with the possibility that Washington State may refuse to accept the proposed 'double containment' rational, make reliance on B-Plant for pretreatment questionable.

E.1.D Proposed HWVF

Title II design is premature. The vit building design is out of sequence with the resolution of technical pretreatment issues affecting the site plan and a multiplicity of process issues affecting the building floor plan. These uncertainties make site development a risky first step. Title I baseline design is under configuration control and Title II design is underway, even before a functionally acceptable site plan and building floor plan have been developed. A myriad of basic questions regarding the building floor plan, functioning of critical systems, and maintenance of facility equipment remain unsettled.

Based on the above observations, the Facility Subgroup concludes that continuation with the present design is likely to result in a facility that is inefficient, difficult to start-up, operate, and/or maintain.

E.2 Discussion of Issues/Findings/Concerns

E.2.A Background

E.2.A.1 Review process

The focus of this review is on the facilities engineering practice applied to: a) the identification and definition of the inputs required to formulate the design criteria used to develop HWVF design, b) the identification, definition, and evaluation of B-Plant retrofits to meet current regulations, and c) the formulation of the entire HWVS problem. The review did not verify calculated results or evaluate the personnel availability.

E.2.A.2 Facility locations

The facilities that comprise the HWVS are situated on both the East and West sides of the Hanford 200 area, with B-Plant and the proposed HWVF in the east 200 area and tank farms and associated piping systems in both areas. B-Plant is 47 years old and is the oldest existing HWVS facility. The DST's and the connecting piping systems range in age from 5-23 years. Start of construction on HWVP is scheduled for April 1992 [1].

E.2.A.3 General Findings

Findings of the Facilities Subgroup based on document review and staff interviews identify no insurmountable technical problems in the HWVS. The only potentially insurmountable problem is the regulatory interpretations and approvals required to use B-Plant for pretreatment.

E.2.A.3.a Engineering and planning activities for the retrieval facilities appear to have good technical leadership and managerial oversight [2,3].

E.2.A.3.b The latest engineering study that assesses B-Plant's suitability and selects it for pretreatment was issued in January 1990 [4]. Reference #5 is a detailed comparison of B-Plant compliance to DOE Order 6430.1A and other codes. This document provided the basis for the list of items requiring upgrades described in Reference #6. The annual 5 year planning activity produces an Activity Data Sheet that lists the latest retrofit needs [7]. Each retrofit activity will require significant funding to serve the waste vitrification process in a timely manner.

E.2.A.3.c The design of the proposed HWVP meets the guidelines in DOE 6430.1A [8] orders and other federal and state regulations.

E.2.A.4 Formulation of HWVP design criteria

The original intent of the DOE-HQ three-phased Waste Management Plan was to apply the experience gained from each step to the next. The WHC interpretation of the directive to "take full advantage of the technical expertise and experience gained at DWPF" in order "to achieve the most efficient use of available resources" [9] was implemented by allowing or directing the A/E to copy the DWPF facility design to the extent possible to reduce A/E costs. Performance of crucial conceptual design iterations whose purpose is to avoid serious design flaws was circumvented. The significance of the differences in wastes, campaign length, cold chemical processing facility requirements, plant operating philosophies, design engineering methods, and applicable regulations between DWPF and HWVP are, in hindsight, substantial.

In an effort to satisfy project, DOE and Tri-Party schedules, DOE-RL/WHC managed the HWVP design in a "fast-track mode". They placed a significant portion of the facility baseline definition and design responsibility with their A/E firm, Flour-Daniel Inc. FDI was contracted and budgeted through the DOE to develop a baseline facility design. Based on the DWPF example, FDI is aggressively producing a Title II design and seems to be limited only by available funding. In conflict with Title II design progress, the vit building design process is still in the conceptual stage. This is evidenced by results of a recent engineering study that recommend substantial changes to the building layout and to critical building systems after assessing competing functions and requirements. [10]

The contractual agreements between DOE-FDI and DOE-Westinghouse complicated successful implementation of the facility design process. The Hanford DOE office is responsible for the FDI expenditure profile. Westinghouse is responsible for technical direction of FDI design activities. Project inconsistencies and conflicts arise because budget and technical scope responsibilities reside with different organizations.

At the time of this review, facility engineering technology transfer from DWPF to HWVP was underway. DWPF is experiencing serious building system start-up and operational problems. The opportunity exists to profit by 'lessons learned' from DWPF design and start up [11]. Communication to provide technology transfer between HWVP and DWPF occurs at regularly scheduled managerial level meetings and day-to-day through a single resident engineer. Realization of the technology transfer opportunities appears very limited at the working level, considering the quantity of useful information and value of the findings being generated at DWPF.

E.2.B Issues Associated with the Double Shell Tanks

E.2.B.1 Current status

The DST's and tank farms are the newest existing facilities in the HWVS and consequently are the least in need of retrofit. The design engineering and experiment planning for the retrieval facilities and development activities appear to have good technical leadership and managerial oversight [2,3]. Retrieval experiments using mixer pumps with approximately 1/3 scaled flow rates in full scale tanks [12,13] and modeling to predict results from 1/12 the scaled experiments [14] show successful suspension of tank sludges.

The tank farms and the B-Plant are currently connected by old transfer piping systems that would not meet seismic or double containment requirements.

WHC has developed plans to replace transfer lines between the tank farms, B-Plant and HWVP with double wall (2 pipe) seismically designed systems, except for two short lines between the AR Vault and the first diversion box [15,16]. Seismic analysis has just been initiated and only preliminary design criteria and methodology are available [15]. Problems are not anticipated with the input definitions and the analysis/design of the transfer piping for seismic requirements.

E.2.B.2 Full Scale Retrieval Experiments to Support HWVP

Translating experiment results into full scale facilities and equipment is necessary and significant activity. Modifications on tank farm facilities require design and construction of pump pits in the upper surface of a tank, with appropriate electrical, and process piping and plumbing services [2,3]. The current funding profile does not support timely input to the HWVP. Pilot scale experimental results from retrieval experiments are scheduled for completion in 1997 - or only 2 years before scheduled hot operation of HWVP.

E.2.B.3 Lack of Contingency Tank Facilities

The immediate facility concern involves lack of extra DST space to provide for contingencies and projected additional waste generated by pretreatment process. If problems occur with or in a tank, the storage volume for emergency transfer has to be obtained by 'overfilling' approximately a dozen other tanks. Waste transferred from a problem tank would mix with waste in receiving tanks, complicating waste characterization, compromising historically known composition of tank contents, and possibly compounding pretreatment problems. Additional space to move large quantities of liquids is not available in either B-Plant or the HWVP. In other words, moving the 1 million gallon liquid volume through the pretreatment and vitrification processes will require more residual tank space than is currently available.

E.2.C Issues Associated with Pretreatment

E.2.C.1. Current status

The baseline plan assumes utilizing B-Plant and the 244-AR Vault as the pretreatment facility for the HWVP [1]. B-Plant is a canyon facility which was purposely designed and constructed to provide versatility as a radioactive processing or preprocessing facility. Three previous studies [4,17,18] considering HWVP pretreatment alternatives have concluded that B-Plant is the best TECHNICAL alternative. The Nordhoff report issued in January 1990, WHC-SP-0464, Rev. 1, "Assessment of Double-Shell Tank Waste Pretreatment Options" is the latest study assessing engineering and technical parameters to select B-Plant for the pretreatment facility. There is currently a newer study in process with results scheduled to be released in October 1991.

E.2.C.2 Regulatory compliance issues

Because B-Plant was constructed in the 1940s, many features now required by DOE Order 6430.1A were not included. There has been an extensive study done to compare plant physical structure and critical systems with DOE Orders, other regulations, codes and several standards [5]. Another reference provides a list of action required to resolve noncompliance items in the several areas that include structural design, process, building ventilation, fire protection, electrical systems, utilities and services, process piping, vessel confinement, instrumentation and controls [6]. Retrofitting B-Plant to reach compliance without DOE waivers will require substantial expenditures and lengthy construction. A modest structural modification and an extensive and invasive qualification procedure is required for strict seismic compliance. Double containment of piping in the cells and the pipe trench and mitigation of corrosion in the process piping is necessary to bring B-Plant into compliance with current regulations. Such extensive retrofit is complicated by residual radioactivity in the cells that will require using remote PAR arms for construction.

E.2.C.2.a Seismic qualification

As now envisioned by Westinghouse, a statistical approach would be taken to determine the material properties and QA requirements [19,20] to support the analyses. This would be expected to require a special review and a request for a waiver from strict compliance.

To qualify the retrofitted B-Plant facilities without the need for special petitions or reviews, the general design criteria requirements and its supporting documents would have to be met directly. A complete review and analysis of the entire facility with the new systems incorporated in the models would be required. The geometric definition of the facility, including the rebar in the concrete, would require confirmation because historical documentation is not complete and QA procedures used at the time of construction are not those currently required. The definition of the material properties would require a complete, invasive post construction testing program of the type defined for the Savannah River Plant if direct qualification is sought [21,22] . This has not been proposed by Westinghouse nor has a plan been developed that could be used to estimate the cost and impact on scheduling.

If a problem is identified in either B-Plant or the AR Vault, a solution must be defined and a retrofit designed. Then, the cost and schedule impact must be considered, and finally the retrofit has to be implemented. Even in the cases where no problems occur in the analysis, the geometry (e.g. rebar location and size) and material properties (e.g. concrete properties) used in the analysis must be supported. If the data are supported on a statistical sampling basis, the facility will not be in direct compliance with DOE requirements [8]. A request for a waiver would generally be required with the possibility of a schedule delay, a requirement for additional data, or the ultimate rejection of the request. It should also be noted that even if a retrofit is designed and accepted, it will generally not be the optimum facility design.

E.2.C.2.b Double containment issues

A mechanical retrofit of the B-Plant process piping is proposed to bring it into compliance with the Washington State laws. The most recent study completed to demonstrate B-Plant compliance with the INTENT of the regulations states that "The system design does not categorically conform with any one of the three types of secondary containment systems that are called out in the Washington Administrative Code (WAC-73-303-640) [23]. Meeting the regulations in strict compliance would require considerable funding, longer construction and PAR arm technology to implement.

E.2.C.2.c Corrosion in process piping

There is no current information as to the extent of corrosion in process piping in B-Plant. A recent maintenance exercise used a robot to visually inspect surfaces of the cell drain header [24]. This effort met with reasonable success. Establishing actual condition and executing retrofit to repair damage is likely to require substantial funding, long construction efforts using CCTV and remote technology to implement.

E.2.D Issues Associated with Vitrification

E.2.D.1 Open design issues

Prudent engineering practice prescribes that design trade-off studies and open significant technical issues be settled during preliminary design. Initiating configuration control before completing design trade-off studies discourages or precludes changes that would close open issues and provide a firm and acceptable definition for detailed design. Open issues uncovered by WHC process, operations, and facilities personnel are being resolved in a painstakingly slow and adversarial mode because Title II design is proceeding under configuration control. The example that causes most concern involves the untimely comment resolution of HVAC system concerns identified as early as July and August 1990. The Flour Daniel HVAC System Optimization Study completed in July 1991, recommend complete change in HVAC design philosophy that effects building shape and space allocation. Several other open issues (location of the sand filter and switch gear generator buildings, narrow corridor widths, realistic plant population, solid waste handling disposal requirements) relate directly to building floor plan changes or rearrangement of out buildings on the site plan [25].

HWVP design changes that result from closure of open issues could produce a successful, operable, less costly and much more maintainable vit building. A memo listing 53 open technical issues identified as having considerable impact on the site plan, building floor plans, plant operations and maintenance that are not being addressed in a timely fashion [25]. This situation indicates that the "over the shoulder review" process is not providing timely open issue resolutions that might ultimately avoid major building design flaws.

E.2.D.2 Noncompliance with codes and standards

A notable exception to the Uniform Federal Accessibility Standards [27] is the lack of handicapped access to the building. Construction without handicapped access requires express and single line approval by the Secretary of Energy to the Chairman of the General Services Administration for each instance.

E.3 Supporting Information

E.3.A. Background

E.3.A.1 HWVP design history

There is no single design criteria document that contains the detailed facility and process technical scope for meeting the proposed HWVP objectives. Many documents contain limited facility and process scoping information and very cursory definitions of the functional design criteria. Early design criteria documents are of limited technical value because they focus on reporting and billing processes rather than on technical substance of the design problems. This lack of a single, detailed technical document requires perusal and assimilation copious prose to discover the central question and purpose behind the design. Documents that comprise the written record of design scope for the HWVP building were written over a span of several years and issued by several corporate entities. The design documents, the author, Hanford contractor, and date of issue are listed below [28].

Document Title	Author	Hanford Ctr	Date
Prelim Concept Design	Kaiser	Rockwell	1984-1986
Reference Concept Design	FDI	RHO/WHC	4/86-6/87
Advanced Concept Design	FDI	RHO/WHC	5/87-1/88
Preliminary Design	FDI	Westinghouse	1/88-9/90
Detailed Design	FDI	Westinghouse	1/90-6/94

The listing of engineering contractors and their responsibility is as follows [28]:

Engineering Services	Kaiser Engineers Hanford
Construction Contractor	UE&C Catalytic Inc.
Detailed Design	Flour Daniel,Inc.
Contract Integrator	Westinghouse Hanford Co.
Technology Development	Pacific Northwest Laboratory

Because the mission, scope, and campaign length for the DWPF and HWVP differ greatly, several major systems have required significant changes in the design to make the building functionally useful for HWVP needs. The facility size and shape, HVAC system, the offgas system, Distributed Control System, the weld cell, shield door, redundant and seismically-qualified HVAC system and equipment, control room and canyon crane were largely modified or completely redesigned [29]. HWVP is an even larger construction project than DWPF and is significantly different because the design and proposed construction lag by about 9 years.

E.3.A.2 Seismic/structural considerations

The seismic considerations for review are limited to the B-Plant and the AR Vault for use as the pretreatment facility. No new technology has been proposed or is required to analyze the facilities to meet seismic requirements. The focus of the seismic review is on the engineering practice applied to evaluation and analysis of existing B-Plant facilities and equipment that must be upgraded, e.g., the containment boundary, the underground ducting run from the B-Plant ventilation system to the filters, and the short piping runs from the AR Vault to the first diversion box. A detailed report on the seismic review is given by Merchant, 1991 [30].

The seismic input for the Hanford site is controlled by a hierarchy of documents starting from general DOE requirements [8] and ending with the site specific earthquake input definitions [31,32,33,34]. For a high hazard facility other than a reactor structure, the seismic acceleration level is 0.2 g (Zero Period Amplitude, ZPA) with the spectrum given in Reference [32]. This information is incorporated in a design criteria document along with the spectra for a near field earthquake [35]. For structural analysis, including soil/structure interaction and the determination of local floor spectra in the facilities, a time history must be generated that envelopes the spectra. This process is not unique, i.e. an infinite number of time histories can be generated that will envelope the spectra. Westinghouse Hanford Company (WHC) and Fluor (with their consultants) developed their time histories independently and therefore they are not identical [19,36,37,38]. Although this technically would make no difference in the conservatism of the end result, it would be an advantage for direct comparisons or for reviews, if all structures in the "HWVS" used the same input definitions.

A study was made to compare the effects of the near field and far field (DBE) on the structure and internal systems and equipment [39]. Simplified soil/structure interaction models of existing structures at the Hanford site were used in the comparison. The time histories were generated to fit the median spectrum but the conclusions should also apply to enveloping spectra. The results are interpreted to indicate that the DBE controls the structural design and the near field can control the internal equipment or floor spectra. In this case, it would have been appropriate to use the same time histories as those used for the

B-Plant and HWVP. There was apparently no attempt made to plan and coordinate the seismic inputs beyond the basic criteria document [35]. The analyses of B-Plant and the HWVP have been separate as have the input specifications.

The seismic input for the HWVP was referenced above. A design guide has been prepared for the HWVP facilities and systems as well as a seismic qualification program [40,41]. If the evaluations are performed as outlined and iterations in design and analysis carried out when unacceptable results are obtained, no problems are anticipated in meeting seismic qualification. However, only scoping static analyses (factor of 2 seismic loads over free field) have been performed on the HWVP facility and systems [36] to date. Soil structure interaction analyses are now being performed. Dynamic analyses based on these results will be performed on all Class 1 and related structures and systems. As contrasted with the B plant, the HWVP is not constructed or under construction and no penalty results if an analysis shows a seismic problem, except the cost and time involved in design iteration.

The B-Plant has been analyzed in two steps. The first was a preliminary effort in the 1988-89 time frame [42,43,44,45] using a 0.25 g ZPA and a subsequent set of analyses in the 1990-91 time frame issued as final reports [46,47,48,49,50,51] using the required 0.2 g ZPA spectrum. Supplemental reports were also issued on the B-Plant drain header [52] and material properties [20]. An independent review was made of the preliminary analyses [53]. The initial studies and review raised questions which were addressed in the subsequent studies. The review questioned the modeling in some cases, and in particular, the completeness of the models and the disjointed approaches for the related analyses.

The supplemental calculations as reflected in the referenced documents, and in particular, in the summary report [46] still do not provide a firm background for the selection and/or justification of the adequacy of the items addressed in references 47-51. This set of final reports do not draw final conclusions. Rather, a number of suggestions for additional analysis and modifications to the facility are recommended. Until these analyses are made, and conclusions drawn, the full magnitude and impact of retrofits cannot be determined.

Modifications were recommended for such items as air locks and joint seals but further analyses were identified for such things as a time history analysis of the rocking mode of the canyon end walls and a dynamic analysis of the end of the canyon and adjacent bays, i.e. analysis of a more complete model. Other analysis areas include the 271-B, 221-B interface and the portions of the filters and ducting which will be retained in the retrofitted facility.

E.3.A.3 <u>Mechanical and Ventilation system considerations</u>

The ventilation system described in the vit building 'baseline' drawings is largely a DWPF copy. The main variation is the addition of control dampers.

The 'baseline' system developed by FDI contains 51 modulating control dampers, plus vortex dampers which are controlled by the Distributed Control System (DCS). There are also various 'automatic' two-position shut-off dampers and numerous manual dampers. These instability sources, which are currently causing start up and operational problems in the DWPF ventilation system, have been incorporated and elaborated in the HWVP 'baseline' design.

The ventilation system redesign recommended by the HVAC System Optimization Study [10] recommends significant changes in the building floor plan. This recommendation indicates that the vit building design was prematurely frozen and placed under configuration control.

All present HVAC designs use a sand filter on the Zone 1 exhaust. Except for the similarity to DWPF, the sand filter represents the reuse of an old technology. The sand in the filter does not meet seismic requirements. A previous HVAC system study [reference] selected PALL metal fiber filters as the desired choice for the Zone 1 exhaust partly because they could be designed to meet seismic and DOE 6430.1A regulations. Techniques and equipment to perform remote replacement of HEPA filters and/or in-situ cleaning of metal filters (PALL) need development to address ALARA.

If the sand filter becomes contaminated, it would generate thousands of cubic feet and tons of additional radioactive waste. The space and related construction cost reductions associated with eliminating the sand filter, massive exhaust tunnel, and present exhaust stack by relocating the Zone 1 exhaust filters and fans inside the vit building would be substantial. Lower operating fan h.p. requirements, as well as avoiding costly disposal of the hundreds of tons of newly contaminated waste would substantially reduce operating and decommissioning costs.

The DCS for the entire facility is estimated at nine million dollars and projected to require ten full-time maintenance programmers after completion. Eliminating the HVAC control function from the DCS would simplify system software and hardware, and reduce initial capital and follow on operating costs. A modern HVAC control system based on PLC units distributed throughout the building to control an equivalent HVAC system could be installed in a commercial (non-DOE) facility at a fraction of the additional cost and effort required to append the HVAC control function to the DCS.

E.3.A.4 Electrical considerations

The electrical power system drawings were being upgraded at the time of this review but should meet DOE 6430.1A requirements. Parts of the elaborate system are justified to support an economical process shutdown. It is not clear that this level of design robustness is required or justified.

Review indicates that the electrical system is well designed with numerous redundancies. The primary High Voltage Power System (230KV) provides two power independent sources to the HWVP site. Off site power comes from the Bonneville Power Administration. Overhead 230K transmission lines feed a 230KV ring BUS which feeds two 230KV to 13.8KV 25/33/42 MVA 3-Phase transformers. Two main 13.8KV/480 volt transformers supply two 13.8KV switch gears for normal power. The 480 volt distribution system includes a normal power distribution system, stand by power distribution system, UPS System and a DC System which include numerous redundant 480 volt transformers and switch gears. The standby power system includes two 3MW diesel generators to supply required safe shutdown loads. In addition, a class 1E power system that includes two additional 350 KVA diesel generators has been added to serve the Safety Class 1 loads.

E.3.A.5 Architectural Considerations

The HWVP annex currently under design to handle the NOx offgas scrubbing equipment does not offer much additional space to build in-tank surge capacity or pretreatment capabilities. Lengthening HWVP by 40 ft will not provide enough room for process modification to handle wastes other than the NCAW or NCRW waste streams. Limited waste partitioning requirements (i.e., filtration, ion exchange) may be included in the operation of the HWVP with minor floor plan and equipment changes.

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APPENDIX F

REGULATORY REQUIREMENTS SUBGROUP ASSESSMENT

F.1 General Description of Regulatory Requirements

Historically, the regulatory framework and standards for high-level waste (HLW) at DOE weapons sites has been the responsibility of DOE and its predecessor agencies under the Atomic Energy Act. The primary vehicle for specifying the definition, handling, and treatment of HLW has been by DOE order, in which the Secretary of Energy has the final authority. However, because future plans call for placing defense HLW in the same repository as the spent fuel and vitrified wastes from commercial reactors, NRC has jurisdiction over waste form acceptance and repository performance. Additionally, environmental standards for the repository disposal of HLW are the domain of the EPA, the lead Federal agency regulating radiation protection of the public. As such, the EPA is responsible for setting the environmental standards for specific radionuclide activities/sources that are under either DOE or NRC jurisdiction.

The EPA also regulates hazardous waste management practices at DOE sites through its responsibilities under the Resources Conservation and Recovery Act (RCRA) and the Comprehensive Environmental Response, Compensation and Liability Act (CERCLA). By virtue of its control over hazardous chemicals and the hazardous chemical components of mixed waste (HLW and LLW waste forms are classed as mixed waste) the EPA has jurisdiction over HWVP. The shutdowns of the 242-A evaporator and the PUREX plant within the past two years are evidences of growing EPA involvement in regulating Hanford facilities.

The Washington Department of Ecology (Ecology) has been authorized by the EPA for regulating air and water quality programs, as well as the hazardous waste program. On this basis, Ecology is the primary regulatory agency for environmental activities at Hanford and is a full participant in the Hanford Federal Facility Agreement and Consent Order (the "Tri-Party Agreement", or TPA).

Regulatory requirements applicable to the HWVS fall into three categories: 1.) those imposed by federal statues, regulations, and requirements; 2.) those imposed by state and local statutes, regulations, and requirements; and 3.) those imposed by DOE directives. A compilation of the principal, potentially applicable and appropriate prescriptive regulatory requirements were employed as screening tools in conducting the regulatory compliance review. Included were the Occupational Safety and Health Act (OSHA); the Toxic Substances Control Act (TSCA); the Clean Air Act (CAA); the Clean Water Act (CWA); the National Environmental Policy Act (NEPA); the Resource Conservation and Recovery Act

(RCRA); and the Comprehensive Environmental Response, Compensation and Liabilities Act (CERCLA) and the Superfund Amendments Reauthorization Act (SARA); the DOE Orders implementing As Low As Reasonably Achievable (ALARA) provisions for radiation protection.

The projected HWVS effluents (solid, liquid, and gas) were discussed with WHC staff specialists. Specific attention was given to the comparison of these projected effluents with applicable regulations to assess whether all pertinent requirements for the protection of the environment the health and safety of the work force and the public have been addressed by the project. Judgement was used to assess the waste technologies proposed for compliance with environment safety and health requirements within the perspective of accepted engineering practice. In turn, these judgements were applied within the broad institutional framework of the HWVP. Consideration was also given to the integration of elements of the regulatory compliance program(s) across the elements of the HWVS; ie, the Tank Farms, Pretreatment options, HWVP itself, and final waste product disposition.

This investigation was, in general, conducted as a line of inquiry directed at cognizant technical representatives from WHC who are involved in tank waste resuspension and transfer operations, pretreatment, vitrification, waste product storage and disposal, and effluent emission monitoring and control. The investigation also consisted of:

F.1.A Reviews of documentation related to safety analyses, environmental impact analyses, and environmental regulatory compliance (Environmental Compliance Manual, TPA, Hanford Site Environmental Report, NEPA and Risk Assessment documents among others)

F.1.B Participation in overview presentations,

F.1.C Participation in detailed regulatory compliance presentations,

F.1.D Meetings with a representative of Ecology,

F.1.E Discussions with selected technical representatives and/or groups to clarify specific concerns, and

F.1.F Question/answer sessions with technical representatives from DOE, Westinghouse and Ecology on regulatory requirements pertaining to the Project.

The objective of the regulatory requirements review was to identify major compliance issues that could potentially delay or stop the progress of the Project. One such issue is the waste acceptance criteria for both of the final HLW and

LLW forms, as product acceptability for these waste forms is somewhat unclear (see Appendices D and E). Another is the set of permitting issues, particularly in hazardous waste permitting. Consideration was also given to possible regulatory "outliers" (ie, requirements for which no plan is shown, or those likely to evolve) that could arise as the project progresses, as it was believed that recent experience with DOE projects suggests some risk from such occurrences. Examples are retrofitting of new design criteria, safety analysis and effluent/emission permitting requirements on the HWVP.

The attached tables summarize the information gathered on the effluent streams from the HWVS. Based on available data, it appears that the effluents from all elements of the HWVS will be well within the current regulatory limits. For worker radiological exposure, WHC has adopted an ALARA (As Low As Reasonably Achievable) goal of 2 rem, 2.5 times more restrictive than the current regulatory limit of 5 rem. Areas where information is not complete are the radiological and non-radiological effluents (and resulting doses) for the proposed preprocessing operations in B Plant, under the current baseline for the pretreatment program, and the planned waste retrieval operations in the HLW tank farms.

F.2 Double Shell Tank Issues

The Tank Farms consist of double shell-tanks (DST's) and single shell-tank (SST's), valves and valve boxes and transfer lines. The compliance issues relating to Hanford's DST's are predominated by the RCRA Part B and State Water Discharge permits, the ALARA issues associated with the new mission ie, resuspension of the tank wastes and transferring the waste materials to a preprocessing facility, and compliance with the National Environmental Policy Act (NEPA). The only significant issue appears to be the length of time potentially required to secure the necessary permits, which could potentially delay operations at the tank farms which support HWVP operations or production schedules. The SST compliance issues have not been specifically addressed, as they will be revisited in accordance with the provisions of NEPA as noted in the Record of Decision for the Final EIS (DOE/EIS-0113, December 1987).

One potentially significant issue arises from the proposal to include SST 241-C-106 wastes into the HWVP feed stream (given its characteristic similarities to NCAW). The Record of Decision (ROD) for the EIS makes a distinction between the DSTs and the SSTs in implementing the Department's preferred alternative (HWVP). DST wastes will be processed through HWVP; SST waste will be stored and monitored pending additional waste characterization and additional analysis of waste retrieval and disposal options regarding stabilization and disposal of these wastes. "A decision to process 241-C-106 wastes with the DST wastes could challenge the ROD distinction, effectively compromising a DOE commitment". Alternatively, the EIS for the SSTs could be initiated sooner than planned to address all SST's including 106-C.

The existing DST's and designs for the proposed transfer lines between the tank farms and the preprocessing plant, and between the preprocessing plant and the HWVP, generally meet DOE 6430.1A (General Design Criteria) and RCRA requirements for double confinement and leak monitoring. There are several pending actions which leave open the question of strict compliance with regulations. These areas are discussed below.

F.2.A Areas of Uncertain or Non-Compliance

Characterization of the DST wastes has not been completed to satisfy the requirements of RCRA. Neither has integrity assessment of the tanks been performed to determine whether they leak, required by January 12, 1990 in accordance with RCRA; both characterization and leak test issues are the waste currently being negotiated via the TPA. The central issue is that the DST's cannot be pressurized for leak testing due to the designed air flow through the annulus. Thus, a robotic non-destructive examination (NDE) of the primary tank integrity is proposed as an alternative. Dimensions of the areal surface for this NDE are in negotiation; the State wants most (if not 100%) of the surface examined, the DOE is proposing 15%. The issue will impact the operations of HWVP only if resolution is not reached in a timely fashion to permit the assessment to be completed in support of HWVP and/or pretreatment operations.

A second major RCRA requirement calls for full secondary containment of all tanks, valve boxes, and piping associated with hazardous waste underground storage tanks. Historically, catch tanks at the tank farm are not pumped within the required 24 hours and do not have secondary containment; neither do diversion boxes, directly-buried transfer lines, transfer lines encased in concrete, vent system piping, seal pots, or clean out boxes. As with the leak testing requirement, this issue does not appear to pose a non-compliance issue which would substantively impact the Project. However, it is difficult to predict the outcome or timeliness of TPA negotiations. Failure to reach closure on the issues could delay the HWVS by requiring engineered modifications to this equipment prior to transfer operations.

Planned waste retrieval operations at the tank farms in support of the HWVP mission are likely to result in larger personnel doses than historical records for tank farm exposures indicate, particularly in view of the large number of tank internal structures that must be removed as part of waste mobilization and retrieval.

Potential plugging problems along the transfer lines may occur when large quantities of slurry are transferred over long distances. Increased direct repair or maintenance activities are certain to increase worker doses. Also, problems with converting unstirred, viscous waste into slurry may require much more direct maintenance with only portable shielding at the tanks or along transfer lines. Experience data on past transfer operations should be reviewed, and potential worker doses evaluated for the planned transfer operations. The SAR upgrades should address these issues.

F.2.B Technology Development and Engineering Practice.

New liquid waste discharge permits are required for the Tank Farms. As required by the permits, an engineering assessment of the best available technology (BAT) is underway for the treatment of steam condensate and cooling water discharges from the aging waste tanks (241- & 242-S) . Decisions regarding the acceptability of the BAT analysis will be part of the on-going TPA interactions, contemporaneous with permit processing under WAC-173-216, the State Waste Discharge Permit Program. Because this comprises a new permitting activity for all three TPA parties, some delay in processing the application and/or the permit may be expected. Of particular note, the estimated issuance of this permit is approximately the year 2000, sufficient time to permit technology and engineering enhancements at the Tank Farms, as well as evolution of new discharge limitations.

The safety analysis report for the Tank Farms is being upgraded to assess the new mission, as required by DOE Order 5481.1B (Safety Analysis and Review System). However, determination of the hazard classification per DOE Order 5481.1B is uncertain, as is the level of risk assessment to be performed for the safety analysis.

The pending negotiations of the NDE of primary tank integrity are important from the perspective that current tank access hatch configurations will permit limited access to robotic NDE equipment. If the negotiations determine that a surface area to be examined is greater than is currently accessible, new access portals may need to be engineered into the tanks.

The recently enacted Model Toxics Control Act (WAC-173-340) contains underground storage tank clean-up provisions which may impact designs or proposed operations at the Tank Farms. Assessing the impacts of these regulations on the Tank Farms has not been done. The proposed installation of near-field monitoring wells at the Tank Farms has also been cited as a potential unintentional pathway for leaking contaminants to access the ground water and/or the Columbia River (Tiger Team Assessment, 1990). This citation may encumber the monitoring of the tanks, also required by RCRA.

F.2.C Prudence Issues

Prudence would dictate a detailed study of expected radiation exposures to determine whether the worker dose guidelines of Order DOE 5480.11 (Radiation Protection for Occupational Workers) can be met in future tank farm retrieval operations. Worker doses during past tank farm operations have been easily within ALARA goals; however, dose during waste retrieval for vitrification can be expected to be significantly higher due to increased direct repair and maintenance activities. Retrieval operations will require direct access for clearing of in-tank equipment; conversion of unstirred, highly viscous waste in the tanks into slurry; and clearing of pipeline pluggages when large quantities of slurry are transferred over long distances. Portable shielding and remote tooling and methods will be necessary for most of these operations.

Encapsulated Cs and Sr disposal plans are not sufficiently formulated to allow assessment of whether this operation might introduce regulatory compliance issues.

F.3 Preprocessing Issues

Current plans call for preprocessing of stored wastes to partition the bulk of the radioactive materials into small volumes that can be immobilized in borosilicate glass in the HWVP. The purpose of the preprocessing separations is to minimize the amount of material that must be processed into glass, and thereby reduce the overall costs. The preprocessing steps will be different for the four different DST wastes (NCAW, NCRW, PFP, and CC). For NCAW, the process steps consist of initial removal of the supernatant liquid followed by sludge washing and ion exchange for Cs removal from the supernatant and wash solutions. Later in the schedule, the preprocessing for NCRW, PFP, and CC wastes will be expanded to include the TRUEX process for removal and concentration of the transuranic constituents from the non-radioactive components prior to vitrification in HWVP.

The proposed NCAW processing steps are fairly well developed and are quite similar to those performed on a large scale with the wastes at West Valley. The proposed TRUEX process, on the other hand, is in the early stages of development , having been demonstrated only on a laboratory scale. Although TRUEX is basically a solvent extraction process and has basic similarities to the PUREX process that has operated successfully for years at Hanford, there is nevertheless a significant amount of development required for the equipment and procedures to be employed at full scale to support the HWVP. Because the flow sheets for the TRUEX preprocessing are at an early stage of development, and no SAR is available, (the new B plant SAR, covering the NCAW pretreatment initially, is scheduled for completion after January 1993) the question of regulatory compliance for the processes is premature.

No major non-compliance issues were identified in the area of worker protection and ALARA (DOE 5480.11), based on the successful operating record in existing Hanford canyon facilities.

Obtaining a RCRA permit for B-Plant would be precedent-setting in the DOE complex. No other canyon facility has been issued a permit under the provisions of RCRA. Given the age of the plant, the new general design criteria for DOE facilities (DOE Order 6430.1A), and the requirements for secondary confinement, this issue has the potential to disqualify B-Plant as a pretreatment facility. Thus, convincing the State, EPA and the public that it is acceptable as the pretreatment for HWVP will be a significant undertaking.

F.3.A Areas of Uncertain or Non-Compliance

F.3.A.1 Conversion of B-Plant

RCRA permitting of B-Plant prior to its use in preprocessing will be negotiated with state representatives pursuant to the TPA. From the Ecology point of view the three major qualifications issues for B-Plant are: 1) Seismic capability, 2) RCRA double containment and 3) existing piping integrity and ability to withstand the very corrosive fluoride solutions that would be used in future preprocessing operations. Because of the combination of these concerns, Ecology is opposed to the use of B-Plant for full scale preprocessing. They do appear to be willing to approve the use of the facility for the initial preprocessing pilot studies, however.

Structural requirements invoked by 6430.1A and UCRL 15910, may require waivers from strict compliance with seismic qualification. To seismically qualify B-Plant (and AR vault) without waivers would require a complete review and analysis of the entire facility (including the improvements) and perhaps a complete invasive, post-construction testing program. This issue is further addressed in the Facilities Section of this report. Significant costs and schedule delays will result if full qualification is required without waivers. WHC and DOE are engaged in negotiations with the state to resolve the issues of compliance with these regulations. Convincing analysis of all three issues by DOE and Contractors will be required for the State to reach a decision to confirm B-Plant's adequacy as the pretreatment facility for HWVP.

A related issue is that the State may not have the needed technical resources to adequately address the B plant requalification issues in a timely manner to support HWVP start-up schedules.

F.3.A.2 Preprocessing Issues

The RCRA permit application for B-Plant preprocessing of NCAW wastes is currently in the strategy (Phase I) stage. The expected completion of the strategy is October 31, 1991, with a submittal of the completed application predicted to be on or before November 30, 1992. Coupled with the air permitting requirements, both for the Prevention of Significant Deterioration (PSD) and National Emission Standards for Hazardous Air Pollutants (NESHAP) permits, and the State Waste Discharge Permit for liquid effluents, significant regulatory obstacles confront B-Plant.

F.3.A.3 <u>Acceptance of Grout LLW Waste Form by the State</u>

The acceptance of the LLW grout waste form under the WDOE regulations is an open regulatory compliance question at this time. Appendix E contains a detailed discussion of this issue.

A potential problem exists in meeting the Hanford 90°C maximum grout temperature limit during the setting phase, and concerns have been raised by the State of Washington on the low compressive strength of the grout plant product. A shutdown of the grouting facility could impact preprocessing operations. A related concern is that the dilution of the feed material prior to grout preparation may violate RCRA requirements. This item will require closure, although in and of itself, it does not appear to pose significant impact on the HWVP.

F.3.B <u>Technology Development and Engineering Practice</u>

Two issues were identified which relate to regulatory requirements for pretreatment.

F.3.B.1 <u>TRU Monitor Development</u>

A radiation detector will be used to determine if liquid effluent streams to B-Plant contain a TRU content low enough that the grout product will be well under the limit of 100 nCi/g for LLW. Although it will be checked periodically by laboratory analyses, this instrument will be the primary production control on TRU content of material from B-Plant which is destined for grout. The monitor is comprised of four BF_3 neutron detectors using coincidence counting. The prototype is to be tested in WESF in the 1994 time frame.

The significance of this situation is two fold (1) an acceptable TRU monitor not yet operated and (2) our understanding is that this control method is essential to maintaining a high preprocessing-production rate in B-Plant.

F.3.B.2 <u>Process Development</u>

Development of TRUEX poses some potential as a compliance problem, since there are uncertainties as to the effluent waste streams that will be generated by the process. For example, there is uncertainty as to the quantities of organic solvent that will be discarded a a waste stream during operation of the TRUEX process. Since this stream would be a mixed waste it poses difficult disposal problems, not unlike the benzene waste stream from the preprocessing at DWPF (although we would expect much smaller quantities from HWVP).

Consequently, there are some regulatory compliance questions that cannot be answered now. Based upon some of the past operations and practices at Hanford there is some cause for concern, although in principle there is nothing about the proposed preprocessing that is unduly hazardous if good engineering practice is followed. It remains for safety and environmental analyses to predict the releases of these effluents, and an assessment made as to the regulatory acceptability of the predictions. Alternatively, in-tank processing as planned for Savannah River HLW tanks may hold potential for applicability at Hanford.

Three development projects are in progress to allow termination of soil column disposal of liquid waste: ion exchange/reverse osmosis water treatment, liquid effluent retention in covered basins, and closed solar evaporator systems. Waste containing radioactive or chemical contamination will not be routed to open ponds.

F.3.C Prudence Issues

One regulatory requirement issue has been identified that would make the decision to go ahead with preprocessing in B plant, as currently planned by WHC, questionable. Securing a RCRA permit for B-Plant may take an inordinate length of time given the substantial analyses required to convince the State that the Plant can serve the intended mission. Submittal of the application, for example, will not be made until September 30, 1993, well after construction has begun on HWVP. Without the permit, the plant cannot operate. Completion of the B-Plant Double Containment Report will be crucial to TPA negotiations with respect to B-Plant acceptability. Likewise completion of the SAR for B-Plant's proposed new mission will play a key role in assessing the plant's acceptability.

In view of the State disposition on B-Plant, it would be prudent to invite plans for alternative pretreatment facilities.

F.4 HWVP Issues

The PSAR for HWVP has reasonably bounded the accidents and accidental releases from the facility, and has met the requirements of DOE Order 5481.1B. All applicable requirements appear to have been addressed in facility planning, although a dedicated commitment action tracking system (separate from the TPA) is under development by a subcontractor (SAIC). Historically, compliance "planning" at Hanford has been driven by notices of deficiency (NOD's), rather than by critical self-assessment, as recommended by the DOE Secretary's Ten Point Plan, and as reinforced by the Tiger Team Assessment (1990).

F.4.A Areas of Non-Compliance or Uncertainty

Regulatory requirements for the HWVP appear to have been adequately addressed. The only exceptions are the State Waste Discharge Permit for the concrete batch plant, and the potential permitting of the melter as a hazardous waste incinerator. The water discharge permit is a new requirement. It will constrain both the batch plant and the greenwash water effluents to collection and treatment prior to discharge, versus direct discharge to the soil column. The timing of this permit application could delay the proposed April 1992 construction start-up, even though concrete will not be required initially.

Permitting of the melter as an incinerator will require a test run analysis and State approval prior to production operations. Given the variability of the predicted HWVP feedstock, test runs could be required every time feed characteristics change significantly. The impact this may have on the HWVP is most likely going to be on the production schedules.

F.4.A.1 Acceptance of HLW Package into the Repository
There are continuing questions about the acceptability of the glass waste form for the HLW repository. See Appendix D for a detailed discussion.

F.4.A.2 Disposition of Spent Process Equipment, Including Melters
The planning for the disposal of the old equipment removed from the HWVP canyons is based on the capabilities of the planned new on site Waste Receiving and Processing (WRAP) facility. A spent melter, for example, will be sent to WRAP where it will be remotely decontaminated. The HLW (scrap glass and refractory from NCAW feed) from this operation will be returned to HWVP and incorporated into the glass canisters. The decontaminated equipment will be packaged as TRU waste for transport to WIPP in New Mexico or to the on-site LLW disposal site. The regulatory significance is that new on-site facilities for TRU storage may be required if WIPP does not open in time to handle WRAPs wastes.

F.4.A.3 End of Life Decommissioning
The decommissioning and restoration of the HWVP will be described in Chapter 11 of the RCRA Permit Application, however the closure plan included in the chapter will not contain the required details until the plant construction is completed. There is some regulatory risk here because decommissioning, decontamination, dismantlement, and entombment options may be foreclosed by the time the closure plan is developed.

F.4.B Technology Development and Engineering Practice
Almost 10 years have lapsed since borosilicate glass and Synroc were assessed as the two top HLW forms and some experts in the technical community are claiming that technical progress outside the DOE complex calls for a reassessment of the 1982 decision. In the last few years, Synroc development has been carried on only in Australia and Japan. Although the recent research in Australia indicates that the leach rate of titanium from the Synroc matrix is orders of magnitude lower than that for constituents from the borosilicate glass matrix, congruent leaching of Synroc has not yet been demonstrated. This suggests that Synroc may be a superior material from the standpoint of leachability, but its capability to retain the radionuclides in a range of repository environments is still an open question.

The conclusion is that determining waste form performance is complicated. It is very difficult, but extremely important, to quantify the environmental conditions that the waste package will have to withstand in the repository. Because the different waste forms will perform differently in different environments, it is imprudent to compare the forms on the basis of one or two parameters. For example, recent research at Argonne National Laboratory (ANL) indicates that leachability by flowing water is limited by colloid formation processes, rather than simple solubility, as had been assumed in the past. As a backup position for meeting NRC requirements, much can be done in the package design to make a more robust container with a longer life than the 300-1000 years projected for the stainless steel canister (as is being done in Sweden).

The conclusion, based on investigations summarized above, is that the decision to use borosilicate glass for HWVP is a reasonable one <u>and supports HWVP as currently scheduled</u>. If, however, the project should incur significant delays, then reconsidering the use of borosilicate glass in favor of a second generation material may be appropriate.

F.4.C <u>Prudence Issues</u>

There is an apparent lack of integration of the large number of regulatory requirements bearing on the HWVS. Given the extensive findings by the Tiger Team an Hanford in July of 1990, prudence would appear to suggest improved interactions among the regulatory compliance representatives from the Tank Farms, B-Plant, HWVP, and the waste management organizations. One significant action would be mapping out the full set of commitments/actions (in addition to those spelled out in the TPA), and then assigning responsibility for critically assessing, tracking and closing them. This would go a long way in establishing a firm baseline for System-wide compliance.

F.5 <u>Overarching Concerns</u>

The following is a summary of significant regulatory issues identified during this review.

The TPA is the predominant regulatory instrument used to ensure protection of the public health, welfare and the environment in and around Hanford. It is a consensus decision-making vehicle, and decision making by consensus is slow, even if well founded. The pace at which these crucial regulatory decisions are are likely to be made, and the uncertainty of the results, do not appear to support the ambitious HWVS schedule.

F.5.A <u>Tri-Party Agreement Issues</u>

Specific major issues of concern are:

F.5.A.1 Seismic qualification of B-Plant

F.5.A.2 Double containment of B-Plant sumps and transfer lines

F.5.A.3Adequacy of the B-Plant piping to accomplish the new mission

F.5.B Regulatory Compliance

The NEPA documentation in place for the HWVP Project appears to be insufficient because: (1) the "Analysis of the Environmental Effects of the HWVP (June 1990) has not been approved by DOE-HQ; (2) incorporation of SST 241-C-106 wastes in the DST feedstock may violate the existing ROD; either of these issues could potentially re-open the EIS process, which could substantially delay the construction and start up of HWVP, and (3) securing a RCRA Part B permit for B-Plant is by no means certain. Considerable work will be required to demonstrate that the Plant can meet RCRA requirements over the long time line envisioned for the Project. Adequate characterization of tanks wastes for hazardous constituents has not been completed.

The Superfund Act Reauthorization Amendments (SARA), Community Right-to-Know provisions could result in project delays if it were argued that the EIS process for the HWVP had not adequately integrated with CERCLA's right to know provisions.

The current system of commitment actions tracking is based on Notices of Deficiency (NOD), rather than on a critical self-assessment of compliance versus applicable, prescriptive requirements. Mapping or integrating these issues for the assessment of applicability through assignment of action through closure is a needed activity requiring implementation over the next three to six months.

Additionally, Facility Environmental Monitoring Plans (FAMP) are in preparation, unavailable for review until November 9, 1991. These Plans should be reviewed to address the planning compliance with emission criteria.

F.5.C Regulatory Outliers

Based on recent experience with start up and operation of other DOE facilities, it appears that the greatest regulatory risk to HWVP may lie in unplanned and unexpected or (outlier) occurrences. There is an obvious potential for outliers in the present climate of intervention by advocacy groups. The process of attempting to implement a strict compliance of older facilities with the intent of newer regulations is particularly vulnerable to criticism. This opens a door for delaying tactics. Extreme care should be taken in tracking all applicable requirements and documenting all approval steps and input of parties to agreements.

Another potentially significant issue is the effect of future changes/ additions to regulations. For example, the current waste management strategy at Hanford incorporates the planned new WRAP facility. The HWVP melters, among other items, would be sent to this facility for decontamination of HLW elements and packaged for transport to the WIPP in New Mexico or to the LLW burial vaults on-site. If WIPP does not become operational this strategy would have to be revised. The effect on HWVP operations could be significant.

F.6 Regulatory Compliance Subgroup Reference

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14. Nelson, Grier, LaRue, et al, Red Team Presentation Materials, WHC, July 8-12, 1991, Richland, WA.

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REGULATORY REQUIREMENTS SUBGROUP - *Engineering Reqmts (6430.1A)*

Subsystem	Hazard Classification	Safety Class Systems	Double Containment	Emergency Power	Natural Hazard Resistance	Other Items?
Waste Tanks (DST's, existing operations)	Low hazard, except aging waste tanks and the evaporator are moderate hazard	Vent system and monitors to be upgraded to Safety Class 2	Partial double for liquid; blowers maintain negative gas pressure	Class 1 diesel generator for tank farm treatment system only	Future mods. will provide accommodation for ash fall, seismic and tornado	
Pretreat Process (B plant, existing operations)	High hazard	Canyon exhaust system and monitoring system are Safety Class 1	Double containment issue under evaluation; double for vault tank and 3 zones for air	Class 1 diesel generator	Need end wall reinforcement and stronger access doors to meet seismic	
HWVP	High hazard	Vitrification and switch gear bldg, fan house, canister vault and zone I ventilation system are Safety Class 1	Double for liquids; 4 zones for air	Class 1 diesel generator	Seismic, high winds and ashfall	

REGULATORY REQUIREMENTS SUBGROUP - *Effluents, Routine*

Subsystem	Gaseous		Liquid		Solid	
	Rad	Non-rad	Rad	Non-rad	Rad	Non-rad
Waste Tanks (DST's, existing operations)	Offsite limit 10 mrem/yr; actual offsite <0.01 mr/yr for all 5 stacks combined	Unknown	7 streams to soil column; have agreed to apply for 216 permit.	tank farm sanitary sewer	Removal of tank internals prior to slurrying for removal of liquids/solids	Normal industrial trash
Pretreat Process (B plant, existing operations)	Offsite limit 10 mrem/yr; actual offsite <1 mr/yr for all 5 stacks combined	Not determined	4 streams to soil column; have agreed to apply for 216 permit.	B plant sanitary sewer	Contaminated equipment in large disposal boxes; rags clothes, etc.	Normal industrial trash
HWVP	Offsite limit 10 mrem/yr; actual off site1.1E-2 mrem, 0.30 pers rem	Major releases of CO, SO_X, NO_X, minor releases of F_X, NH_3 (all within permitted limits)	None	HWVP sanitary wastes	Spent contaminated equipment; eg melters, process equipment, radioactive trash	Normal industrial trash

REGULATORY REQUIREMENTS SUBGROUP - *Worker Impacts*

Subsystem	Rad Exposure	Non-rad Exposure	OSHA Regs	Other IS&H Regs		
Waste Tanks (DST's existing operations)	Site administrative limit 1-2 rem/yr; experience is about 100 mrem/yr	Unknown	Have site wide OSHA program	Site wide IH program administered by ES&Q		
Pretreat Process (B plant, existing operations)	Site administrative limit 1-2 rem/yr; experience is about 250 mrem/yr	Unknown	Have site wide OSHA program	Site wide IH program administered by ES&Q		
HWVP	Site administrative limit 1-2 rem/yr; projected 400 mrem/year	NO_X, SO_X, and CO	Have site wide OSHA program	Site wide IH program administered by ES&Q		

REGULATORY REQUIREMENTS SUBGROUP - *Effluents, Accidents*

Subsystem	Gaseous		Liquid		Solid	
	Rad	Non-rad	Rad	Non-rad	Rad	Non-rad
Waste Tanks (DST's, existing operations)	Aging waste tank bump-5.4 rem on site; 0.3 rem off site	NH_3, volatile organic compounds	No known leaks from DST's to date	None	None	None
Pretreat Process (B plant, existing operations)	Offsite 70 man-rem	Not determined	Leaks through expansion joints to soil, magnitude unknown	Not determined	Not determined	Not determined
HWVP	Ashfall-0.51 rem on site; 0.008 rem off site	Formic and nitric acid vapors	None	Formic and nitric acid spills	None	None

APPENDIX G

MANAGEMENT AND CONTROL SUBGROUP ASSESSMENT

G.1 Summary

G.1.A Purpose

The Management and Control (M/C) Subgroup evaluated the Department/contractors readiness to proceed with the construction of the Hanford Waste Vitrification Project (HWVP). The M/C Subgroup pursued three lines of inquiry:

- Is the HWVP integrated into the larger HWVS.

- From a M/C perspective, what is the status of HWVS engineering practice?

- Are management processes adequate to insure success of the integrated HWVS?

G.1.B Scope

The HWVP is a subsystem of the HWVS. The HWVS encompasses the development and implementation of Double Shell tank (DST) waste characterization, retrieval, pretreatment, low level waste disposal in grout, high level waste disposal in glass, and interim glass storage. To evaluate scientific, engineering, and production integration, the total HWVS was selected for the M/C inquiry.

G.1.C Conclusions

Our conclusions are:

- HWVP planning, design, construction, and operations planning are managed as an integrated project.

- The HWVP and HWVS are managed as separate entities.

- The success of the HWVP is dependent on the success of the total HWVS.

- The separation of HWVP and HWVS management has resulted in scientific, engineering, and production disintegration, representing a substantial risk to programmatic objectives.

- HWVS engineering practice definition and implementation are currently not adequate to ensure success of programmatic objectives.

- With the current HWVS technological uncertainties, improved DOE-RL and Westinghouse Hanford Company (WHC) management processes are needed to achieve the programmatic objectives.

G.1.D Additional Findings

G.1.D.1 Key integration findings are:

G.1.D.1.a Two DOE-RL organizations and WHC Division 85000 perceive ownership/responsibility for the HWVS, including the HWVP element. Communication and coordination between the DOE-RL organizational owners is inadequate. Accountability is diffused.

G.1.D.1.b An integrated, validated, detailed plan does not exist for the HWVS. Three owners are reacting independently to programmatic questions and concerns. Reactions driven by DOE-HQ questions include the Risk Assessment Study, the Redefinition Study, multiple pretreatment assessments, and the Red Team Review.

G.1.D.1.c DOE-RL and WHC are using a task-based "discovery" approach in place of pro-active, integrated program management. Available funds, rather than pro-active, integrated program planning, define the extent of tasks authorized, placing the HWVS at risk.

G.1.D.1.d Technology uncertainties were not fully recognized in the initial HWVS definition, were under-budgeted, and have been under-resourced. Detailed HWVS schedule milestones have slipped and disconnects are emerging.

G.1.D.1.e Funding fluctuations in each fiscal year make effective HWVS planning and management difficult and result in loss of program integration.

G.1.D.2 Key engineering practice findings are:

G.1.D.2.a HWVS source documents (Record of Decision, Tri-Party Agreement, DST Waste Disposal Integration Plan) have not been effectively converted into a technical requirements document hierarchy that drives the program and the HWVP subsystem. The absence of a controlled requirements document hierarchy has resulted in numerous interpretations of program assumptions and requirements that are not always consistent or cost effective.

G.1.D.2.b Technical assessment studies (Burris Report, Noordoff Study, PNL technology development reports) are used directly as specifications and requirements documents without formal management review and endorsement.

G.1.D.2.c HWVS engineering practices are inadequately defined in procedures and are informally applied to work activities. The formal, consistent use of standard engineering practices such as statistically developed experiments and specifications, analysis of data for statistical validity, engineering design of experiments, QA reviews, and process tolerances/specification ratios was not evident.

G.1.D.2.d An unarticulated requirement for zero technical risk is an element of on-going engineering efforts, is consuming resources, and is probably unachievable in light of historical funding practices.

G.1.D.3 Key management processes findings are:

G.1.D.3.a Technical performance metrics are not sufficiently defined or used to assess development progress. A formal, management controlled, well-understood and executed, technical assessment and decision process is not evident. As a result, it is not evident that management is bringing technical uncertainties and development efforts to closure. Schedule preparation appears to be managements' primary decision-making process.

G.1.D.3.b Technical assessments and decisions can be made at the working level without management review and approval, and without program impact considerations.

G.1.D.3.c Management lacks a pro-active process for identifying and addressing emerging regulatory issues.

G.2 Supporting Rationale for HWVS Conclusions and Findings

The basis for the HWVS conclusions and findings of these issues is described in the following sections:

G.2.A Integrated Issues

We used a simple model to assess program integration and execution. First, a crisp definition of the program ownership is essential. This enables the owner to formally define the assumptions and to carry out high level and formal detailed program planning. Detailed plans enable the definition of detailed performance requirements (technical, cost, and schedule) and work breakdown structures (WBS). Defined requirements and the WBS enables effective communications and productive, integrated, quality work. As the work proceeds and issues surface, the owner, in collaboration with key personnel, makes technical, cost, and schedule assessment and decisions based on the plans and requirements. Technical assessments and decisions may narrow the range of efforts, focusing resources on high payoff options. Decisions are definitively communicated to all personnel and are used to modify planning and requirements documents. Disciplined documentation, customer validation, and stakeholder involvement are essential to successful program integration and execution. After an initial iteration, execution is fluid and dynamic. The elements of the model are extremely interdependent - for example, if detailed plans and assumptions are not available - requirements (the basis for work) are difficult to develop, validate, and integrate. This simple model was the basis for assessing the HWVS and the HWVP subsystem management and control.

HWVS ownership is not crisply defined. Two DOE-RL organizations perceive territorial ownership, funding responsibility, and decision making authority, which leads to program fragmentation. WHC Division 85000 also perceives ownership of the HWVS/HWVP. The three HWVS/HWVP owning organizations are not actively coordinating their separate actions and decisions. As examples, the VPO manager unequivocally stated that HWVP operation does not require waste feed pretreatment, while certain WHC HWVS managers state that pretreatment is required to obtain a cost effective program solution. HWVP and pretreatment subsystem managers have agreed to disagree, without owner intervention, on the HWVP feed specification.

DOE has mandated but apparently not validated multi-year site plans, which include the HWVS and the HWVP. Neither the DOE-RL or the WHC owners have carried out <u>detailed</u> HWVS program planning as a pro-active management tool. Such planning would include, for example, parallel technology development path planning; technology, cost, and schedule based decision tree planning; technical, budget, cost and schedule contingency planning; and technical and regulatory risk assessment and mitigation planning. HWVS program management has focused primarily on schedules as the singular objective and metric. The schedule focus appears to be the result of implementation oriented management processes, a positive WHC management effort to change the site level-of-effort entitlement culture, and the Tri-Party Agreement milestones. However, these schedules do not reflect the technical go/no-go options and decisions which are being addressed at the working level (see also Engineering Practices section).

The absence of crisp ownership definition and of pro-active, validated, detailed planning documents has resulted in an almost total void of management endorsed, hierarchically structured technical requirements documents. As one example, while intuitively obvious, the frequently articulated requirement to use pretreatment to reduce the number of glass canisters appears to be self-imposed, since it is not a part of a planning or source document. Without detailed plans and corresponding hierarchically structured requirements documents as the basis for articulating HWVS management, DOE-RL has been reacting rather than responding to Department questions regarding HWVS/HWVP substance and consistency. Portions of essential program plan documents have been developed in reaction to DOE-HQ questions. WHC has received task assignments to develop documentation relative to program risks and baseline redefinition options. These tasks and documents do not appear to be viewed by HWVS management as integrated elements of a larger planning need - but rather as added scope, which must be carried out with appropriate change order requests to DOE-RL, to proceed with HWVP implementation.

Managements ability to effectively plan and execute the HWVS has been adversely impacted by several external influences, including short-term fluctuation of resources, a new Westinghouse Defense Waste Management structure and personnel, a change in site mission from production to remediation, a WHC shift from a level of effort, entitlement culture to a defined work scope/schedule culture, and a shift from contractor directed activities with Department over-site to Department managed activities implemented by contractor task assignment. The impact of any of these external influences on the HWVS/HWVP should be cause for significant management concern. The shift to Department management appears to be the most significant short term concern, as the contractor's knowledge of the customer's expectations is less clear (pro-active planning, management back-pressure to the customer). Without clear customer articulation of assumptions and requirements and outstanding communications, the contractor can develop a "victim" attitude. A development program which spans a ten year period is certain to face this type of external influence and the additional issue of continually emerging technology. Pro-active management planning is essential in this environment.

WHC HWVS management uses a single program path schedule and effective change control as the principal Program management tool. Emphasis is on prompt identification or "discovery" of technology development outcomes which differ from the single planned path, so that change requests can be processed to DOE-RL. However interviews with working-level managers and engineers indicate that the program has a number of known uncertainties related to waste characterization, retrieval, and pretreatment technology. In the current early development and application stages of these uncertainties, personnel are identifying and considering several options. There is no formal procedure which calls for inclusion of these options and consideration of resultant program impact in the schedule process. Therefore, management is relying on the change control "discovery" process to address these program contingencies. For example, a decision point for the go/no-go use of TRUEX is absent. Contingency plans for waste characterization "discoveries" which may necessitate modified or alternate retrieval technologies are not evident. It is also unclear what contingency plans (alternate schedule paths) support these uncertainties and whether estimated costs have been include for them.

DOE-RL and WHC management are also reacting to funding constraints by making less than optimum business decisions. Work is divided into "affordable", rather than requisite pieces. An example is the repeated selection of a 40-year old facility to support a long term pretreatment process (when SST remediation is considered). The plan to characterize and pretreat waste using a batch methodology is another example. A "work" driven plan would call for expediting high risk, front end development activities such as waste retrieval and characterization.

The absence of essential management plans, requirements documents, and of a pro-active, integrated planning approach have led to ad hoc program funding decisions. As a result, given curtailed funding guidance during FY91, essential development activities, such as tank characterization, retrieval technology, sludge washing, and TRUEX development were severely curtailed. Technology development in general seems to have a low priority with management, suggesting a lack of appreciation for the challenges. In our interviews, we were unable to ascertain the planning basis for funding cuts, the decision process used to make the cuts, or the final responsibility for the decisions. In the absence of HWVS requirements documents, program elements are not effectively integrated in a well balanced execution plan encompassing performance, cost, and schedule. Resource allocation across the HWVS/HWVP are not made with a clearly defined understanding of critical path schedule issues and with the amount or timing of resources to resolve issues. Program milestones for the elements mentioned above have slipped during the last two years and the schedule discontinuity between the HWVP and other Program elements is growing. non-HWVP Program element funding requirements are being postponed to subsequent fiscal years, effectively forcing all non-HWVP Program elements onto the critical schedule path and resulting in schedule compression that may not be made up.

During FY91 WHC HWVS management (either at DOE-RL request or with their concurrence) has redirected key program resources to respond to fluctuating HWVS funding guidance. Working level managers consistently explained that a significant fraction of their time and resources were consumed revising schedules and related cost estimates in response to about seven "what if" funding scenarios (cases) initiated by DOE-HQ through DOE-RL. The significant FY91 cases are summarized as follows:

HWVS Element	Case 2 (7/90)	Case 5 (12/90)	Guidance (4/91)
	($ in millions)		(Case 6A)
B-Plant	45.5	41.9	36.8
Pretreatment/Projects	28.9	28.2	11.7
Grout	33.0	30.1	28.1
PTSO	2.3	2.3	2.3
HWVP Operational	0.8	0.8	0.6
HWVP-Other	25.0	18.0	18.0
	135.5	121.3	97.5

HWVP personnel also report less than anticipated progress due to receipt of only 25% "phased" construction funding in the first quarter and a decision to reprogram approximately $40M to other waste management programs early in the second quarter. These budget exercises cause personnel to stop or delay planned work when funding guidance announcements indicate resource reductions. Others accelerate their activities in an attempt to maximize their resources, creating disintegration. Time is also lost while the re-planning effort is proceeding. Resources which are already limited are redirected to revising schedules and budgets rather than carrying out planned work such that the program management becomes extremely difficult.

In addition, the HWVS is the Department's third site priority behind tank safety and SST waste remediation. As such, the non-HWVP must compete for funding with higher priority programs as well as with ongoing site facilities maintenance and decommissioning mortgages. On the other hand, the HWVP element has dedicated funding, resulting in inconsistent progress with other HWVS elements subjected to "competitive begging". Also, inside WHC the non-HWVS must compete for funding further compounds the problem of fluctuating fiscal year funding. As a result, program element integration suffers.

G.2.B <u>**Engineering Practice Issues**</u>

An informality of engineering practice was noted in the HWVS. As mentioned in the integration issues section, technical requirements are not formally developed from source documents, hierarchically documented, and endorsed by management. The use of some typical standard engineering practices was not observed. Technical assessment and decision processes were also not evident. The informality seemed more typical of a small operations (implementation) oriented company.

In the absence of a formal integrated requirements documents hierarchy some program engineering participants are using their own interpretations of source documents, such as the Record of Decision and the Tri-Party Agreement, to develop program element assumptions and requirements. Technical assessments, such as the Burris Report, the Noordoff Study, and PNL technical studies, are also being used as source documents to develop requirements and specifications for individual program elements. It is not evident that management has sanctioned these assessments as program source documents. Further requirements development using this fragmented approach may result in program elements working towards different end results.

Technology development and application options appear to be identified and resolved by working level engineers and managers, without concurrence from program management. As a result, working level technical assessments and decisions may be made without due regard for their impact on the entire program's technical baseline, cost, and/or schedule.

Standard engineering practices, such as statistically based experiments and specifications, response surface design of experiments, process control methodologies, statistically valid data requirements, application of QA methodologies to scientific and development activities, and the use of process capability/requirement ratios such as Cpk, were not evident. Procedures which do exist appear to be informally applied. Neither DOE-RL, WHC, or PNL management are mandating and enforcing typical engineering practice standards and procedures.

Zero risk engineering is an unarticulated requirement and a practice within the HWVS. Engineering personnel appear to be continually and non-productively fine tuning the science and engineering basis of the program. A zero-risk engineering practice is probably unachievable and inhibits focus on high risk/high pay-off issues. One example is the continuing refinement of the glass composition knowledge base (39 glass formulations) while retrieval and pretreatment are under-staffed and under-funded. HWVS management does not appear to be disinvesting some long standing engineering activities to focus resources on other critical issues. This apparently results, in part, from the absence of a formal management process for technical assessment and decision-making, well-understood at the working level, to bring scientific and engineering activities to closure. The focus of the program decision process is schedule. Management does not use technical metrics to measure and communicate progress towards successful completion of key program requirements, issues, or activities.

Engineering interfaces and protocols also appear to be informally defined, documented and implemented. As an example, WHC engineering personnel look to the QA organization to add appropriate quality specifications to PNL test plans. The QA organization thought the engineers were including those requirements. Both WHC groups thought PNL was taking appropriate QA requirements into account when they did the work - but PNL management expected WHC to include all of the requirements in the test plan. Most managers thought QA formalism was not really that important for scientific and development engineering activities. A formal QA hierarchy exists within the HWVP but is not defined for the HWVS.

Communications within WHC management and engineering chain appear to be open but apparently not effectively utilized to resolve technical issues. Communications between WHC and PNL management and engineers do not appear to be as open.

G.2.C Management Issues

WHC HWVS and DOE-RL VPO and WHC HWVP management appear to have an operations or implementation-based set of management skills and processes. As discussed in the engineering practice issue section, management lacks a formal, well understood process for technical assessment and decisions. Pro-actively developed, detailed, documented assumptions and plans and requirements are not available as a basis for technical assessments and decision. Technical metrics are not used by management to access progress. Scientific and engineering activities do not appear to be brought to closure, with resources refocused on high risk or emerging technical issue.

Schedule development appears to be the primary, implementation-based, decision process. The schedules do not appear to include decision points related to the overarching or detailed technical uncertainties of the HWVS.

All of the WHC HWVS and DOE-RL VPO and WHC HWVP managers we interviewed appeared to be dedicated to the success of the Program/Project, knowledgeable, and hard working. A significant number of the WHC HWVS and HWVP senior managers have outstanding nuclear reactor design, construction, and operations credentials. However, there was a general lack of understanding, confusion, and misinterpretation of our questions related to technical performance assessment, metrics, and decision processes. The management skills and processes required for successful N-reactor implementation may not be optimum for the technology uncertainties of the HWVS. The informality of engineering practice is also indicative of a smaller, more intimate, technologically uniform work group.

The management skills and processes of the PNL managers we interviewed are customer/task based. PNL does not appear to comfortable with assessing, making decisions, or being accountable for technological uncertainty issues. PNL works hard to provide the customer with the scientific and engineering studies the customer defines as necessary.

DOE-RL management has experienced significant personnel changes and restructuring in the past several years. In the limited on-site time available, the M/C Subgroup was unable to interview DOE-RL management to determine if they had the requisite skills and processes, as required in the FY92 implementation of the DOE-RL Site Management System, for assessing and decision-making with regard to the HWVS technological uncertainties.

DOE-RL and WHC management do not seem to use a pro-active approach to addressing regulatory uncertainties which have potential for affecting program success. Recent regulatory examples include the NRC determination of the definition of low level waste, the absence of effort on glass canister repository requirements, and the discovery of the need to obtain permits for B-plant.

G.2.D Issues Unique to HWVP

The Management and Control Subgroup did not identify HWVP unique issues of equal importance to those identified in the overarching HWVS. As an subsystem of the HWVS, the Hanford Waste Vitrification Project issues mirror, to a significantly lesser degree, program issues described in Section III. HWVP participants (DOE-RL, WHC, PNL, FLUOR, UCAT) management is structured to meet the requirements of Department Order 4700.1 and appears to be functioning effectively. The "fenced" funding environment in which the HWVP operates is a significant management advantage over the "competitive begging" environment of the HWVS. The differences between the HWVP and the HWVS management environment, while important to the HWVP success, only accentuate the issue of Program integration. HWVP management and personnel are confident that the Project management structure will aid Project unit success. They are also intimately aware of the detrimental HWVS issues. As a result, HWVP management seeks to differentiate and distance its self from the program of which it is an integral element.

DOE-RL and WHC HWVP management do not appear to be taking optimal advantage of the technical and operational issues and data available at the Savannah River DWPF prototype of the HWVP. Only one WHC manager is resident at the DWPF. Scheduled technical interchanges appear to be deferred more than they have occurred in recent months. The Department decision to link the implementation of the two facilities was sound. With the start-up difficulties at DWPF, it is difficult to imagine that one resident manger can fully access the wealth of DWPF lessons-learned information available for HWVP design improvement.

Several HWVP management practices deserve special recognition. The project is operating under an Integrated Management Team concept fostered by the VPO. Senior participant managers meet weekly to discuss and resolve Project issues. Working level personnel are aware of this vehicle to address inter-participant issues. Unfortunately, working level participant interfaces more closely resemble the difficulties of the program.

WHC management has integrated its HWVP functional elements in a single organization, simplifying and clarifying the lines of authority and responsibility. The WHC Project manager and his direct subordinate managers appear capable of successfully carrying out the design and construction of the HWVP.

Procedures have been and are being developed and documented for key HWVP development, design, and construction processes. Implementation of the procedures, however, shows evidence of informalities existing in the Program.

The HWVP operations manager is a member of the HWVP development team. DOE-RL VPO and WHC HWVP Management are commended for this forward thinking action.

G.2.E Other Concerns

The Management and Control Subgroup identified several additional HWVS concerns not covered in the previous sections.

The Defense Waste Remediation Strategy Redefinition Study requirements and objectives, as presented by WHC/PNL to the Red Team, are inadequately defined to provide a definitive basis for a Department decision. The requirements do not include an analysis of life cycle cost (development, procurement/construction, operation, and decommissioning) versus benefit or an analysis of risk (technical, schedule, and cost) versus benefit for each of the key pretreatment options. At present, the key redefinition objective appears to be the minimization of glass cannisters regardless of total Program life cycle cost or risk. The objective of decommissioning DSTs was not included.

The recently completed HWVS Risk Assessment appears to underestimate the HWVP element risk. A "0.0" HWVP success risk does not appear to be consistent with the use of the Savannah River DWPF as a design basis and the current DWPF start-up difficulties. Risks were defined in terms of increased cost, not schedule or technical performance. DWPF difficulties may delay HWVP start-up given the Department's intention to have each facility learn from its predecessor. An adequate program has not been defined and resources allocated to address those high risk elements identified in the Risk Assessment which will not be affected by the Redefinition Study, such as retrieval and pretreatment.

G.3 Background and Supporting Information

The Management and Control Subgroup pursued its three lines of inquiry through review of available and requested documentation and through presentations from and interviews with DOE-RL, WHC, PNL, and UCAT managers and engineers.

The subgroup reviewed appropriate HWVP documents in the Red Team library. In addition, we requested, received, and reviewed the HWVS and HWVP documents listed in Table 2. After listening to general as well as specific management and control presentations, detailed interviews were conducted with the personnel listed in Table 1. All requested interviews were completed, except the interview with the DOE-RL Waste Management Division Manager. Interviews were based on 18 questions which addressed:

- Delineation and documentation of requirements (technical, cost, schedule, assumptions, validation),

- Participant and element interface protocols (planning, communications, work breakdown definition, decision process)

- Participant and element integration (roles, responsibilities, accountability, metrics)

- Risk and contingency assessment and planning.

The HWVS and HWVP participants, and WHC in particular, were very supportive of the Red Team Management and Control Subgroup information, documentation, and interview requests. The comprehensive review procedures we followed, coupled with the excellent WHC and DOE-RL VPO support, were sufficient to successfully assess our three lines of inquiry.

TABLE G - 1

INTERVIEWS

NAME	ORG	TITLE	POSITION
Appel, J. N.	WHC	Manager	Waste Pretreatment Technology
Barker, S.	WHC	Engineer	Truex Process Development
Brown, R. W.	DOE-RL	Manager	Vitrification Project Office
Cahill, M. A.	WHC	Manager	Waste Pretreatment Engineering & Projects
Creer, J. M.	PNL	Manager	HWVP Technology Development
Danford, G.	WHC	Manager	East Area Tank Farm
Denton, T. L.	WHC	Manager	Defense Waste Remediation Financial Administration
Epstein, J. L.	WHC	Manager	Grout Facilities
Frick, D. C.	WHC	Manager	Program Planning and Controls
Gasper, K.	WHC	Engineer	Waste Tank Safety Prog. Office Planning Engineer
Johnson, M.	WHC	Engineer	DST Sludge Wash Process Development
Kruger, O.	WHC	Engineer	Vitrification Technology Integration
Meyer, G. A.	WHC	Manager	Defense Waste Remediation Program
Newland, D. J.	WHC	Manager	Defense Waste Remediation Division
Roecker, J. H.	WHC	Asst. Manager	Defense Waste Remediation Division
Smith, R. A.	WHC	Manager	Hanford Waste Vitrification Plant Project
Smith, S.	WHC	Manager	Restoration & Remediation Quality Assurance
Stegen, L. C.	WHC	Manager	Retrieval Technology
Taylor, W. J.	UCAT	Proj. Director	HWVP Construction
Weber, E. T.	WHC	Manager	HWVP Applied Technology

TABLE G - 2

MANAGEMENT AND CONTROL DOCUMENTS

- HWVP Project Integrating Procedures, Index, 1 Page, Uncontrolled
- HWVP Administrative Operating Procedures Index, 2 Pages, Uncontrolled
- DWRP ADS to WBS Crosswalk Spreadsheet, 1 Page, Uncontrolled
- DWRP OBS to WBS Crosswalk Spreadsheet, 1 Page, Uncontrolled
- DOE-RL Memorandum, Hanford Waste Vitrification Plant Progress Report for May 1991, July 8, 1991
- HWVP Monthly Review, March 7, 1991, Viewgraph Copies, 82 Pages, Uncontrolled
- DWRP Strategy Revision Meeting Minutes Folder; Minutes from 7/10/91, 6/25/91, 6/7/91, 5/23/91, 5/17/91, 5/7-9/91, 5/2/91 Meetings
- HWVP Cost and Schedule Performance, June Status Meeting, June 18, 1991, Fluor Engineers, Uncontrolled
- HWVP Cost and Schedule Performance, May Status Meeting, June 19, 1991, Fluor Engineers, Uncontrolled
- WHC Internal Memo, Award Fee Evaluation Plan - Reporting Responsibility, June 20, 1991, 11 Pages
- A Collection of Document Excerpts, Prepared for HWVP Red Team M/C Subgroup, "HWVP Feed Specification Documents, Change Notices, and HWVP/DWPF Feed Specification Difference Justifications, ~150 Pages
- PNL Management and Staff Experience as Applies to HWVP, 2 Pages, Prepared for HWVP Red Team M/C Subgroup
- Double Shell Tank Waste Disposal, Mission and Function Requirements, 2/7/91, 26 Pages, WHC Controlled Document, EDT 105596, WHC-SD-WM-DB-005, Rev. 0, 2/7/91
- WHC Management Requirements and Procedures - Corrective Action Management System, September 17, 1990, Doc. No. WHC-CM-1-3, Section MRP 5.1, Rev. 1, 13 Pages
- WHC Quality Assurance, Manual WHC-CM-4-2, Section QR18.0, Rev. 1, August 8, 1988, 3 Pages
- WHC QUEST Code Matrices, 7/9/91, WHC Uncontrolled Document 9, Pages
- WHC Audit and Appraisal Document IAA-91-0002-AUD, Findings 1-4; Observations 1-10; Audit Date 2/22/91, C. B. McKee; with Corrective Action Attachments, 25 Pages Total
- WHC B-Plant Integrated Schedule as of June 1991; 90 Day Bar Chart, 42 Pages, Uncontrolled
- WHC DWRD Integrated Level III Schedule, 1991 Budget Case V, 3/91, ~75 Pages, Uncontrolled
- WHC DWRD Integrated Level III Schedule, Revision 2, 1991 Budget Case II, 11/90, ~75 Pages, Uncontrolled

- WHC DST Waste Disposal Integrated Level I & II Schedules, 3/90, ~25 Pages, Uncontrolled
- WHC DST Waste Disposal Integrated Level I & II Schedules, Revision 1, 11/89, 14 Pages, Uncontrolled
- WHC Waste Vitrification Division B-Plant System Test and Start-up Schedule, ~250 Page Binder, Uncontrolled
- DOE-RL Environmental Restoration and Waste Management Site Specific Plan for the Richland Operations Office - Hanford Site Five Year Plan FY1993-1997, DOE-RL-91-25 Predecisional Draft
- WHC Fiscal Year 1989 Defense Waste Management and Environmental Program Plan, WHC-SP-6428; November 1988
- WHC Fiscal Year 1990 Defense Waste Management/Environmental Restoration Programs, WHC-SP-0573, March 1990
- WHC Waste Vitrification Division Integrated Level III Schedule Revision 2, 1991 Budget Case II, 11/90, Element Detail, ~500 Pages, Uncontrolled
- WHC Defense Waste Remediation Division Integrated Level III Schedule, 1991 Budget Case V, 3/91, ~500 Pages, Uncontrolled
- DOE-RL Memorandum to Ms. Christine O. Gregoire, Director, State of Washington Department of Ecology et. al., February 6, 1991, "Hanford Federal Facilities Agreement and Consent Order (Tri-Party Agreement) Change Packages"
- Battelle PNL Project Management Support Department "Essentials of Project Management, 6/91 Draft
- WHC Hanford Waste Vitrification Systems Risk Assessment-Final Report, WHC-EP-0421, Draft Revision A, September 1991
- WHC Hanford Waste Vitrification Systems Risk Assessment-Final Report Supporting Information, WHC-EP-0421, Part 1, Draft, September 1991
- DOE-RL Project Management Plan-HWVP, HWVP-89-002 Revision 1, September 1990
- WHC Double Shell Tank Waste Disposal Integration Plan, WHC-EP-0229, Revision 1, January 1990
- WHC Hanford Waste Vitrification Plant Project Monthly Review, May 23, 1991, ~75 Pages, Uncontrolled
- WHC Management and Control System Description, WHC-EP-0388, October 1990
- WHC Organization Charts and Charters, February 12, 1991, 46 Pages, Uncontrolled
- WHC HWVP CWBS Listing, 5 Pages, Uncontrolled
- WHC Performance Report for Defense Waste Remediation Division - June 1991, Memo, July 3, 1991
- WHC Project B-595, HWVP Plant Project Manager's Monthly Progress Report for May 1991, Correspondence No. 9153046
- U.S. Department of Energy, RL, VPO Fluor Daniel, Project Cost Estimate, 9/7/90 Contingency Estimate, Uncontrolled
- WHC Memo, Project Funds Status and FY1991 Work Plan Mid-Year

Assessment, July 16, 1991, ~25 Pages, Uncontrolled

- WHC HWVP Change Control Log - Budget - 2/5/91, 22 Pages, Uncontrolled
- DOE-RL FY1993 Field Budget Request Construction Project Data Sheet; May 22, 1991; May 4, 1990; May 19, 1989; April 01, 1988
- WHC Hanford Waste Vitrification Plant Project Office Management Plan, WHC-SP-0677, Draft, Revision 0, June 1991
- Record of Discussion DOE-EM Director and Washington State Department of Ecology Director, May 2, 1991, 2 Pages
- Barr and Pie Chart of Defense Waste Remediation Division Exempt Staff Experience, 2 Pages
- Memo, R. J. Bliss, WHC VP Restoration and Remediation to J. P. Hamric, DOE-RL Deputy Manager for Operations - "Double Shell Tank Waste Disposal Program," February 15, 1991
- Memo, J. P. Hamric, DOE-RL Deputy Manager for Operations to T. M. Anderson, President, WHC; "Defense Waste Remediation Risk Resolution Studies," March 21, 1991
- Memo, C. M. Cox, WHC Manager Defense Waste Remediation Division to J. P. Hamric, DOE-RL Deputy Manager of Operations; "Defense Waste Remediation Risk Resolution Studies," March 29, 1991
- Memo, L. C. Williams, DOE-RL Director-Project Management Division to the President, Westinghouse Hanford Company, "HWVP Justification for New Start, w/attachment," October 29, 1987
- Diagram - DST Waste Disposal Program Technical Design Document Hierarchy, 5 Pages, Prepared at the Request of the HWVP Red Team Management and Control Subgroup
- Memo, R. A. Smith, WHC HWVP Project Manager to J. M. Creer, PNL HWVP Technology Development Project Manager; Revision of Pretreated Neutralized Current Acid Waste Composition for FY91 Pilot Testing
- WHC HWVP Applied Technology Plan, WHC-EP-350, December 1990

APPENDIX H

HIGH-LEVEL RADIOACTIVE WASTE DISPOSAL REQUIREMENT

The performance requirements that must be met by the engineered barrier system for the permanent disposal of high-level radioactive waste are included in 10 CFR Part 60. This regulation, developed by the Nuclear Regulatory Commission (NRC), presents three subsystem performance requirements for the engineered barrier system and geologic setting which are:

1. The pre-emplacement groundwater travel time between the disturbed zone and the accessible environment shall be at least 1000 years or greater.

2. The waste package must provide substantially complete containment for 300 to 1000 years.

3. Release rates for any radionuclide from the engineered barrier system shall not exceed one part in 100,000 per year of the inventory of that radionuclide calculated to be present at 1000 years following permanent closure.

The NRC did not establish direct performance requirements on the waste form itself. There are, however, waste-form design requirements in 10 CFR Part 60.135. Waste-form performance requirements are derived in a secondary manner from the required performance of components within the engineered barrier system. The performance requirement for the engineered barrier system is an annual release rate of 1 part in 100,000 for each radionuclide present at 1000 years after closure. The engineered barrier system will be composed of the waste form (borosilicate glass for Defense High-Level Waste), a pour cannister (no performance credit will be taken), an outer container (a hermetically sealed metal container of unknown material or design), possibly backfill of some type around the waste package inside the emplacement borehole or other emplacement concept. The boundary of the engineered barrier system in the concept is the boundary of the emplacement hole.

The ability of the engineered barrier system to meet the NRC's standard will depend on the ability of each component to meet some assigned requirement. The assurance that the vitrified waste will be accepted for emplacement in the repository will come from the assurance that the engineered barrier system is acceptable. The borosilicate glass can satisfy the acceptance requirement of the Repository Program, but the program staff have yet to establish any basis of assurance that the NRC will judge the waste acceptable. The current position of the Office of Civilian Radioactive Waste Management (OCRWM) is that there is no reasonable expectation that Waste Acceptance Preliminary Specification (WAPS) certification testing and documentation can address compliance with 10

CFR Part 60 on postclosure performance requirements. Their position appears to be to establish nominal criteria for acceptance of waste with no concomitant assurance that NRC will accept the product. This might not be a difficult position if work was ongoing on the potential performance of the engineered barrier system. However, no work appears to be underway to establish the conceptual approach to building the regulatory argument and the data set that will have to be provided to demonstrate that the engineered barrier system actually will work. At the present time it is not clear whether this will be an easy or a difficult argument to win.

The NRC believes that there is a relationship between the WAPS, the allocation of performance to engineered barrier system components and the engineered barrier system postclosure performance requirements. They appear to be uneasy with the line of argument taken by the Department of Energy. In the licensing process, it is the staff of the NRC that will have to argue for or against the position taken by the Department in its license application. At present there are strong indications of uneasiness with the Department's position because there is little in the way of technical support to show that it is technically valid and that it represents a sound licensing strategy.

It is possible that waste produced between years 2000 and 2005, that is considered acceptable by the Office of Civilian Radioactive Waste Management, could be found to be unacceptable for the repository in the licensing review that will be completed around 2010. Some action now to establish the range of uncertainties regarding the borosilicate glass and the engineered barrier system is necessary by OCRWM.

APPENDIX J

LOW-LEVEL RADIOACTIVE WASTE DISPOSAL REQUIREMENT

The Department of Energy's internal requirements governing the management and disposal of radioactive waste, including low-level waste are contained in DOE Order 5820.2A "Radioactive Waste Management". In this controlling document, the definition of low-level waste is as follows:

> Low-level waste - Waste that contains radioactivity and is not classified as high-level waste, transuranic waste, or spent fuel or 11e(2) byproduct material as defined by this Order. Test specimens of fissionable material irradiated for research and development only, and not for the production of power or plutonium, may be classified as low-level waste, provided the concentration of transuranic is less than 100 nCi/g.".

In the above definition, the Department has established a category of low-level waste by default; if material is contaminated with radioactivity and it is not high-level waste or TRU waste, then it is low-level waste. There is no qualification of requirements for radioactivity content necessary to satisfy this category.

The Department's definition of high-level radioactive waste is nearly the same as that of the Nuclear Regulatory Commission (NRC) which has legal authority to regulate the disposal of the Department's high-level radioactive waste. NRC has no comparable authority to regulate low-level waste generated by the Department.

Since the Department has established a definition for low-level waste that provides for no qualification of radionuclide content, the establishment of the category at a site that produces high-level radioactive waste will depend entirely on the interpretation of the high-level waste definition. To establish an alternative reference for the purpose of demonstrating that the waste stream to be sent to the low-level disposal site is truly low-level, the Department is turning to the NRC standard as a benchmark for radionuclide concentrations.

The NRC standard is contained in 10 CFR Part 61. It contains no elementary definition of low-level waste, but establishes a detailed methodology for establishing several categories of low-level radioactive waste. The classification system of NRC, outlined in Part 61, is presented in Figure J-1.

The Department considers the low-level waste stream to be Class C, and such waste must satisfy two basic criteria, one related to the maximum concentration of radionuclides in the waste form and a second related to the physical characteristics of the waste that could affect the disposal site stability. The second criteria requires that the strength and configuration of the waste form be such that it has long term structural stability; the disposal site should not subside as a result of waste form decrepitation. The fact that the waste will be made into grout and placed in a well engineered and constructed vault is strong evidence that the low-level waste will satisfy this requirement.

The first criteria for concentration of radionuclide as Class C waste is as follows:

$$\left(\frac{[\text{Ni-63}]\ \text{Ci/m}^3}{700}\right) + \left(\frac{[\text{Sr-90}]\ \text{Ci/m}^3}{7000}\right) + \left(\frac{[\text{Cs-137}]\ \text{Ci/m}^3}{4600}\right) \leq 1$$

Since the low-level waste also contains toxic or hazardous substances regulated under the Resource Conservation and Recovery Act, this law also will be applied to its disposal operations. The waste form will, therefore, have to satisfy the EPA's test. Because the grout's leaching characteristics are affected by the temperature of the grout, an upper limit on ambient temperature of 90C has been established. This in effect will drop the Sr limit from 7000 Ci per m^3 to 266 Ci per m^3 and Cs limit from 4600 Ci per m^3 to 372 Ci per m^3. This represents a thermal power output of 1.75 watts per m^3.

The concentrations (Ci per m^3) of the radionuclides going into the grout are significantly below the maximum limits accepted by society for commercially licensed low-level radioactive waste disposal sites. The following Table J-1 provides a representative picture of the radionuclide expected in the grout.

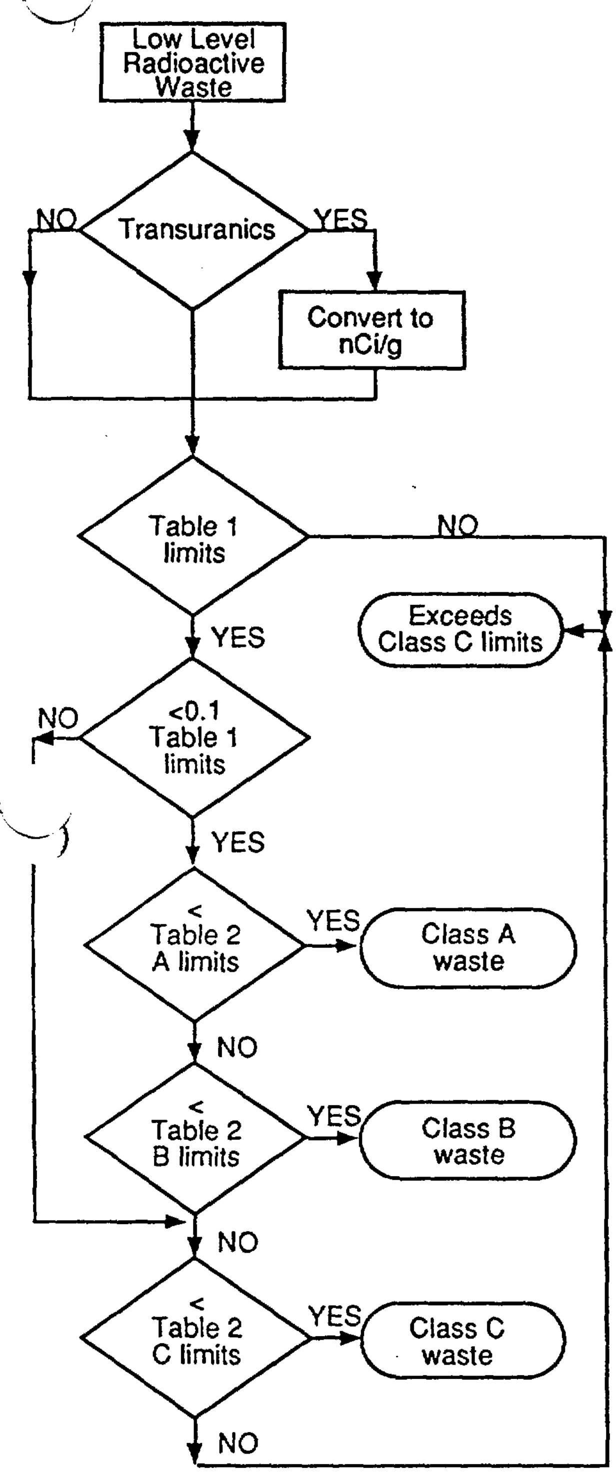

Table 1
Long-Lived Radionuclide Concentration Limits

Nuclide	Ci/m^3	Nuclide	nCi/g
C-14	8	TRU($t_{1/2}$ > 5yr)	100
C-14*	80	Pu-241	3,500
Ni-59*	220	Cm-242	20,000
Nb-94*	0.2		
Tc-99	3		
I-129	0.08		

Table 2
Short-Lived Radionuclide Concentration Limits

Class A Limits

Nuclide	Ci/m^3
$t_{1/2}$ < 5 yr	700
H-3	40
Co-60	700
Ni-63	3.5
Ni-63	35
Sr-90	0.04
Cs-137	1

Class B Limits

Nuclide	Ci/m^3
Ni-63	70
Ni-63*	700
Sr-90	150
Cs-137	44

Class C Limits

Nuclide	Ci/m^3
Ni-63	700
Ni-63*	7000
Sr-90	7000
Cs-137	4600

* In activated metal

Figure J-1: NRC Low-Level Waste Classification System

Table J-1

Concentrations of Radionuclides in Low-Level Radioactive Waste Grout at Hanford

Radionuclides	Class C LLW Concentration Limits Ci/m^3	Estimated Total Radioactivity MCi	Estimated Concentrations Ci/m^3
Long-Lived			
C-14	8	0.0027	0.012
Tc-99	3	0.0016-0.0028	0.07-0.12
I-129	0.08	$33X10^{-6}$	0.0001
TRU	nCi/gm	MCi	nCi/gm
	100	0.002-0.01	30
Short-Lived			
Sr-90	7000	1-8	4.4-35
Cs-137	4600	6-7	26-31

APPENDIX K

FURTHER STUDIES BY ENGINEERING REVIEW GROUP

K.1 Technical Status of the TRUEX Process

The TRUEX process can be a critical fulcrum on which the economics of the processing of waste is balanced. There are significant uncertainties as to the actual technical situation. With regard to this process, it needs to be more thoroughly examined before a final decision regarding the start of construction is made in December 1991. The process holds great potential for cost reduction, but the conditions under which the process can be successful are extremely tenuous. While the actual TRUEX process may be adequate, the conditions for processing the waste may create such a hostile processing environment it may not be possible to make it work. This needs to be examined so a more definitive picture of the strengths and weaknesses of the process are understood on a technical level.

K.2 Coordination with Other Projects

Two projects similar to the HWVP are currently running in parallel with the HWVP. The DWPF has been constructed and is going through cold checkout at the present time. Significant difficulties have been experienced in the effort which reflect the inadequacies of previous development and control processes. Greater involvement of the operations staff from the HWVP at DWPF, as they bring the facility and process on line, could be uniquely beneficial; no other plant with such similar characteristics to HWVP will be brought on line before it.. The value of these practices and the number of individuals to be involved needs to be examined so that the true value of lessons learned are effectively transferred. One man supporting the design effort on the DWPF site does not appear to be sufficient.

K.3 Economic Analysis to Determine the Total Cost of Producing Canisters of Glass

The financial commitment for a canister of glass is currently defined in terms of the cost to produce the glass and the cost of disposing of the glass. The current figure of $600,000 per canister may be an inadequate and invalid number depending on the scenario that actually results for the production of glass. The current basis for production cost and the disposal fee are $250,000[1] and $350,000[2] , respectively.

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[1] Cost basis for production provided by WHC.

[2] Cost basis for repository disposal fee from Federal Register/Vol. 52, No. 161, Page 31508-14 (August 20, 1987.)

The current basis for the cost of production is not well documented and it does not appear that the current estimates includes all the costs that are actually involved in the preparation of the feedstock. In addition, if the actual number of canisters is significantly greater than the 1500 included in the development of the repository costs, then the current allocation for disposal costs will have to be reevaluated. These numbers need to be thoroughly defined so that the real costs of the waste disposal operation are known.

APPENDIX L

PROCESS/CHARTER FOR INDEPENDENT ENGINEERING REVIEW

The following diagram outlines the structure of the Independent Engineering Review Organization. The organization and operation of the review process is the responsibility of the Department of Energy. The purpose of the organization is to conduct technical assessment of major projects.

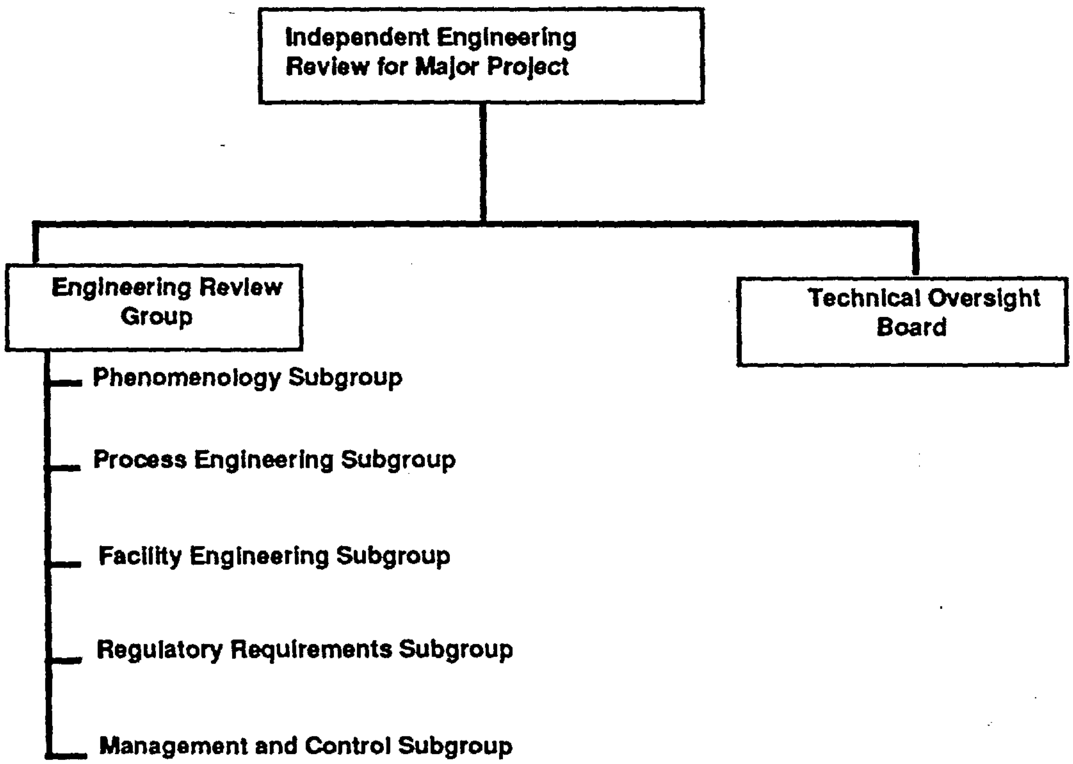

Figure L-1. Organization For Independent Engineering Review

The organization is further subdivided into two additional groups, the Engineering Review Group and the Technical Oversight Board. The Engineering Review Group comprise the technical experts that must examine the details of a project as the basis for conducting the technical assessment. This Group must develop the thorough understanding of the Project and the factors and conditions that are important to its eventual success. Because of the broad nature of engineering projects, the Engineering Review Group is further subdivided to provide for a concentrated level of expertise to examine the basic elements of a project. These include subgroups that address the topics of phenomenology, process engineering, facility engineering, regulatory requirements, and management and control requirements and practices.

It is intended that such a review process be long term and therefore it must be institutionalized. The Los Alamos National Laboratory has provided, for the review of the Hanford Waste Vitrification Project, a pilot operation to determine the operational characteristics that allow such a review to be useful. The Laboratory is responsible for the organization and staffing of the Engineering Review Group and will provide the subgroup leaders who will be responsible for organizing the detailed technical lines of inquiry into a project.

The Technical Oversight Board will be composed of senior level individuals who have extensive experience in the development, execution, management and evaluation of large and technically involved projects. They are to provide a solid reference point of experience and ideas against which the Engineering Review Group can test its ideas regarding line of inquiry and the logic and validity of findings and conclusion.

Figure L-2. shows the organizational relationship within the Office of Environmental Restoration and Waste Management for the Independent Engineering Review of the HWVP.

The following is the charter for the organization responsible for the Independent Engineering Review of Major Projects.

L.1 Charter

L.1.A Purpose:

Provide an independent engineering review of the major projects being funded by the Department of Energy, Office of Environmental Restoration and Waste Management. The independent engineering review will address questions of whether the engineering practice is developed to a point where a major project can be executed without significant technical problems. The independent review will focus on questions related to:

L.1.A.1 Adequacy of development of the technical base of understanding;

L.1.A.2 Status of development and availability of technology among the various alternatives;

L.1.A.3 Status and availability of the industrial infrastructure to support project design, equipment fabrication, facility construction, and process and facility operations;

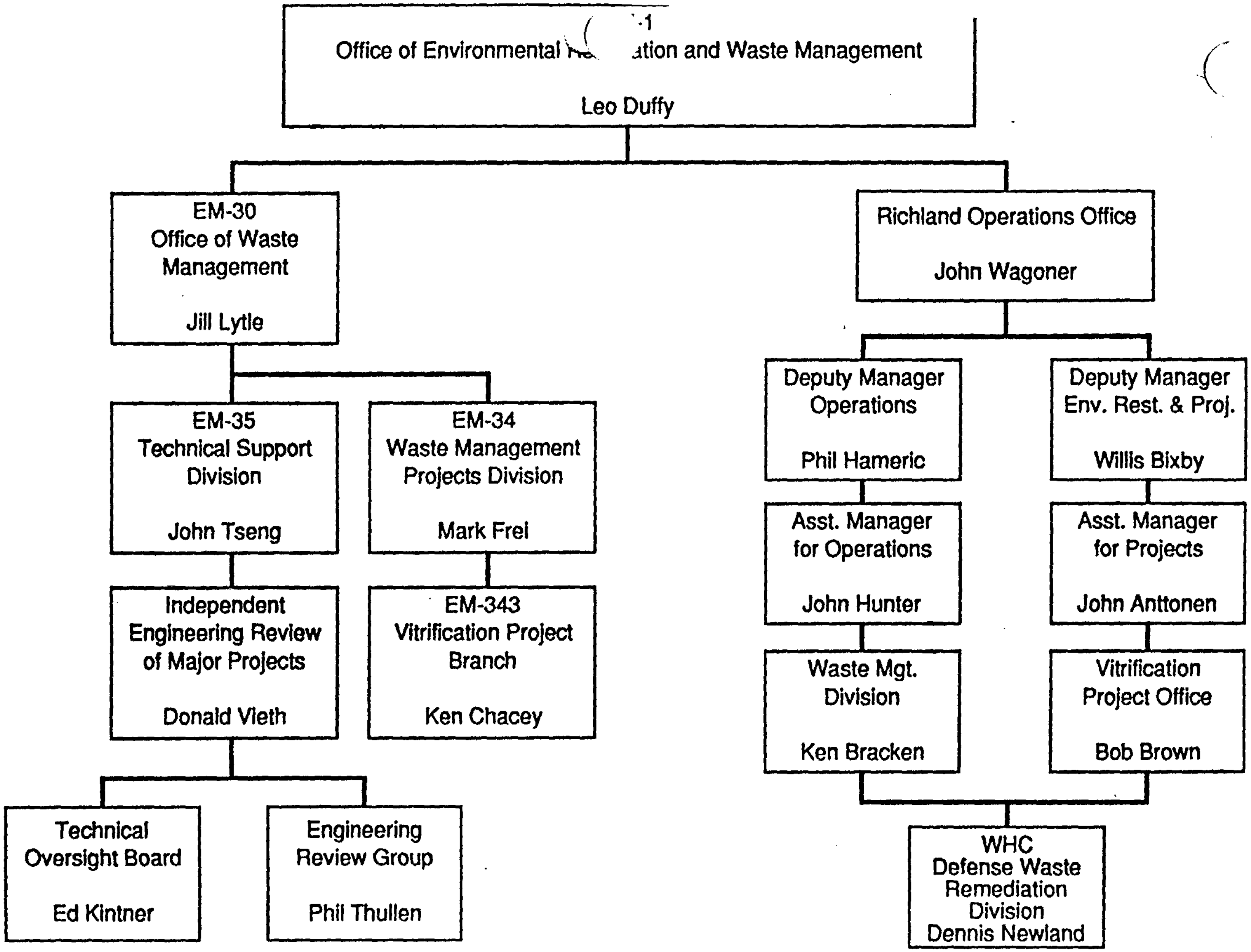

Figure L-2: Relationship of Independent Engineering Review and the HWVP Organization

L.1.A.4 Adequacy of the design effort to provide a sound foundation to support execution of project;

L.1.A.5 Ability of the organization to fully integrate the system, and direct, manage, and control the execution of a complex major project.

L.2 Objective:

To produce a documented, independent, engineering review of major projects funded by DOE-EM and specifically assigned to DOE-Waste Management. The focus will provide a factual understanding of the actual situation and the nature of the recognized difficulties that will have to be overcome in the successful execution of the project. The output of the review will be a clear articulation of the strengths and weaknesses in the technology and engineering, the major uncertainties that are involved, and suggestions as to courses of action that could be beneficial.

L.3 Organization:

The Independent Engineering Review Unit will report to DOE-Waste Management. It will be supported by two organizations: the Engineering Review Group and a Technical Oversight Board. The reporting relationships are presented in Figure L-1 (see page L-1). Their functions are as follows:

L.3.A Engineering Review Group comprises technically experienced and qualified individuals who will review the scientific and engineering bases that underlie major projects to be executed by the Department of Energy. Specific areas critical to the success of a project will be identified and independently confirmed.

Individuals with the requisite experience and knowledge will be selected to serve as team members to review the systems that make up specific major projects. The Engineering Review Group will be divided into five subgroups that will address the project with regard to:

L.3.A.1 Phenomenology that serves as the primary basis for the project and the secondary phenomena associated with side effects that can interfere with the project, to assure that they are fully understood, that the technology proposed is compatible with the phenomenology, and to minimize the potential for major surprises in process or facility operations;

L.3.A.2 Process Engineering necessary to convert the feedstock into the final product to assure that the configuration and technology of the process will achieve the desired end result;

L.3.A.3 Facility Engineering necessary to assure that the site and buildings selected and designed will provide a safe, environmentally sound, and functionally suitable place for housing the process;

L.3.A.4 Regulatory Requirements to assure that rules and regulations that must be satisfied have been incorporated into the planning and will function properly.

L.3.A.5 Management and Control of the project to assure that the necessary discipline, structure, and organization is in place to meet safety, health, and environmental prerequisites while simultaneously meeting the production requirements, specifications, and schedules.

L.3.B Technical Oversight Board is established to serve as a group of technically experienced and qualified individuals with the responsibility to review and comment on the proposed approach to be taken by the Engineering Review Group in its review of major projects to be executed by the Department of Energy. The Board will function as a check to assure that the scope and depth of the science and engineering review of a major project is adequate, and to assure the proper systematic evaluation of the project. The Board will also examine the results of the review to assure internal technical consistency and to confirm that findings are supported with sufficient information.

The following is the membership of the Technical oversight Board and the Engineering Review Groups

MEMBERSHIP-TECHNICAL OVERSIGHT BOARD

Edward Kintner - Chairman
James Duckworth
Richard Baxter
William Hamilton, Sr.
Dr. Colin Heath
Dr. Mujid Kazimi
Dr. Kermit Garlid

MEMBERSHIP- ENGINEERING REVIEW GROUP

<u>DIRECTOR</u> - Dr. Philip Thullen

<u>PHENOMENOLOGY SUBGROUP</u>

Subgroup Leader - Paul W. Reimus
Dr. Steven Agnew
H. Thomas Blair
Dr. Lee F. Brown
Timothy Gardner
Claude B. Goodlett, Jr.
Ronald K. Nakaoka
Dr. Arlin K. Postma

<u>PROCESS ENGINEERING SUBGROUP</u>

Subgroup Leader - James W. Barns
Grant Bloom
Dr. Rudolph J. (Jack) Dietz, Jr.
Dr. Walter B. Loewenstein
Otto M. Morris
Donald C. Nichols

<u>FACILITY ENGINEERING SUBGROUP</u>

Subgroup Leader - Dr. Gloria A. Bennett
Gordon M. Albury, Jr.
Dr. James A. Corll
Dan W. Knobeloch
Dr. Howard C. Merchant
Arthur T. Salgado
Wendell A. Scott

<u>REGULATORY REQUIREMENTS SUBGROUP</u>

Subgroup Leader - Dr. Donald R. MacFarlane
John C. Elder
Dr. Thomas S. Elleman
Anthony Rutz
Timothy S. Stirrup

<u>MANAGEMENT AND CONTROL SUBGROUP</u>

Subgroup Leader - Douglas Weaver
Gerald Barr
Alice Maese
Richard H. Shaw
Dean Terry
Jerry Zimmerman
John Marinuzzi

APPENDIX M

CREDENTIALS OF ENGINEERING REVIEW GROUP PARTICIPANTS

Name: Philip Thullen

Position: Los Alamos Team Leader

Education: BS. ME, Purdue University, 1965
MS. ME, MIT, 1967
ScD., MIT, 1969

Affiliation: LANL, NPR/SPO

Education: Prior to joining the Los Alamos National Laboratory, from 1969 through 1976, Dr. Thullen was an Assistant and Associate Professor of Mechanical Engineering at MIT. He was a member of the thermal and fluid sciences division performing research on the application of superconductors to electrical power equipment, and teaching classical thermodynamics, cryogenic engineering and related subjects. Since 1976 he has been at Los Alamos where he has been a staff member, Deputy Group Leader and Program Manager working in energy related fields. He continued to work on engineering applications of superconductivity and the design of electromagnetic systems for plasma fusion applications. From 1985 to 1991 he was the Program Manager for Construction of the Confinement Physics Research Facility (CPRF), an $80M, seven year construction project employing 70 FTEs. This experience has given Dr. Thullen a depth of experience in both applied research and in the organization and management of R&D facility construction.

Name: Paul W. Reimus

Position: Subgroup Leader, Phenomenology

Education: B.S., CE, Michigan Technological University (1981)
M.S., CE, New Mexico State University (1983)

Affiliation: LANL, N-6

Experience: Since 1989 he has been a staff member in the Nuclear Engineering and Safety Analysis Group at Los Alamos National Laboratory, where he has been responsible for conducting safety analysis reviews for DOE non-reactor nuclear facilities. Prior to joining Los Alamos, Mr. Reimus worked for 5-1/2 years at Battelle Pacific Northwest Laboratories, where he participated in research and development activities in high-level nuclear waste repository programs and high-level waste vitrification programs. His responsibilities included the development of dynamic, stochastic simulation models to predict the composition of nuclear waste glass exiting melters.

Name: Lee F. Brown

Education: B.S., CE, Notre Dame University (1951)
M.S., CE, the University of Delaware (1955)
Ph.D., CE, the University of Delaware (1963)

Position: Subgroup Member, Phenomenology

Affiliation: LANL, N-6

Experience: He has over 35 years professional experience in chemical engineering research, development, design, production, reservoir engineering, safety and risk analysis, teaching, and administration. He has been a staff member at Los Alamos National Laboratory since 1981, where his research specialties have included transport within and structure of porous materials, gas-surface interactions, and kinetics of heterogeneous and catalytic reactions.

Name: Steven Agnew

Position: Subgroup Member, Phenomenology

Education: B.A. Evergreen State College (1976)
Ph.D., CP, Washington State University (1981)

Affiliation: LANL, INC-4

Experience: Since 1984 he has been a staff member in the Isotope and Structural Chemistry Group at Los Alamos National Laboratory, where he has been active in a number of research areas including high pressure chemistry, materials characterization, characterization of conducting polymers, and sensor development. Dr. Agnew is currently serving on the DOE Hanford High-Level Waste Tank Task Force, and is developing ultrasound and acoustic techniques for mitigation of hydrogen gas venting in Hanford waste tanks.

Name: Claude B. Goodlett, Jr.

Position: Subgroup Member, Phenomenology

Education: B.S., CE, Clemson University, 1954.

Affiliation: Consultant

Experience: Mr. Goodlett has extensive experience at the Savannah River Plant in the production of high density UO_2, thoria production and dissolution, processes and equipment for reprocessing of irradiated reactor fuel, permanent disposal of radioactive waste and evaporation and storage of radioactive waste. Mr. Goodlett's experience includes design, construction and supervision of facilities and equipment similar in nature to that used in the HWVP. He has numerous publications in the field.

Name: Arlin K. Postma

Position: Subgroup Member, Phenomenology

Education: B.S., CE, Oregon State University, 1958
PhD., CE, Oregon State University, 1970

Affiliation: Consultant

Experience: Dr. Postma has worked as an engineer of General Electric at Hanford, and for the Battelle Pacific Northwest Laboratories. Since 1975 he has be a consultant working for organizations such as the Nuclear Regulatory Commission, Westinghouse Hanford Company, Rockwell Hanford Co., PNL, EPRI, SNL, ORNL, and other firms. He specializes in chemical engineering, air cleaning and nuclear safety.

Name: Timothy Gardner

Position: Subgroup Member, Phenomenology

Education: B.S., CE, Alfred University, 1981
M.S., Ceramic Science, Pennsylvania State University, 1983.

Affiliation: SNL

Experience: Since 1983 he has worked in the Ceramics Processing Division at Sandia National Laboratories, where his responsibilities have included the chemical preparation of ceramic materials, the tape casting of ceramics for multilayer devices, the characterization of laser machining damage to aluminate substrate materials used in microelectronics, traditional ceramics processing (preparation, densification, machining, and property evaluation of mixed oxide ceramics), and ceramics facility design.

Name: H. Thomas Blair

Position: Subgroup Member, Phenomenology

Education: B.S., Ceramic Engineering, University of Utah, 1968
Short Courses in: Strategy of Experimental Design, Glass Melting and Forming, Ceramic Forming Processes, Partial Pressure Analysis, Nuclear Criticality and Vacuum Calculations

Affiliation: LANL, NMT-1

Experience: Since 1986 he has been a staff member at Los Alamos National Laboratory, where he has been responsible for development, fabrication, and characterization of advanced nuclear fuels. Prior to joining Los Alamos, Mr. Blair worked at Battelle Pacific Northwest Laboratories for approximately 12 years, where he was involved in the process development of high-level nuclear waste vitrification systems. His responsibilities included the development and testing of melter feed systems, optimization of joule-heated ceramic melter operating conditions, development and testing of the in-can melting concept, and the development of waste form alternatives to glass.

Name: Ronald K. Nakaoka

Position: Subgroup Member, Phenomenology

Education: B.S. Fort Lewis College (1981)
M.S. Montana State University (1984).

Affiliation: LANL, EM-7

Experience: Since 1990 he has worked in the Waste Management Group at Los Alamos National Laboratory, where he is responsible for the removal and immobilization of TRU-contaminated incinerator ash. Prior to joining Los Alamos, Mr. Nakoaka worked for 6 years at Battelle Pacific Northwest Laboratories, where his responsibilities included nonradioactive testing of joule-heated ceramic melters and the development of advanced melter designs for immobilization of high-level nuclear wastes.

Name: James W. Barnes

Position: Subgroup Leader, Process Engineering

Education BS. Chemical Engineering, Oregon State university, 1957
MS. Chemical Engineering, MIT, 1961.
PE State of New Mexico, 1975.

Affiliation: LANL, MST-3

Experience: Mr. Barnes has extensive experience in the design of process systems and equipment. He designed and evaluated waste management systems during 10 years with the Atlantic Richfield Hanford Company. He joined Los Alamos in 1973 and has been involved in the design, construction and operation of radioactive material processing systems. He is presently the Project Coordinator for a $5M fusion reactor experimental fuel cleanup system. He presently works at the Tritium Systems Test Assembly at Los Alamos.

Name: Donald C. Nichols

Position: Subgroup Member, Process Engineering

Education: BS. Physics, North Georgia College, 1948

Affiliation: Consultant, Nichols Associates Inc.

Experience: Mr. Nichols has extensive past experience in health physics, environmental analysis and planning, tank farm operation and management, plant operation, and Task Team Manager and Production Superintendent for the Defense Waste Processing

Facility (DWPF). Before retiring he was Operations Manager for the DWPF. His wide ranging experience with the design and planned operation of the DWPF is directly applicable to the review of the HWVP, the design of which is based on the DWPF.

Name: Otto M. Morris

Position: Subgroup Member, Process Engineering

Education: MS. Chemical Engineering, Georgia Tech., 1951.

Affiliation: Consultant

Experience: Mr. Morris has close to 40 years of experience in operations with radioactive materials at the Savannah River Plant. His final assignment was in Waste Management Technology as department superintendent. His supervisory assignments were in plutonium finishing lines, canyon separations, tritium operations, heavy water and waste management. In the area of waste management Mr. Morris was responsible for receipt, storage, and evaporation in 51 one million-gallon carbon steel tanks. This included tank heat loads, radionuclide content, corrosion control chemistry, in-tank processing, sludge removal demonstration and salt removal with slurry pumps.

Name: Rudolph J. (Jack) Dietz, Jr.

Position: Subgroup Member, Process Engineering

Education: SB. Radiochemistry, PhD. Nuclear Chemistry/Engineering, MIT, 1959

Affiliation: Laboratory Associate, LANL

Experience: Dr. Dietz has been involved in radio-chemical separations technology and in the analysis of nuclear processes and facilities for over three decades. At Los Alamos he has served as a Program Manager for Waste Management, Nuclear Intelligence and Nuclear Facility Safeguards system Design. In 1975, he formed the laboratory's first Nuclear Safeguards Systems Group and served as its leader, and subsequently Program Manager for Safeguards Research and Development. Since his retirement from full-time activities in 1989, Jack has served on various advisory and review groups for the Laboratory, DOE and other Federal Agencies. His office currently resides within the International Technology Division Complex.

Name: Grant Bloom

Position: Subgroup Member, Process Engineering

Education: ASEET, Texas State Tech, 1978
EE course work, University of New Mexico, 1978-82.

Affiliation: SNL

Experience: Mr. Bloom is a Senior Technical Associate project leader within the Electronics Subsystems engineering department at Sandia National Laboratories. His thirteen years of design, development , and production engineering efforts have concentrated on supporting various DOE and DoD special weapons system with advanced embedded control techniques. Past assignments include: integrated aircraft weapon avionics; communication and control systems; and arming and firing assemblies. Currently Mr. Bloom is involved in research and development of embedded control systems for environments, biomedical and process control applications.

Name: Walter B. Loewenstein

Position: Subgroup Member, Process Engineering

Education: BS., Mathematics, University of Puget Sound, 1949.
PhD., Physics, Ohio State University, 1954.

Affiliation: Consultant

Experience: Dr. Loewenstein is a former Deputy Director of the Nuclear Power Division and Director of the Safety Technology Department at EPRI. Prior to joining EPRI he was the director of the Applied Physics Division at the Argonne National Laboratory. He is the author of over 40 publications and the holder of three nuclear reactor patents. Dr. Loewenstein was one of the participants in the "Risk Assessment Review Group Report" to the U.S. Nuclear Regulatory Commission. He is a member of the National Academy of Engineering

Name: Gloria A. Bennett

Position: Subgroup Leader, Facilities.

Education: BS, Mechanical Engineering, Colorado State University, 1970
MS, Engineering Science & Mechanics, VPI, 1972
PhD, Mechanical Engineering, University of New Mexico, 1991
Registered Mechanical Engineer, New Mexico

Affiliation: LANL, NPR/SPO

Experience: Dr. Bennett has been a technical staff member at LANL since 1973 serving as a principal investigator and Deputy Group Leader. She has been responsible for design and analysis of software to simulate thermal-hydraulic process equipment and experimental hardware. Examples include simulating tornado depressurization of Pu processing facilities, heat pipe radiator and heat pipe heat exchanger systems for satellite use, laser pyrolysis of coal for structural characterization, cooling systems for high power electronics, and numerous other activities involving thermal management systems. Most recently she was responsible for the structural analysis of a fusion reactor support structure.

Name: Gordon M. Albury, Jr.

Position: Subgroup Member, Facilities

Education: B Science, B Architecture, Georgia Institute of Technology, 1956
Registered Architect, New Mexico, Florida.

Affiliation Consultant, Merrick Engineering

Experience: Mr. Albury is an architect with a depth of education and experience in the design of large research and development facilities. He is a registered Architect in New Mexico and Florida. He worked at Los Alamos starting in 1976 as a staff member in construction project development and engineering manager on large projects. Currently he is employed by Merrick Engineering as senior architect on the Waste Characterization Facility at the Idaho National laboratory. Past project experience at Los Alamos includes:

- Upgrade of the radioactive liquid waste treatment facility

- New Tritium Facility
- Space Science laboratory
- Nuclear Safeguards Technology laboratory
- Target Fabrication Facility.

Mr. Albury was involved in the preparation of design criteria, project management and oversight and close interaction with large A.E. firms and DOE through all phases of project design and construction.

Name: Arthur T. Salgado

Position: Subgroup Member, Facilities

Education: BS, Civil Engineering, New Mexico State University, 1973
Graduate work in construction project management.
Registered Civil Engineer, New Mexico

Affiliation: LANL

Experience: Mr. Salgado has 18 years of experience in the facility construction field: five years in civil/structural detail design, six years of field project engineering, and more recently facilities project development (conceptual design, design criteria development, preliminary and definitive design) and facilities project management of general plant and line item projects. He most recently worked in the management of the Special Nuclear Materials Research and Development project, a Major System Acquisition at Los Alamos.

Name: Dan W. Knobeloch

Position: Subgroup Member, Facilities

Education: BS. Biology, New Mexico State University, 1976
BA. Chemistry, New Mexico State University, 1981

Affiliation: LANL

Experience: From 1976 to 1979 Mr. Knobeloch was a technician in the Plutonium Chemical Operations Section, Nuclear Materials Technology (NMT) Division, at Los Alamos National Laboratory (LANL). From 1979 to 1984 he was a staff Member, Actinide Metal Purification Section, NMT Division. From 1984 to 1989 he was a staff member in the Robotics Section, Mechanical and Electronic Engineering (MEE) Division. From 1989 to 1991 he was a staff member in the Special Facilities Design and Engineering Section, Special Nuclear Material Laboratory (SNML) Project. Most recently he has been a staff member in the Uranium Processing Section, Materials Science and Technology (MST) Division, at LANL.

Name: Wendell A. Scott

Position: Subgroup Member, Facilities

Education BS. Electrical Engineering, New Mexico State University, 1964
Registered Professional Electrical Engineer, New Mexico.

Affiliation: LANL

Experience: Mr. Scott spent five years with PG&E in Stockton, California as a power engineer working in distribution and planning engineering. For the past 17 years he has been with the Los Alamos National Laboratory where he has worked on facilities design and contract coordination of lump sum construction projects. He has been engineering manager and electrical engineer for the LANL project development group for line item projects , and worked in electrical maintenance. He was Construction Project Manager on the ATAC Program and the Material Science Laboratory at Los Alamos through the project development and the AE selection period. Most recently he was construction project manager and liaison-resident engineer to Fluor Daniel Incorporated on the Special Nuclear Material Laboratory project at Los Alamos.

Name: James A. Corll

Position: Subgroup Member, Facilities

Education: BS. MS. PhD. Case Institute of Technology
Registered Mechanical Engineer, New Mexico

Affiliation: LANL

Experience: Dr. Corll is an experienced mechanical engineer specializing in HVAC. He is most widely known for the development of the computer codes for PC simulation of complex HVAC water systems. Dr. Corll is presently the resident facility engineer fro the Plutonium Research Laboratory at LANL. He is in charge of the facility section responsible for design, operation and maintenance of the auxiliary (ventilation, hat and chilled water, steam, compressed gas, etc.) systems.

Name: Howard C. Merchant

Position: Subgroup Member, Facilities

Education: BS. Mechanical Engineering, University of Washington, 1956
SM. Mechanical Engineering, MIT, 1957
PhD. Mechanical Engineering, MIT, 1961
Registered Mechanical Engineer, Alaska, California, Oregon, Washington

Affiliation: Consultant, MerEnCo Inc.

Experience: Dr. Merchant's experience in the area of seismic analysis and facilities associated with the nuclear industry include the analysis and review of systems and components of the N reactor, the Fast Flux Test Facility and Washington Public Power reactors at the Hanford site in Richland Washington. Test and analyses have also been performed on casks and the road vehicles for their transport for Nuclear Packing Inc. As Professor of Mechanical Engineering and Adjunct Professor of Geophysics at the University of Washington he taught and did research in the area of earthquake engineering. He has also had experience in weapons effects analysis and testing with Sandia Livermore Laboratory and Physics International Company. His current consulting activities are performed through his consulting company, MerEnCo Inc., including his work with Los Alamos National Laboratory (LANL) were projects have included dynamic analyses of accelerator components and a nuclear driven laser system.

Name: Donald R. MacFarlane

Position: Subgroup Leader, Regulatory

Education: BS. Chem. Eng. Illinois Institute of Technology, 1952
MS. Chem. Eng. Purdue University, 1957
PhD. Nuclear Engineering, Purdue University, 1966

Affiliation: LANL N-6

Experience: Dr. MacFarlane has over 35 years of diverse experience in the following areas:

- Safety/accident analyses for nuclear proven systems,
- Environmental impact evaluations for nuclear facilities,
- Chemical plant accident evaluations,
- Computer modeling of fluid dynamics and heat transfer phenomena.

Name: John C. Elder

Position: Subgroup Member, Regulatory

Education: BS. Mechanical Engineering, University of New Mexico, 1958
MS. Radiological Health, University of Oklahoma, 1972

Affiliation: LANL

Experience: Mr. Elder is a member of the Los Alamos National Laboratory's Safety and Risk Assessment Group where he performs safety analyses and reviews of safety analyses for Los Alamos nuclear facilities. He works in developing standardized methods for performing hazard classification of Los Alamos facilities to stipulate level of safety analysis and review. He also performs independent safety reviews of DOE nuclear facilities outside Los Alamos.

Name: Anthony Rutz

Position: Subgroup Member, Regulatory

Education: BS, Biological Sciences, Michigan State University, 1969.
MPH, Environmental Health, University of Michigan, 1973
PhD, Course work completed, University of Michigan.

Affiliation: Consultant, WASTREN, Inc.

Experience: Mr. Rutz is currently managing WASTREN's technical support functions for the DOE Idaho Operations Office for a broad range of tasks, including the INEL Site-Wide Waste Management Environmental Impact Statement (EIS), a Plutonium Recovery demonstration project, regulatory compliance roadmaps and strategic plans, and several ES&H training programs. He recently supported the completion of the WIPP Supplemental EIS, and is working toward closure on both the LANL implementation of DOE Order 5820.2A for waste management and RCRA compliance activities, and Waste Minimization Plans for the INEL and West Valley Demonstration Project.

Name: Timothy S. Stirrup

Position: Subgroup Member, Regulatory

Education: BS. Chemistry, BS. Biological Sciences, New Mexico Tech, 1988
MS. In Progress, University of Idaho

Affiliation: Consultant, WASTREN, Inc.

Experience: Mr. Stirrup has provided compliance support to EG&G Idaho for the Environmental Monitoring Group. Performed a compliance assessment of the DOE Order 5400.xx series by providing draft air emissions effluent monitoring plan. Work involved investigating prescriptive requirements and assessing the current monitoring program through personnel interviews and document searches. His strong, detailed knowledge of Clean Air Act, State of Idaho Air Quality Bureau Regulations, State of Idaho SIP, DOE Orders, and the associated permitting requirements-including NESHAPS, PSD and PTC applications and permits.

Name: Thomas S. Elleman

Position: Subgroup Member, Regulatory

Education: BS. Chemistry, Denison university, 1953
PhD. Physical Chemistry, Iowa State University, 1957

Affiliation: Consultant, North Carolina State University

Experience: Dr. Elleman was Associate Head of Chemical Physics at Battelle Memorial Institute from 1957 to 1964. From 1964 to 1972 he was an Associate Professor at North Carolina State University. During 1972-3 he was head of advanced Fuels Development

Department at General Atomics Corporation. He was Head of Nuclear Engineering at North Carolina State University from 1973 to 1979. From 1979 to 1985 he was a Vice President of Carolina Power and Light. Most recently he was the Associate Dean of the College of Engineering at North Carolina State. He is presently a Professor of Nuclear Engineering

Name: Douglas Weaver

Position: Subgroup Leader, Management

Education: BSET, DeVry Tech. Institute, 1966

Affiliation: SNL

Experience: Mr. Weaver has been employed by the Sandia National Laboratory since 1967. During that time he has held a number of technical and supervisory positions. From 1984 to 1986 he was supervision of the Radiation hardened Integrated Circuit II Development Division. In this capacity he was responsible for developing the microelectronics technology and process clean room, and facility concepts for the 167, 000 sq. ft.,$67M RHIC II facility. Most recently he has been the Department Manager of Microelectronics Component Development, including technology and process development, prototyping, DoD and industry reimbursable projects, and advanced microelectronics packaging development. He has been responsible for the activities of over 100 PhD, MS, and BS engineers, technicians, and hourly personnel with and annual budget of $15m.

Name: Gerald Barr

Position: Subgroup Member, Management

Education: PhD. Engineering Mechanics

Affiliation: SNL

Experience: Since 1980, Dr. Barr has been active in the development of management systems for large projects at Sandia National Laboratory. This included work as Supervisor of Pulsed Energy Projects Division, Manager of the Plant Engineering Planning and Services Department, and Manger of the Facilities management Department. He is presently Manager of the Project Management Project Department. This Project was established to help define and bring the good business practices associated with project management to Sandia National Laboratories.. The objectives of the project are to: (1) Define a generic project management process; (2) Develop a long-term implementation plan for the project management architecture/infrastructure that must exist for project management to become a reality; (3) Facilitate the implementation of project management into the business systems and culture of Sandia National Laboratories.

Name: Alice Maese

Position: Subgroup Member, Management

Education: BA. Accounting
CPA since 1975

Affiliation: SNL

Experience: Ms. Maese has two years experience as a Bank Examiner for the Department of the Treasury, five years as Senior Auditor in a "Big 8" public accounting firm, two and a half years as External Auditor at Sandia, one year on the Project Management Project team at Sandia, and 20 years combined experience in financial management and auditing. She is a member of the Rio Grande Chapter of the Project Management Institute.

Name: Richard H. Shaw

Position: Subgroup Member, Management

Education: AS. Instrumentation Engineering

Affiliation: LANL

Experience: Mr. Shaw has over 26 years experience in government and private industry involving quality assurance, project management, and product and facility design. Assignments for the past 15 years have primarily been in quality assurance related to the nuclear field. He has worked as a Quality Assurance Officer of t major nuclear project with management responsibilities which included establishing and implementing and ASME NQA-1 QA program which ensured and documented compliance to government regulations primarily concerning public and worker safety and the environment. At Los Alamos he has been the Quality Assurance Officer for the Special Nuclear Materials Research and Development Laboratory Project. The $385M project includes the design and construction for new laboratory facilities, office, a and infrastructure in addition to the decontamination and refurbishment of existing nuclear facilities. This is a nuclear project and all phases must be accomplished and documented in accordance with the requirements of ASME NQA-1.

Name: Dean Terry

Position: Subgroup Member, Management

Education: BSEE, Arizona State University, 1968
MSEE, University of California, 1971

Affiliation: SNL

Experience: Mr. Terry has in excess of 20 years engineering management experience in the commercial semiconductor electronics industry. He has held positions a Director of Electronic Products operations (Advanced Semiconductor Materials, Inc.), Equipment Support manager (Motorola Semiconductor products), Process engineering Department Manager (Motorola Semiconductor Products), Staff Consultant (Integrated Circuit Engineering Corp.), President (Microbotics, Inc.). His duties have included consulting worldwide on the design and construction of ultra-clean semiconducting manufacturing facilities, factory/equipment sizing, staffing, process equipment selection, factory thruputs, production efficiencies, ES&H issues, and production risk identification/management.

Name: Jerry Zimmerman

Position: Subgroup Member, Management

Education: Masters in Public Administration/management, University of Denver, 1964

Affiliation: U.S. DOE, Albuquerque Field Office.

Experience: Mr. Zimmerman is in the Project Management Division of the U.S. DOE. From 1982 to the present he has conducted reviews/analyses of DOE major systems acquisitions, major projects, major line item projects and General Plant Projects (GPP). He has served as Director/Team Chief of management Control Systems-Validation demonstration reviews and special cost estimate reviews. From 1976 to 1982 he was the solar R&D Project Manager.

Name: John Marinuzzi

Position: Subgroup Member, Management

Education: PHD. Management, University of Southern California

Affiliation: LANL

Experience: Dr. Marinuzzi has wide ranging experience in management at Los Alamos starting in 1974. He is presently: Program manager/Chief Scientist for Artificial Intelligence Applications, Knowledge Systems Laboratory at Los Alamos; a member of the Department of the navy "Naval Research Advisory Board (NRAB) for Artificial Intelligence; Program Manager/Principal Scientist, Knowledge Systems Laboratory; and Program Manager for R&D on "Intelligent Process Control and Information Systems."

APPENDIX N

TECHNICAL ASSESSMENT PLAN

N.1 Introduction

At the February 22, 1991 Energy Systems Acquisition Advisory Board meeting, the Hanford Waste Vitrification Project proposal to proceed with construction was reviewed. Numerous issues discussed developed a recognition about the total Project complexities regarding the nature of the waste in the various tanks and its requirements for pretreatment prior to vitrification. Pursuant to that meeting, a memorandum from the Under Secretary noted the need for an independent technical assessment. The memorandum also noted "shortfalls of not utilizing an integrated engineering/scientific approach in planning projects...".

There is a requirement to report the results of the independent technical assessment that reflects a systems perspective to the Energy System Acquisition Advisory Board (ESAAB). The technical assessment must address the question, "Is it prudent for the Department to initiate construction of the Hanford Waste Vitrification Project in April 1992 if there is not reasonable assurance that the plant will operate in an efficient and cost effective manner?" The criteria used to define a successful Project is whether high-level radioactive waste from all the double walled tanks can be processed on a reasonably continuous basis and result in a waste form that is formally acknowledged as acceptable for disposal in the repository (If the HWVP cannot operate for extended periods of time because of inadequate engineering or technology, then the cost for extended and unplanned outages constitutes the basis for "noncost effective operation").

The Department, the Environmental Protection Agency and the State of Washington have entered into the Tri-Party Agreement. A major milestone in the legally binding agreement is the initiation of hot operations in the HWVP by Dec 1999. To achieve this milestone, it is considered imperative that construction of the HWVP begin in April 1992.

The HWVP plant is designed to receive a multiphase (liquid and solids) high-level radioactive waste and convert it into a borosilicate glass suitable for disposal in a high-level radioactive waste repository. Its mission is to convert all the high-level radioactive waste in the double shell tanks at Hanford into borosilicate glass. The facility also provides lag storage capability for vitrified waste canisters until the repository facility is operational in the year 2010. For the HWVP to function successfully, it must be matched to various pretreatment processes necessary to prepare four significantly different varieties of high-level waste currently stored in the double shell tanks. While significant effort has been dedicated toward the technical and engineering development of this major facility, a comparable level of attention has not been given to the pretreatment processes and the facilities that will house them. The concerns are: whether supporting knowledge of the system (tanks, pretreatment and HWVP) is available and sufficient to assure its functioning; and whether processing technology to process all high-level waste tanks is scheduled for development on an appropriate time line with reasonable confidence that it will be available.

N2. Structure of Review Process

Detailed review of the system required to retrieve, pretreat, prepare and vitrify high-level waste will be conducted by the Engineering Review Group under the Independent Engineering Review of Major Projects. This Group is further subdivided into five subgroups addressing areas of Phenomenology, Process Engineering, Facility Engineering, Regulatory Requirements, and Management and Control. The introduction to each subsequent section describes the areas and outlines the general types of points that each will pursue.

The focus of this review will be technical and address the Technology Development and Engineering Practice required for success of the total waste processing effort. The reviews may examine a variety of other factors.

There are two different aspects important in evaluating Technology Development. The first is determining whether the technology proposed for processing will actually perform to the current expectation level. In situations where high-level radioactive waste processing is involved, equipment or process failures are all the more expensive to correct due to the requirement for remote repairs, proper handling of expended equipment, and the level of oversight and regulation that is concomitant with such operations. The second aspect is the ability to adapt newly developed technology that may be more efficient or capable of producing a better product. Because the Department is expending tremendous resources to develop new technology, it is important that organizations responsible for remediation operations remain cognizant about this evolving technology. It is considered their responsibility to understand the nature and availability of evolving technology and schedule it for integration into their systems at appropriate times. In both cases, technology is only useable if the required industrial infrastructure exists to support its continued use. Without the required infrastructure, imaginative technology that cannot be kept running at its expected performance level is not useful; it only represents unproductive capital resource expenditures and provides little contribution to solving the problem at hand.

Engineering Practice is the structured process of utilizing knowledge and understanding of the basic natural phenomena and laws that define their actions to solve practical problems. It provides a disciplined approach to understanding a situation (which phenomena are present and which one dominates) and analyzing factors that must be considered, understood and controlled in developing an acceptable solution to an identified problem. In this area, many empirically established rules and methods are followed to facilitate the management of such activities so that end products can be provided at reasonable costs through coordinated efforts that result in a process and facility that is safe for man's use and is not likely to adversely affect his physical environment. In the end, Engineering Practice involves all the requirements that allow an organization to achieve the capability to produce one or a variety of end products that meet the requirements of a variety of customers.

N.3 Approach to the Review

The review process will be divided into 5 phases. The first phase will focus on the literature review and presentations related to the HWVP. The objective will be to develop a basic understanding of the current situation, and the technical and scientific framework within which the Project is being developed. The review effort will focus on developing a means for developing questions that identify issues to probe the basis of how the Project is structured, controlled and integrated. The underlying issues behind the questions will be the viability and availability of technology proposed for and possibly considered in the near future for the Project, along with the Engineering Practice necessary to make the waste vitrification effort a successful reality.

With a basic understanding of the Project capability and objective, the second review phase will be devoted to visiting the site, listening to oral presentations, and having extended discussions with the engineering and technical staff regarding the Project details. The objective will be to develop a thorough understanding of the Project scope and detail and confirm information gained from the literature.

The third review phase will involve visits to the two major high-level radioactive waste vitrification facilities already constructed by the Department at West Valley, New York and at Savannah River. The objective will be to compare the concept proposed for the Hanford Waste Vitrification Project with the reality of these facilities and the limited experience already gained in the component testing and cold processing operations phase of their development and operations. Approximately one and a half days will be spent at West Valley and three days at Savannah River. During this phase, intensive discussions will be conducted within the Engineering Review Group to outline initial observations, findings and issues. Discussion will occur across subgroup lines to assure a systems review perspective. The effort will be focused on understanding the interrelationship of the various factors that will be potential system failure indicators if initiated prematurely.

After the visits to West Valley and Savannah River, the Group will return to Richland for the fourth review phase which involves more focused discussion on points considered to be the potential basis for the significant issues. This effort will assure that initial information and understanding is correct and that the potential implications related to each issue is accurately perceived and understood.

The fifth phase will involve organizing material developed during the three week review process into a report and a presentation for the ESAAB. A presentation describing the draft report will be shared with the Richland Field Office and the Technical Oversight Committee prior to being forwarded to the Office of Environmental Restoration and Waste Management. The presentation will be given to the Richland Field Office, the Technical Oversight Committee, the Office of Waste Management, the Office of Environmental Restoration and Waste Management, the Office of Procurement, Assistance and Program Management prior to the presentation to the ESAAB.

N.4 <u>Schedule</u>

The schedule for conducting the Independent Engineering Review of the Hanford Waste Vitrification Project is as follows:

JULY 2 - 3	Presentation to Technical Oversight Committee
JULY 8 - 12	Review of Hanford Waste Vitrification Project
JULY 15 - 16	Visit to West Valley Plant
JULY 17 - 19	Visit to Savannah River - DWPF
JULY 22 - 26	Review of Hanford Waste Vitrification Project
JULY 27 - SEPT.12	Preparation of draft report and presentation for Energy Systems Acquisition Advisory Board
AUG. ??	Briefing to Richland Operations Office
AUG. 28	Preparation of findings and comments to Technical Oversight Committee
SEPT. 11	Brief appropriate offices in environmental restoration and waste management, including Leo Duffy
SEPT. 12	Presentation of findings and comments to Energy Systems Acquisition Advisory Board

N.5 Deliverable

The Engineering Review Group will prepare two deliverables. The first will be a report that outlines the Group findings and comments. The second will be a presentation for the ESAAB that reports the salient points derived from the engineering review.

N.6 Phenomenology Subgroup

This subgroup will be experienced and qualified with regard to the fundamental science and technology of the process or activity. The basic areas will address the appropriate disciplines of physics, chemistry, mechanics, hydrology, seismicity, etc.

Examples of generic issues that will be addressed by this subgroup include but are not limited to:

* Science of the process
* State of technology to support the process
* Comparative merits of alternate technologies
* Topics that require further development
* Processes relate problem solving (side effects)
* R&D requirements

N.6.A Line of Inquiry

The Phenomenology Subgroup review of the HWVP will focus on the current and projected future level of understanding of the phenomena associated with characterizing, retrieving and pretreating the waste, preparing feed for the vitrification plant and operating the melter and off gas systems.

General phenomenology issues that will be the basis of the inquiry by the subgroup include:

N.6.A.1 Nature and Knowledge of Waste Currently in Double Walled Tanks

- Composition
- Physical distribution of chemical constituents
- Retrieval of waste from tanks

Is there a reasonable knowledge of the composition of the waste in the tanks? Is there an understanding of the level of uncertainty in the proposed composition? Are the estimates of composition and constituents based on calculations and historical records or are they the result of sampling and analytical measurements?

Are the various phases (solids, liquids, and gases) in the waste tanks reasonably well understood? Are their physical characteristics known?

Have methods for removing all the waste from the double waste tanks been considered? Which method appears to have the greatest potential for working on a continuous and effective basis?

Are the phenomena responsible for gas generation in the tanks understood? Can these effects be expected to continue in the pretreatment phase of the waste processing?

N.6.A.2 <u>Pretreatment of Various Wastes to Produce a Feedstock for HWVP That Can Result in an Acceptable Waste Form</u>

Is the knowledge of the composition and constituents of the various waste tanks sufficiently established to define chemical pretreatment to change the composition to one that is desired? Are there specific constituents known that must be removed from the waste stream to prevent problems within the HWVP?

Have estimates been made on the degree of variability in the waste feed to the pretreatment process as a function of time or the amount of waste remaining in the tank? In the pretreatment processes that are being considered, have limits on the variation of the feedstock been considered as a basis for process control? Is there an understanding of how the compositional variation of waste feed will affect the output stream from the pretreatment process.

N.6.A.3 <u>Preparation of Waste for the Melter, Vitrification and Processing Off-gas.</u>

In the evaluation of the variety of materials that will be passing through the melter, have constituents been identified as particular problems? Have the conditions that will be troublesome, based on undesirable constituents, been identified? Can actions in the pretreatment processing be taken to remove undesirable constituents?

Is the situation with noble metals buildup in the bottom of the melter understood? Are there estimates of the limits for noble metal buildup at which time operational actions must be taken to correct the situation? Is there a method to effectively measure or determine the degree of accumulation of noble metals? Will this portion of the radioactive glass be handled differently from the bulk of the glass produced with acceptable characteristics?

Have the performance specifications for the glass, in terms of acceptable leach rate, been converted into specifications for process variables or composition variables that more directly apply to the acceptability of the glass from a production perspective? Have the process variable and compositional variables for an acceptable glass been formally established? Are there metrics that can be used to assure that process or compositional variables are being properly controlled?

Are there conditions under which the efficiency and/or life of the off-gas system are diminished? What type of problems can be expected and are the causative factors understood? Can these be related to melter or feed preparation variables? Has there been significant demonstration of melter and off-gas treatment technology? On what scale have demonstrations of such systems been done? Are off-gas systems sufficiently robust to handle significant deviations from acceptable limits in the melter operation? Are there any specific vulnerabilities in off-gas systems that would require close operational monitoring and control?

Are significant quantities of radioactive material expected to collect in the off-gas system? Have methods have been developed to handle and dispose of these waste forms?

N.7 Process Engineering Subgroup

This subgroup will be experienced and qualified with regard to the basic science and engineering principles and practices related to configuration, operation and control of processes necessary to produce a product that meets the established requirements. This subgroup must have knowledge and experience related to the technology and equipment, and the configurational arrangements necessary to have a controllable and effective process.

Examples of generic issues that will be addressed by the subgroup include but are not limited to:

* Definition of product requirement
* Input/feedstock requirements
* Comparative evaluation of alternative processes
* Selection of process technology
* Operational control systems
* Process control systems
    - Process variable selection
    - Measurement concepts
    - Instrumentation
    - Control/feedback systems
* Electrical requirements and codes
* Maintainability potential
* Reliability potential
* Process equipment/hardware design/specification
* ALARA requirements
* Waste minimization
* Safety/hazard-minimization

N.7.A Line of Inquiry

The Process Engineering Subgroup review of the HWVP will focus on the status of development of equipment and processes, to recover waste from the tanks, the technology for pretreating the waste, processes for preparing the waste feed in the HWVP, and the process for converting the waste into glass.

General Process Engineering issues that will be the basis of the inquiry by the subgroup include:

N.7.A.1 Knowledge of Waste Composition, Process Requirements, Flow Sheets and Mass Balances

Is there a reasonable knowledge of the composition and constituents in the waste in the tanks? Is there reasonable knowledge of the physical characteristics of the waste important to the process of removing the waste from the tanks? Is there a reasonable understanding of the degree of uncertainty or variability of the composition and physical properties of the waste?

Has a technology been identified to mobilize and remove the waste from the tanks? Is homogenization of the waste prior to removal from the tanks an option or requirements? Has any test or development work been devoted to this issue?

Have process description and flow sheets been developed for the pretreatment of the waste from the four different tanks? Have the effects of variation in feed composition on pretreatment processing and vitrification been characterized?

N.7.A.2 Equipment, Hardware Necessary to Facilitate Processing

Has the equipment necessary for recovery of material from tanks, pretreatment processing, waste feed preparation and vitrification been conceived and developed for all DST waste? Have any development testing been done to confirm the effectiveness and reliability of the equipment?

Has the chemistry important for processing been established and have material compatibility issues been identified?

N.7.A.3 Measurement Required and Instrumentation Necessary to Control the Process

Have the parameters important for process control of feed recovery, pretreatment, waste feed preparation and vitrification been identified? Are measurement techniques and sensors to handle these parameters been developed and demonstrated?

N.8 Facility Engineering Subgroup

This subgroup will be experienced and qualified with regard to the design and construction of complex and large industrial processing facilities, both in terms of the functions and durability of the structures and the overall layout of the plants. This subgroup must have capability in the concepts for configuring a structure to support processing operations.

Examples of generic issues that will be addressed by the subgroup include but are not limited to:

* Site suitability
* Plant layout
* Structural stability
* Subsystem isolation/containment
* Maintainability
* Reliability
* HVAC Systems
* Environmental release control
* ALARA requirements
* Radiation protection
* Waste minimization
* Safety and health protection
* Security/physical protection

N.8.A <u>Line of Inquiry</u>

The Facility Engineering Subgroup review of the HWVP will focus on the conceptual and preliminary designs (to determine if they adequately accommodate the processes and equipment scheduled for the facility), and whether the flexibility of the facility is sufficient to accommodate the uncertainties of the processing operations.

General facility engineering issues that will be the basis of the inquiry by the subgroup include

N.8.A.1 <u>General Design Considerations</u>

What is the defined scope of the facility and what are the criteria that the facility is suppose to meet to fulfill its mission? How was the lifetime and the throughput for the facility determined? What assumptions were made with regard to the degree of pretreatment for the various feed stocks in the sizing of the plant?

Which of the Department Orders had the greatest impact on the design of the facility? How were the requirements in DOE Order 6430 for nuclear facilities handled? Will nuclear criticality be a significant in this facility?

Is there a general facility siting plan for the area and is the location of the HWVP consistent with that plan? Does the facility location satisfy the siting requirements for a radiological facility? Have the natural phenomena - earthquakes, winds, tornados, floods - been addressed?

N.8.A.2 <u>Facility Subsystems</u>

What level of analysis has been devoted to the issue of repair or removal of a failed melter? If the melter is to be removed while containing high-level radioactive waste, how will it be handled and where will it be stored? Have the requirements and options for its dismantlement and removal from the facility been considered?

What emergency requirements for the facility operation have been considered? Which utilities, such as power and water supply, must be maintained under emergency conditions? Which subsystems must be maintained operational in an emergency operation?

What scenarios have been considered that will require additional space in the building to handle changes? What philosophy was followed with regard to flexibility in facility design to handle unexpected operational conditions?

N.8.A.3 Risks in Engineering Approach, Reliability and Regulations

What approach has been taken to provide for double containment of all processes that are handling hazardous material? What portions of the facility are designated as Class I?

What approach has been taken with respect to design for radiation protection? What are the accident scenarios for which the facility was designed?

N.9 Regulatory Requirement Subgroup

This subgroup will be experienced and qualified with regard to regulatory requirements (environmental, safety and health) that will have to be met in the design, construction and operation of the process and facility. This subgroup must have the experience and training to recognize the situations and conditions under which regulatory requirement could be violated through process design, facility design, or operational practice.

Examples of generic issues that will be addressed by the subgroup include but are not limited to:

* Radiation protection
* ALARA requirements
* National Environmental Policy Act
* Clean Air Act
* Clean Water Act
* Resource Conservation and Recovery Act
* Comprehensive Environmental Response, Compensation and Liability Act
* Occupational Safety and Health Act
* Toxic Substance Control Act
* DOE Orders
* Risk Acceptance Criteria for Workers and Public
* Federal Facility Compliance Agreements

N.9.A Line of Inquiry

The Regulatory Requirement Subgroup review of the HWVP will focus on the applicable federal and state regulatory requirements inveighed on the HWVP process including: tank waste resuspension and transfer, pretreatment, vitrification, and the ultimate disposition of finished waste from products, and the releases of effluents and emissions within permitted limits.

General regulatory requirement issues that will be the basis of the inquiry by the subgroup include:

N.9.A.1 Environmental Laws and Regulations

Requirements for compliance with RCRA and CERCLA have been formalized since the publication of the HLW, TRU, and Tank Wastes Environmental Impact Statement (DOE/EIS00113, December 1987). Have these changes been factored into plant designs? Do these changes have any potential for re-opening the EIS process (and thereby further perturbing the plant schedule?)

Have interim environmental compliance assessments been conducted since the publication of the EIS which would influence plant design?

Does the the Tri-Party Agreement appear to be having any influence on evolving plant design, particularly on RCRA or CERCLA compliance issues, or on the plant stack filtration and monitoring requirements?

State of Washington Air quality regulations for radionuclide releases were substantially the same as EPA's requirements in 40 CFR 61.92 at the time of EIS publication in 1987. Have these changed, or are there actions pending in the State such that plant designs might require modification?

Could pending EPA or State of Washington actions to regulate mixed wastes pose plant design changes?

Assuming no repository is available, has sufficient lag storage been engineered into the plant, or factored into other contingency planning, to permit both single shell and double shell tank wastes to be processed through HWVP without disruption of plant operations?

What happens if the Vessel Off-Gas (VOG) system is ever plugged during normal operations? Have adequate redundancies been factored into plant design to sustain operations?

N.9.A.2 Radiation Protection Of Individuals, Releases Of Radioactivity And Accident Scenarios

What DOE and other agency requirements related to radioisotope releases, exposure doses or radiation protection must be met during plant operation?

Has an ALARA review been undertaken for the pretreatment and vitrification facilities? What are the results and conclusions?

Have ALARA concepts been incorporated in the plant design?

Is a suitable health physics monitoring and training program planned?

What evaluations of radiation exposures during normal operation of the pre-treatment facility have been undertaken? Of the vitrification facility?

What accident conditions have been evaluated? What are the radiological consequences of the analyzed events? Are the consequences acceptable?

Is there a high potential for accidents that could produce occupational radiation exposures?

Are the analyzed accidents appropriate and bounding?

What man-rem and individual radiation exposures are projected for occupational employees? What plant operations will produce the major exposures?

How does the occupational exposure divide between internal and external sources?

What are expected leach rates of radioactive components from the final vitrified products?

What are the expected volumes and activity levels of radioactive wastes (excluding vitrified material and feed to the grout facility) that will be generated during plant operation?

Are the radioactivity levels in waste products acceptable for disposal?

What criticality analyses have been carried out for plant operations?

What is the off-site man-rem exposure rate (and accumulated man-rem) associated with normal operation? What dose models were employed to make this assessment?

What gaseous releases of radioactive materials are projected to occur during normal operation? During abnormal events?

What dose models have been employed for accidental releases of radioactivity?

What potential exists for hydrogen production and burning during processing? Consequences?

Is there a potential for hydrogen or ferrocyanide explosions which could produce radiation exposures?

What analyses have been carried out on the consequences of potential fires that could occur in the processing facilities?

What reasonable accidents can occur that will produce off-site releases? What are the potential impacts of these accidents?

a. During tank transfer?
b. During preprocessing?
c. During vitrification?

Are gaseous radioactive products released during the vitrification stage? What amounts?

What leach rates of radioactive isotopes are expected for the vitreous product?

Have potential criticality accidents been addressed?

N.9.A.3 Low Level And High Level Radioactive Waste Disposal Requirements

Has any analysis been made of radiolytic reactions that could interfere with the separation processes or create hazardous wastes?

Is the Savannah River experience for sludge suspension and transfer from tanks appropriate for the Hanford tanks?

What radiation exposures are anticipated during the removal and transfer of radioactive material from tanks?

What is known (and what not known) about the specific composition of the Hanford tank contents?

How are mixing pumps going to disperse the crust layer at the surface of some tanks?

Is it believed possible to produce concentration rather than dispersal of some radioactive components during the tank mixing operations?

What bench scale or pilot plant scale studies have been conducted with feed materials similar to those in the waste tanks?

Have any agreements between DOE and NRC been made which could impact plant operations, either in the HLW processed (HWVP feedstock and glass product), or generated (LLW by-product) as a result of plant operations?

If the grouted low-level waste forms fail to meet NRC acceptance criteria, have adequate engineering contingencies (for waste storage or reprocessing) been made to sustain plant operations until the regulatory issues have been resolved?

N.10 Management and Control Subgroup

This subgroup will be experience and qualified with regard to the management and control requirement necessary to manage the design, construction and operation of a process or facility that will be complex in structure and potentially hazardous in character. This subgroup will have experience in the techniques and systems for directing and controlling a large, complex and costly operation.

Examples of the generic issues that will be addressed by the subgroup includes but are not limited to:

* Project management
* Configuration control/management
* System integration
* Production requirements
* Operational procedures
* Schedule development and control
* Cost estimation and control
* Quality Assurance
* Safeguards and Security

N.10.A Line of Inquiry

The Management and Control Subgroup review of the HWVP will focus on customer requirements, the working IMPLEMENTATION of the Project Management Plan (PMP), implementation of participant and technical INTERFACES, and INTEGRATION of the elements of the waste treatment system (double shell tanks to final repository) and the HWVP.

General management and control questions that will be the basis of the inquiry by the subgroup will include:

N.10.A.1 Requirements

- Technical
- Costs
- Schedules

- Assumptions
- Validation

What are the key waste management treatment program requirements? How was each defined? What assumptions were required? How were the requirements and assumptions internally and initially validated? How are the requirements being tracked and integrated into the HWVP?

Focus: Feed stock, Regulatory, Department, and Repository Requirements

What are the key HWVP requirements? How was each defined? What assumptions were made or required? How were the HWVP requirements and assumptions internally and initially validated? What metrics are/will be used to track conformance to requirements?

Focus: Feed stock availability and composition, Pretreatment and Output requirements.

What process was used to define and select the waste treatment system elements, baseline vitrification technology, and baseline facility design to satisfy these requirements? What assumptions were made or required? What internal process was used to internally and initially validate these selections? How are validations updated?

How were the key HWVP cost and schedule baseline elements established? What assumptions were used or required? How were the baselines internally and initially validated, and how are they being managed during the course of the Project?

N.10.A.2 <u>Interfaces</u>
- Decision process
- Metrics
- Communications
- Qualifications and training
- Customers and Suppliers
- Roles
- Responsibilities
- Accountability

What organization and person, at the lowest level, is ultimately responsible for the functionality of the waste treatment system and the HWVP? What mechanisms are used to define and allocate responsibility and accountability to project participants? What metrics are used to assess the performance of these mechanisms?

How are the HWVP participant's roles, responsibilities, and accountabilities defined and implemented? What metrics are used to assess performance?

What are the formal and working relationship and communication channels among the program and project participants?

Within and across organizational activities, how are issues identified and addressed, decisions reached, and conflicts resolved for the waste treatment program and the HWVP? How are waste treatment systems and HWVP decisions reviewed for impact? How are decisions communicated to system and project participants?

N.10.A.3 <u>Integration and Implementation</u>

- Development
- Facility
- Technology

What tools and mechanisms are used by HWVP management and personnel to assure system, technical and project participants integration? How is this done for a system element and its functionality?

How is the evaluation and introduction of technology and program induced changes into the HWVP actually managed? What key changes have been integrated to date?

How were the enabling technology development requirements identified and defined for the waste treatment system? For the HWVP? How is the technology development integrated with the facility design and construction?

What is the operational plan for the HWVP as an element of the waste treatment system? What Assumption were made or required? How was the plan reviewed and validated? Will the plant be productively used for its life cycle? How will the equipment be maintained and replaced, and the plant decommissioned?

N.10.A.4 <u>Risk and Contingency Assessment and Management</u>

- Waste Treatment System
- HWVP
    - Development
    - Production

What are the key risks associated with the waste treatment system and with the HWVP? How was each risks defined/determined? What assumptions were required? How were the risks validated and prioritized?

Focus: Waste Treatment System Elements, Input and Output Requirements, Technology/process, Facility, Production, Organization/Structure, Infrastructure

What on-going process is used to weigh the risk-benefit trade-off in proceeding with or delaying the HWVP?

Focus: Technology, Pretreatment, Repository requirement

What is the methodology for managing system and project risks and what is the performance of the methodology to date?

What contingency planning has occurred in anticipation of waste treatment system and HWVP problems? What is the cost of each contingency scenario?

Focus: Technology, Repository, Pretreatment facility and process, Infrastructure

APPENDIX O

List of Notations
Acronyms and Abbreviations

A/E	architect engineer
ADP	automated data processing
ALARA	as low as reasonable achievable
ALCS	analytical laboratory computer system
Am	Americium
ATC	Associated Technical Consultants
CC	complexant concentrate
CDMC	contact decontamination and maintenance cell
CERCLA	Comprehensive Environmental Response, Compensation and Liability Act
CFR	Code of Federal Regulations
Ci	curies
CMPO	octylphenyl-N,N-diisobutylcarbamoylmethylphosphine oxide
Cs	Cesium
CVS	composition variability study
DBE	design basis earthquake
DCS	distributed control system
DF	decontamination factor
DHDECMP	dihexyl-N,N-diethylcarbamoylmethylposphonate
DOE	U. S Department of Energy
DOE-HQ	U. S. Department of Energy-Headquarters
DOE-RL	U. S. Department of Energy-Richland
DSS	double-shell slurry
DSSF	double-shell slurry feed
DST	double-shell tank
DWPF	Defense Waste Processing Facility
DWR	Defense Waste Remediation
EA	environmental assessment
EIS	environmental impact statement
ELA	equipment lay down area
EPA	Environmental Protection Agency
ESAAB	Energy Systems Acquisition Advisory Board
FDC	functional design criteria
FDI	Flour Daniel, Inc.
GDC	general design criteria
HEME	High Efficiency Mist Eliminator
HEPA	High Efficiency Particulate Air
HDWRP	Hanford Defense Waste Remediation Program

HLW	high-level waste
HPCS	health protection computer system
HVAC	heating, ventilation, and air conditioning
HWVF	Hanford Waste Vitrification Facility
HWVP	Hanford Waste Vitrification Project
HWVS	Hanford Waste Vitrification System
I	Iodine
IMACS	integrated management and control system
IMT	integrated management team
LLW	low-level waste
LLNL	Lawrence Livermore National Laboratory
MCI	million curies (megacuries)
MCC	motor control center
MIS	management information system
MSA	major systems acquisition
NCAW	neutralized current acid waste
nCi	nanocurie (10^{-9} curies)
NCRW	neutralized cladding removal waste
Np	Neptunium
NRC	Nuclear Regulatory Commission
OCRWM	Office of Civilian Radioactive Waste Management
PFP	plutonium finishing plant
PLC	programmable logic controller
PNL	Pacific Northwest Laboratory
Pu	Plutonium
RCRA	Resource Conservation and Recovery Act
REDC	remote equipment decontamination cell
RFI	radio frequency interference
RL	Richland Field Office
SBS	submerged bed scrubber
SME	slurry mix evaporator
SMECT	slurry mix evaporator condensate tank
SMS	site management system
Sr	Strontium
SRAT	slurry receipt and adjustment tank
SRL	Savannah River Laboratory
SRP	Savannah River Plant
SST	single-shell tank
TBP	tributyl-phosphate
Tc	Technetium
TCLP	toxicity characteristic leaching procedure
TDP	technical data package
TNX	experimental area at Savannah River
TRU	transuranic
TRUEX	transuranic extraction
TTT	time-temperature-transformation

U	Uranium
UPS	uninterruptible power supply
VOG	vessel off-gas
WAC	Washington Administrative Code
WAPS	waste acceptance preliminary specifications
WBS	work breakdown structure
WESF	Waste Encapsulation and Storage Facility
WHC	Westinghouse Hanford Company
WVDP	West Valley Demonstration Plant
ZPA	zero period amplitude

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