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Overall Strategy and Program Plan for Management of Radioactively Contaminated Liquid Wastes and Transuranic Sludges at the Oak Ridge National Laboratory

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OVERALL STRATEGY AND PROGRAM PLAN FOR MANAGEMENT OF RADIOACTIVELY CONTAMINATED LIQUID WASTES AND TRANSURANIC SLUDGES AT THE OAK RIDGE NATIONAL LABORATORY

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ACRONYMS AND INITIALISMS

ADM	action description memorandum
ALARA	as low as reasonably achievable
BSR	Bulk Shielding Reactor
CAT	collection and transfer (system)
CH-TRU	contact-handled transuranic
D&D	decontamination and decommissioning
DOE	Department of Energy
DOE-ORO	Department of Energy-Oak Ridge Operations
DOT	Department of Transportation
EASC	Emergency Avoidance Solidification Campaign
EA	environmental assessment
EIS	environmental impact statement
EPA	Environmental Protection Agency
FPDL	Fission Products Development Laboratory
FSAR	final safety analysis report
GPP	General Plant Project
HEPA	high-efficiency particulate air
HFIR	High Flux Isotope Reactor
HIC	high-integrity container
ILW	intermediate-level waste
LW	liquid waste
LHLW	liquid high-level waste
LLLW	liquid low-level waste

LLWDDD	low-level waste disposal development and demonstration
MV-CAT	Melton Valley Collection and Transfer
MVST	Melton Valley Storage Tanks
NCWP	Nuclear and Chemical Waste Programs
ORNL	Oak Ridge National Laboratory
ORR	Oak Ridge Reservation
OSR	operational safety report
PBR	permit-by-rule
PWTP	Process Waste Treatment Plant
R&D	research and development
RAP	Remedial Action Program
RCRA	Resource Conservation and Recovery Act of 1979
RH-TRU	remote-handled transuranic
SLLW	solid low-level waste
SWSA	solid waste storage area
TEC	total estimated cost
TDHE	Tennessee Department of Health and Environment
TPP	Transuranium Processing Plant
TRU	transuranic
WAC	waste acceptance criteria
WHPP	Waste Handling and Packaging Plant
WIPP	Waste Isolation Pilot Plant

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1. EXECUTIVE SUMMARY

The Oak Ridge National Laboratory (ORNL), from its inception in the early 1940s, has operated numerous facilities which have generated radioactively contaminated liquid waste (LW). During much of this period, these wastes have included significant levels of transuranic (TRU) elements because of early operation of nuclear fuel reprocessing pilot plants, as well as the preparation and use of radioisotopes. An extensive underground system has been used for collection of these wastes, which are concentrated by evaporation. Through 1984, the concentrate was converted to a grout and disposed of on the Oak Ridge Reservation (ORR) via hydrofracture in shale formations ~1100 ft below the surface. Because the incremental operational cost for such disposal was very low (~$1.00/gal) and because these costs were not borne by the waste generators, this approach for managing LW was optimized to use to advantage the low cost for LW management and to minimize production of other types of wastes.

The use of hydrofracture was terminated after 1984, and LW concentrate has been accumulated and stored since that time. Currently, the volume of stored LW concentrate is near the safe fill limit for the 11 storage tanks in the active LW system, and significant operational constraints are being experienced. The tanks that provide the storage capacity of the active LW system contain significant volumes of TRU sludges that have been designated remote-handled transuranic (RH-TRU) wastes because of associated quantities of other radioisotopes, including ^{90}Sr and ^{137}Cs. Thirty-three additional tanks, which are inactive, also contain significant volumes of TRU waste and radioactive LW. Many options are being considered in the closure plans for the inactive tanks, and removal of the TRU waste may be necessary. In addition to the concern that stems from decreased operational flexibility, it is recognized that a lack of adequate storage volume for LW jeopardizes ORNL's ability to ensure continued conduct of research and development (R&D) activities that generate LW because an unexpected operational incident could quickly deplete the remaining storage volume.

Accordingly, a planning team comprised of staff members from the ORNL Nuclear and Chemical Waste Programs (NCWP) was created for developing recommended actions to be taken for management of LW. The primary recommendations for the near term (mid-1988 through FY 1990) are to implement in-tank evaporation in the active LW storage tanks for removal of water from the stored LW concentrate and to proceed with the planned initial Emergency Avoidance Solidification Campaign (EASC) to regain a significant initial increment of LW system operational flexibility.

The primary recommendations for the intermediate term (FY 1990 through FY 1997) are that (1) disposal of RH-TRU sludge and associated LW at the Waste Isolation Pilot Plant (WIPP) be adopted as the primary waste management approach for the current waste inventories and (2) a contingency plan for freeing significant LW tank volume be implemented that is not susceptible to potential problems associated with the primary approach.

Relative to the long-term management of LW, a program plan is presented which outlines work required for the development of a disposal method for each of the likely future waste streams associated with LW management and the disposal of the bulk of the resulting solid waste on the ORR.

2. INTRODUCTION

To provide perspective concerning the need for and approach taken during conduct of this study and development of the resulting program plan for treatment, solidification, storage, and disposal of present and future materials collected within the ORNL liquid low-level waste (LLLW) system, information is presented in this chapter on the following topics:

2.1 Background
2.2 Objectives and Approach
2.3 Scope of Planning Efforts
2.4 Recognized Constraints
2.5 Overall Goals

2.1 BACKGROUND

The background for this strategic planning effort is discussed in terms of the following questions:

- How did we get here?
- With what are we dealing?
- What are the primary elements of the problem?
- What are the consequences of nonaction?

2.1.1 How Did We Get Here?

From its inception in the early 1940s, ORNL has operated numerous facilities that have generated radioactively contaminated LW. During much of this period, this waste has included significant levels of TRU elements because of early operation of nuclear fuel reprocessing pilot plants. In addition, radioisotope preparation and usage have produced additional quantities of LLLW and TRU waste which have been discharged to the LW system. Numerous waste management approaches have been employed during the history of the Laboratory, and the supporting facilities for collection, treatment, and disposal have varied significantly over time. In particular, an extensive underground piping system has been employed for the collection of LW.

During most of this period, the LW collection and transfer system (CAT) was designated as an intermediate-level waste (ILW) system, and the discharge of TRU waste into the system was accepted practice. In 1984, the Department of Energy (DOE) requested that the ILW designation be changed because thereafter only LLLW and liquid high-level waste (LHLW) would be recognized. Accordingly, the ORNL ILW system was redesignated as an LLLW system even though the active and inactive parts of the ILW system contained large quantities of TRU waste and means were not available for avoiding continued inclusion of TRU waste in LW discharged to the system. More recently, environmental management procedures have been written to prohibit discharge of TRU isotopes to the LLLW system without regard for the fact that there are no means for avoiding discharge of TRU waste to the system or for the fact that the system contains large quantities of TRU waste. Because the current waste CAT system cannot be operated at present as an LLLW system, it will henceforth be designated as an LW system in this report. In the long term, it should be possible to operate the LW system in a manner that allows solidification and disposal of LLLW on the ORR while minimizing the associated quantities of RH-TRU waste and other solidified LW which must be disposed at a site(s) other than the ORR.

Through 1984, the LW was concentrated via evaporation, and the resulting concentrate was converted to a grout which was disposed of on the ORR via hydrofracture into shale formations ~1100 ft below the surface. The incremental operational cost for disposal of LW via hydrofracture was very low (~$1.00/gal). In addition, practically all costs for operation and maintenance of the LW system were borne by programmatic funds not related to funding for the waste generators. This resulted in an LW generation, treatment, and disposal system that was consciously configured in a manner to use to advantage the low cost for collection, treatment, and disposal of LW.

2.1.2 With What Are We Dealing?

The use of hydrofracture was terminated after 1984, and LW concentrate resulting from evaporation of the as-generated LW has been accumulated and stored since that time. The resulting volume of stored waste concentrate has increased steadily since 1984, and the total volume in storage is currently at a level that results in significantly decreased operational flexibility of the LW evaporator and associated waste concentrate storage system because most of the active tanks are at or near the safe fill limit. An aggressive waste minimization program has been pursued during the past 3 years to minimize further accumulation of LW concentrate; however, additional steps are necessary to adequately handle present and future LLLW and associated TRU waste.

Because the disposal of LW concentrate via hydrofracture was relatively inexpensive, the various waste management facilities were configured and optimized, over a period of years, for minimizing the production of waste types other than LW. As a result, an important element of the current planning activity consisted of determining how the present LW system should be reconfigured to decrease LW concentrate generation and storage to levels below those achieved as a result of waste minimization efforts during the past 3 years.

The 11 tanks that provide the storage capacity of the active LW system contain significant volumes of TRU sludges which have been designated RH-TRU wastes because of associated quantities of LLLW. The sludges result largely from the earlier disposal via hydrofracture of sludges from the ORNL gunite tanks; during the disposal operation, the waste storage tanks located in Melton Valley were used for intermediate surge capacity, and some of the sludges were not removed from these 8 tanks. Thirty-three additional tanks that have received TRU wastes and/or LLLW are now inactive but contain substantial additional volumes of liquids and sludges. The presence of large quantities of TRU waste in the active LW system has, of necessity, broadened the scope of the present planning activity beyond considerations of present and future LLLW treatment and disposal to include actions and constraints associated with the treatment and disposal of the large quantities of RH-TRU wastes contained within the LW system.

2.1.3 What Are the Primary Elements of the Problem?

The primary immediate concern stems from the decreased operational flexibility which is being experienced in operating the LW collection, treatment, and storage system. In addition to the decreased operational flexibility, it is recognized that a lack of adequate storage volume for LW concentrate jeopardizes ORNL's ability to ensure continued conduct of R&D activities that generate LW because an unexpected operational incident that produces a significant volume of LW could rapidly deplete the remaining LW storage capacity. Even in the absence of an unexpected operational incident, the remaining LW storage capacity is expected to be depleted by the fourth quarter of FY 1989. Clearly, a practical long-term approach for treatment and disposal of LW must be implemented after near-term and intermediate-term measures have been taken for freeing some tank volume.

2.1.4 What Are the Consequences of Nonaction?

If timely actions are not taken for addressing the need for increasing the available storage volume in the LW tanks, the following consequences will either occur or are highly likely:

- shutdown of critical and unique Laboratory R&D facilities and isotope production capabilities which generate LW;

- loss of ORNL dominance in affected R&D areas;

- inability to remove inventories from inactive tanks, which may contribute to groundwater contamination;

- in the event of an unplanned event that produces large quantities of LW, the Laboratory could be forced to use LW storage tanks of lesser integrity than the current LW storage tanks or to allow increased discharge of radioactivity to surface streams (both of these actions are highly unacceptable); and

- violation of environmental regulations.

Accordingly, a planning team comprised of staff from the ORNL NCWP was created to accomplish the following:

- examine near-, intermediate-, and long-term aspects of LW management at ORNL;
- develop recommended actions to be taken; and
- develop a program plan outlining the costs and schedules for recommended actions.

2.2 OBJECTIVES AND APPROACH

The objectives of this strategic planning effort and the associated approach that was taken are as follows:

- identify near-term options for increasing available LW storage tank volume;
- identify intermediate-term options for further increasing LW storage tank volume;
- identify options for reconfiguring the LW CAT system that will allow practical long-term LW treatment and disposal (preferably on the ORR);
- prioritize the identified options; and
- develop contingency actions sufficient to ensure the viability of the planned general approach and specific high-priority options via examination of technical, regulatory, and other uncertainties.

For the high-priority options and associated contingency actions, the following steps were taken:

- identify R&D and capital projects necessary for implementation;
- identify required environmental permits and other regulatory- and safety-related actions;
- develop costs and schedules;
- identify funding currently in place or within recognized budget plans and additional funding that will be needed; and
- present information on work to be done, schedules, milestones, and budgets in a long-range program plan.

2.3 SCOPE OF PLANNING EFFORTS

The scope of this strategic planning effort can be best characterized in terms of (1) waste treatment/storage systems and waste types addressed, and (2) time period for implementation of needed actions.

2.3.1 What Waste Systems and Waste Types Are Addressed in This Study?

The present planning effort is concerned with the following:

- present and future LW-generation sources;
- active LW tanks and associated systems for LW collection and storage;
- RH-TRU sludges that coexist with LLLW in the present LW collection, treatment, and storage system;
- inventories of LLLW and RH-TRU sludges in the inactive LW tanks, which may be removed during closure activities and could affect future treatment, storage, solidification, and disposal of LW;
- facilities for treating, storing, and disposing of RH-TRU sludges and associated LLLW present in the active and inactive LW tanks, and underlying R&D and capital projects necessary for constructing these facilities; and
- facilities for collecting, treating, storing, and disposing of newly generated LW after removal of the bulk of the RH-TRU waste and associated LLLW from the active LW system, and underlying R&D and capital projects necessary to construct these facilities.

2.3.2 What Is the Period Covered by the Study?

This study covers a period which can be defined as the interval from the present to that time required for completing actions necessary for: (1) removing the bulk of the RH-TRU sludges and associated LLLW from the active and inactive LW tanks and disposing of the resulting solids in the WIPP and (2) reconfiguring the LW system to allow practical treatment and disposal of solidified LLLW and RH-TRU wastes from the resulting active LW system.

It has been useful in this study to define the following three periods during which the indicated actions are expected to occur: near term, intermediate term, and long term.

- **Near Term (mid-FY 1988 through FY 1990, 2.5 years total)**

  - Period from the present to the time when the currently remaining active LW tank volume will be depleted if no further action is taken.

  - Period required for sampling and analyzing active and inactive tank inventories, conducting treatability studies, and evaluating solidification/disposal options.

  - Period during which the first EASC for solidifying 50,000 gal of LLLW will be completed.

  - Period for completion of conceptual design, project validation, and system design criteria for the Waste Handling and Packaging Plant (WHPP), a proposed major ORNL facility for solidifying RH-TRU waste present in the LW system. All research, development, and demonstration necessary for establishing the system design criteria for WHPP must be completed during this time interval.

- **Intermediate Term (FY 1990 through FY 1997, 7 years total)**

  - Period during which the WHPP Title II design will be initiated (early FY 1991), construction will be completed, and facility operation will begin (mid-FY 1996).

  - Period between the end of near term and the time when the bulk of the RH-TRU waste can be removed from one active LW tank via solidification in the WHPP.

  - Period for removal of waste inventories from inactive LW tanks, as required by closure plan.

- **Long Term (FY 1998 and beyond, period after next 9.5 years)**

  - Period beginning with the first availability of an active LW tank from which the bulk of the RH-TRU waste has been removed.

  - Period during which newly generated LW can be treated, solidified, and disposed of in a manner that allows disposal of the resulting solid LLW on the ORR and minimization of the associated production of RH-TRU waste and other solid waste requiring disposal at sites other than the ORR.

2.4 RECOGNIZED CONSTRAINTS

The following primary constraints were recognized during development of this strategic plan:

1. Construction of additional tanks for storage of LW will not be allowed.

2. Curtailment of Laboratory R&D or critical operations that generate LW cannot occur as a result of lack of capability to manage LW at any time.

3. Operational constraints for disposing of solidified LLLW on the ORR must be considered [low-level waste disposal development and demonstration (LLWDDD) operational constraints in terms of LLWDDD waste acceptance criteria (WAC) and schedule for operation of LLWDDD disposal facilities].

4. Operational constraints must be considered for solidifying RH-TRU sludges and associated LLLW presently in the LW system, as well as similar material to be generated prior to reconfiguration of the LW system and disposal of the resulting solidified RH-TRU wastes at WIPP [WIPP operational constraints in terms of RH-TRU WIPP WAC, the schedule for RH-TRU disposal capacity at WIPP, and the Department of Transportation (DOT) regulations for transporting the solidified RH-TRU waste to WIPP].

5. Future operational costs for collection, treatment, solidification, and disposal of LW will be borne primarily by the generators of this waste.

2.5 OVERALL GOALS

The specific goals and objectives addressed by this strategic planning effort have been grouped to obtain overall goals in the following manner:

1. Identify options for improving the near-term and intermediate-term operational flexibility of the LW system prior to removal of the bulk of the RH-TRU sludges and associated LLLW from the active LW system.

    - Provide significant near-term reduction in volume of waste in active LW tanks.

    - Provide additional intermediate-term reduction in volume of waste in active LW tanks.

    - Modify LW generation sources and system to further decrease LW generation.

2. Identify intermediate-term options for removal of RH-TRU sludges and associated LLLW from active and inactive LW tanks (as required by closure plan).

   - Evaluate options for removal of RH-TRU sludges and associated LLLW from active and inactive tanks.

   - Evaluate options for treatment/solidification of RH-TRU sludges and associated LLLW.

   - Evaluate storage/disposal options for resulting RH-TRU solids.

3. Identify long-term options for future collection and treatment of LW and disposal of the bulk of the resulting solid waste as LLWDDD Class II solid LLW on the ORR while minimizing production of RH-TRU waste or LLWDDD Class IV solid LLW (off-site disposal).

   - Identify options for reconfiguring the LW system to allow practical treatment and disposal of resulting LLLW and associated TRU elements after the bulk of the RH-TRU waste has been removed from the active system.

   - Identify LW treatment and solidification options that maximize disposal of resulting solid LLW on the ORR and minimize quantities of waste requiring off-site disposal.

3. OVERVIEW OF GENERAL STRATEGY AND RECOMMENDED APPROACH

The goals, objectives, criteria, and constraints for the development of an overall strategy and recommended long-range program plan for management of ORNL LW and associated RH-TRU wastes were discussed in Sect. 2. This section summarizes the specific approaches considered for accomplishing the following three overall goals that were identified.

Goal 1. Improve the near-term and intermediate-term operational flexibility of the current LW system prior to removal of the bulk of the RH-TRU wastes and associated LLLW from the active LW system.

Goal 2. Remove the bulk of the current legacy of RH-TRU wastes and associated LLLW from the active and inactive tanks to allow practical long-term management of LW.

Goal 3. Develop an ORNL waste management system for the future collection and treatment of LW and disposal of the bulk of the resulting solid waste as LLWDDD Class II solid LLW, while minimizing production of RH-TRU waste or LLWDDD Class IV solid LLW.

3.1 STRATEGY FOR ACCOMPLISHING GOAL 1

The overall strategy for improving the operational flexibility of the current LW system (Goal 1) is depicted in Fig. 3.1 and consists of the following major elements:

1. Provide significant initial reduction of the volume of LW in the tanks to allow for any unanticipated operational upsets that could result in the need for curtailment of activities that generate LW in the event that this inventory should be removed.

2. Provide continued intermediate-term removal of LW from the tanks.

3. Identify and implement near-term and intermediate-term system modifications that will reduce the volume of LW generated.

Two alternatives were considered for providing significant near-term reduction of the LW volume in the tanks. These are in-tank evaporation of water and the previously planned EASC, which will result in the solidification of about 50,000 gal of LLLW.

Two alternatives were considered for the intermediate-term removal of LW from the tanks. These alternatives are the continued use of in-tank evaporation and the execution of solidification demonstrations, including additional EASCs. The use of additional EASCs would be dependent on the results from the initial solidification campaign and

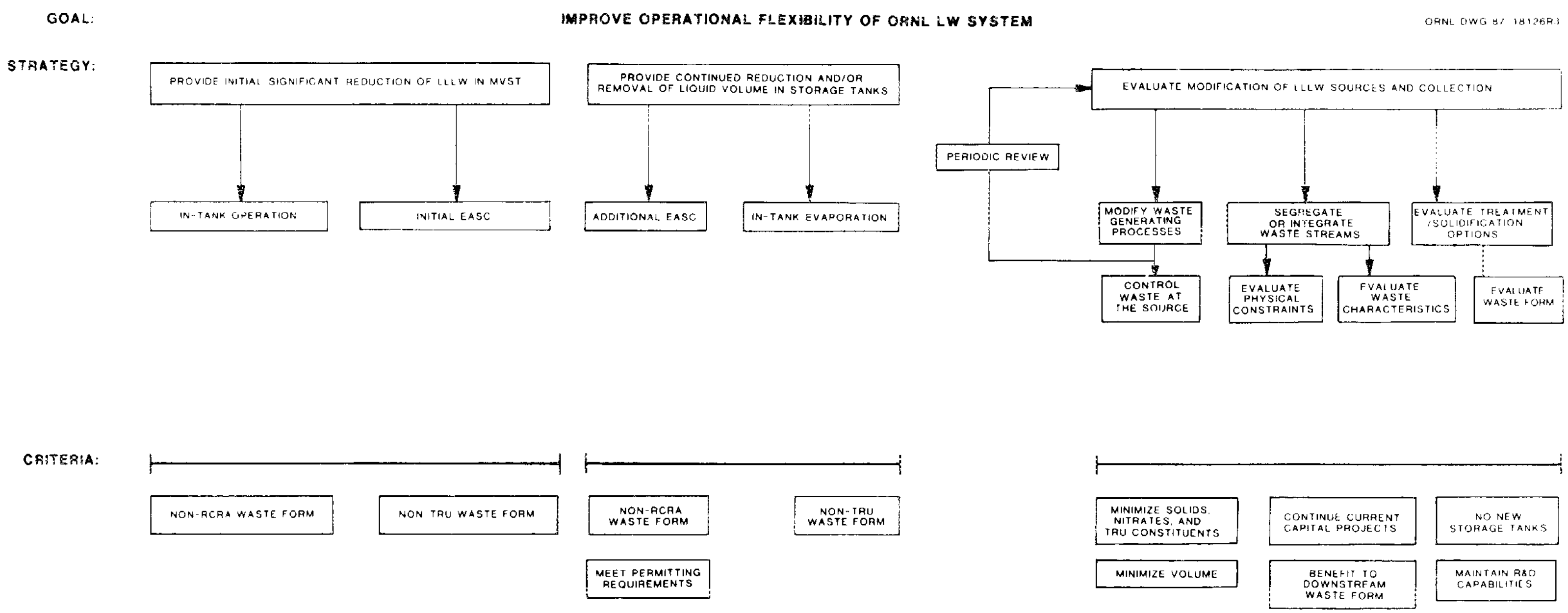

Fig. 3.1. Overall strategy for improving operability of the current liquid waste system.

regulatory requirements. Although the initial EASC will depend on decantation to remove LLLW from the Melton Valley storage tanks (MVSTs) without removal of associated RH-TRU sludges, it was recognized that early demonstration of separation methods, such as filtration, of the LLLW from the RH-TRU solids may be of high importance, not only for the conduct of additional EASCs, but also for the long-term solidification of LW. Demonstration of filtration would provide an important backup to the decantation approach to be used during the first EASC if difficulties should be encountered with this approach.

The alternative of conducting solidification demonstrations using RH-TRU sludges or newly generated LW was examined. Although this alternative would be quite effective for reducing the quantity of LW in the storage tanks, a suitable solidification process and an acceptable facility for near-term conduct of this type of demonstration have not been identified.

The primary current LW-generation sources were reviewed, and several possible near-term system modifications that would reduce the volume of newly generated LW were identified. Options were examined for eliminating certain LW streams that currently flow to the LW tanks, and modifications were evaluated which could be made at the sources and/or within the collection system to minimize the volume of waste being transferred to the tanks (e.g., ways to minimize the mass flow of solids fed to the evaporator, which would reduce the volume of LW concentrate passing from the evaporator to the LW storage tanks). Characteristics of the waste streams were examined to identify streams that can be combined or pretreated to minimize waste volume or solids content. Further review of waste stream characteristics could also result in the proposal that certain waste streams be diverted to the Process Waste Treatment Plant (PWTP) instead of to the LW Evaporator Facility, which would further decrease the volume of waste concentrate. A review of physical constraints for accomplishing modifications of the LW system was also conducted.

The primary conclusions related to achieving Goal 1 are as follows:

- In-tank evaporation represents a highly effective means for offsetting the detrimental effects of continued LW generation during the next several years.

- The first EASC represents an effective near-term approach for increasing the operational flexibility of the LW system.

- The implementation of LLLW solidification demonstrations using actual LLLW could be important for providing improved LLLW solidification technology.

- Early demonstration of the separation of LLLW from associated RH-TRU solids is of significant importance for the conduct of additional EASCs and serves as a backup to the decantation approach to be used during the first EASC. In addition, all processes currently envisioned for long-term treatment and solidification of LW would employ a step for separation of RH-TRU solids from other constituents of the LW.

The primary recommendations related to achieving Goal 1 are as follows:

- Implement in-tank evaporation as soon as possible, including an aggressive R&D program for providing the information necessary for using this approach.
- Proceed with the first EASC to regain a significant initial increment of LW system operational flexibility.
- Identify LLLW solidification demonstrations that can be implemented, as necessary, prior to removal of RH-TRU wastes from the active LW system, including the R&D necessary for implementation of these demonstrations.
- Complete work in progress for demonstration of the separation of LLLW from RH-TRU solids via filtration of actual wastes from the MVSTs.

3.2 STRATEGY FOR ACCOMPLISHING GOAL 2

The strategy for accomplishing removal of the current legacy of RH-TRU wastes and associated LLLW from the active LW tanks (Goal 2) involves three possible scenarios, as shown in Fig. 3.2, for removal, treatment, and disposal of (1) RH-TRU sludges and the associated LLLW, (2) RH-TRU sludges only, and (3) LLLW only.

In considering these options, several factors important to the removal of the RH-TRU sludges and associated LLLW were recognized:

1. The quantity of TRU waste present in the MVSTs results in the mixture of the MVST inventories being designated as RH-TRU waste.

2. RH-TRU wastes must be disposed of in the WIPP rather than on the ORR, and repository space sufficient for disposing of the solidified ORNL RH-TRU wastes has been designated at the WIPP.

3. The most likely transport fluid for removal of the RH-TRU sludges from the MVSTs is the associated LLLW because introduction of additional water or other solutions would increase the total waste volume, which is highly undesirable.

4. The quantity of LLLW associated with the RH-TRU sludges is the approximate amount necessary for removal of the sludges from the MVSTs based on sludge-removal experience. If the introduction of

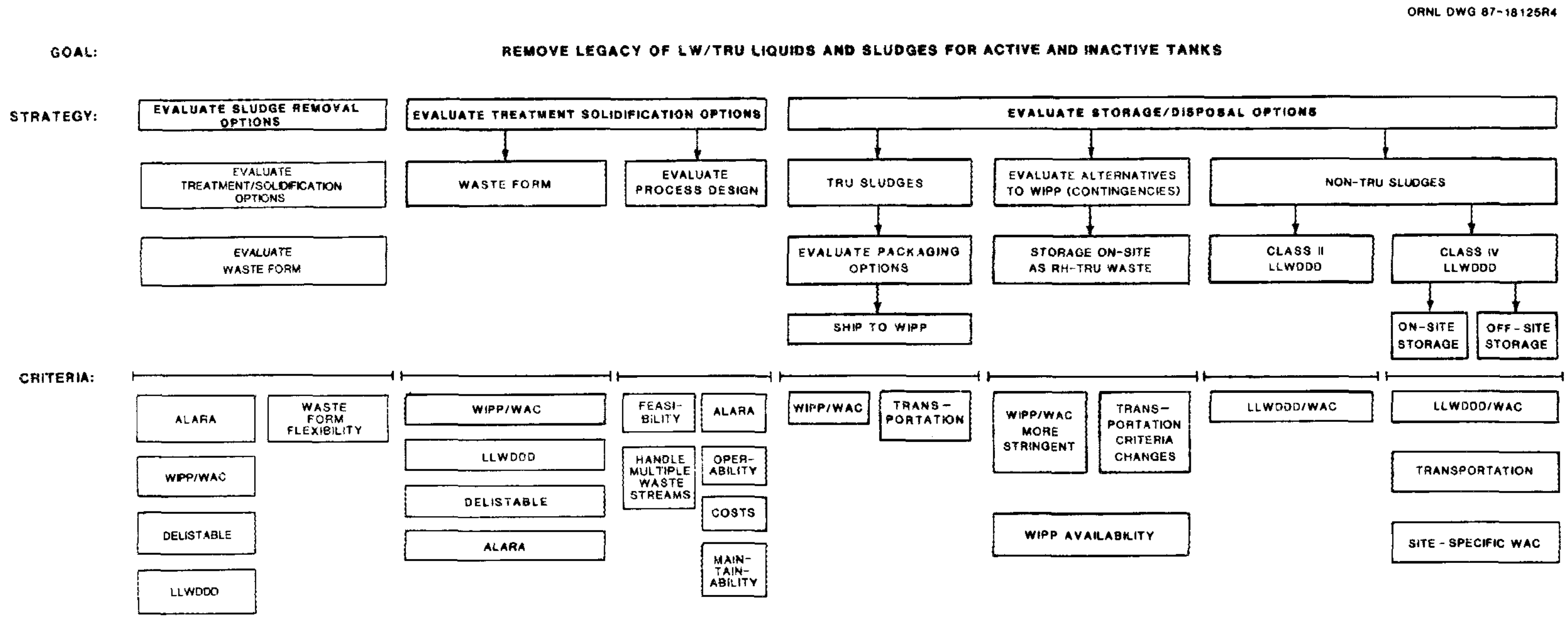

Fig. 3.2. Overall strategy for removal of the legacy of the liquid waste/TRU liquids and sludges from active and inactive tanks.

additional water is necessary, an evaporator would be required to provide condensate for additional flushing of the tanks.

5. Past studies conducted by the DOE RH-TRU Program have shown that separation of TRU wastes from associated LLLW will not be cost-effective in most cases. The quantity and type of nontransuranic radionuclides present in the MVSTs are acceptable within the WIPP WAC and will not complicate significantly the solidification, transport, or disposal of the RH-TRU wastes.

6. The RH-TRU WIPP WAC have been formulated primarily on the basis of factors important during transport and storage of RH-TRU wastes and depend on geologic separation for minimizing risk to the public rather than the adoption of waste forms that will maintain high leach resistance for hundreds of years.

7. The DOE RH-TRU Program is committed to removing the bulk of the large national inventories of RH-TRU wastes from interim storage and disposing of these wastes at WIPP, which will become operational in October 1988. The congressionally mandated window for disposal of these wastes and the presence of the bulk of these wastes at ORNL provide significant urgency for the construction of facilities, at ORNL, necessary for removal of the RH-TRU sludges from the active LW storage tanks beginning in FY 1996. Removal of the RH-TRU wastes from the active LW tanks provides the most viable means for increasing the available volume in the active LW tanks in both the near and the intermediate term. Disposal of RH-TRU waste and associated LLLW at WIPP represents a unique interim opportunity because the necessary RH-TRU disposal space is available and will be lost if it is not used during WIPP operations for disposing of CH-TRU waste. In the long term, however, minimization of the volume of RH-TRU waste resulting from treatment and solidification of newly generated LW must be adopted.

In considering the option of removing, treating, and disposing of the RH-TRU sludges in a manner that would minimize the quantity of associated LLLW, the following factor was recognized:

- A highly efficient separation of LLLW or other inert materials from the RH-TRU sludges would not be cost-effective for the national RH-TRU Program. Although highly efficient separations of the transuranic elements from other materials present in the MVST are technically feasible, this approach cannot be justified on the basis of potential cost savings to the national RH-TRU Program relative to the costs for treatment, storage, transport, and disposal of the solidified RH-TRU sludges and associated LLLW.

In considering the option to remove, solidify, and dispose of the bulk of the LLLW separate from the associated RH-TRU sludges, the following factors were recognized:

- The resulting LLLW solids would require disposal on the ORR as LLWDDD Class II waste. Although it might be possible to dispose of some solidified LLLW at sites other than the ORR, numerous obstacles (primarily political) to this approach exist; thus, the only prudent course would be to assume disposal on the ORR, which would require that the resulting solid LLW meet LLWDDD Class II WAC.

- Although draft LLWDDD Class II WAC will not be available until the end of FY 1988, it is clear that disposal of Class II wastes on the ORR will require dependence on waste forms which will remain highly leach resistant for hundreds of years in contrast to the flexibility that derives from the use of a geologic repository in the case of the RH-TRU waste. While the LLWDDD Class II disposal approach is technically feasible, the costs for treatment, disposal, and post-disposal monitoring of solidified LLLW are judged to be much higher than those involved with disposal of the RH-TRU wastes and associated LLLW at WIPP.

In view of these and other considerations, three conclusions were reached:

- The preferred interim approach for managing the RH-TRU sludges and associated LLLW is to remove, solidify, and dispose of these materials as RH-TRU wastes at WIPP.

- Although the above approach appears to provide a highly effective means for freeing significant LW tank volume in the intermediate term, the consequences of significant delays in schedule or failure to realize completion of this approach are unacceptable. Therefore, it will be necessary to implement a contingency approach which provides a basis for freeing LW tank volume in the intermediate term that is not susceptible to factors that may delay or prevent completion of the preferred approach.

- Removal of the RH-TRU wastes from the active and inactive LW tanks will provide ORNL an unprecedented opportunity for initiating practical waste management approaches for LW generation, collection, storage, solidification, and disposal.

Conclusions related to WHPP, the principal proposed ORNL facility to be constructed for solidifying the RH-TRU wastes, include the following:

- Facilities for removal of the RH-TRU sludges and associated LLLW from the LW storage tanks should be included within the scope of the WHPP line-item construction project because the sludge removal facilities will be operated over an 18-year period and have a single purpose that is inherently part of the overall WHPP mission.

- Additional work is needed for providing a viable design basis for removal of RH-TRU sludges from the MVSTs, and significant opportunities exist in this area for decreases in the total estimated cost (TEC) for WHPP.

- Although initial process feasibility studies related to solidification of RH-TRU sludges and associated LLLW show promise, much additional process development work will be necessary to provide a viable design basis for the solidification step.

- Significant potential exists for minimizing the WHPP TEC via consolidation of the facilities for RH-TRU sludge removal, RH-TRU waste solidification, and repackaging of other stored RH-TRU wastes.

The following actions are recommended:

- Disposal of the RH-TRU sludges and associated LLLW at WIPP should be adopted as the primary waste management approach for the current inventories of the active and inactive LW tanks.

- A contingency waste management approach for freeing significant active LW tank volume which is not susceptible to potential problems associated with the preferred approach should be implemented, and necessary R&D should be pursued to provide a fall-back basis in case difficulties are encountered with the preferred approach.

- Removal of the bulk of the RH-TRU wastes and associated LLLW from the active LW system should be anticipated and included in near-term and intermediate-term strategic planning for LW management to maximize the benefits realized.

- The scope of WHPP should be expanded to include facilities for removal of the RH-TRU sludges from the active LW storage tanks.

- An aggressive program should be pursued for review of past experience on sludge mobilization, and R&D should be conducted as necessary for ensuring a viable design basis for sludge removal.

- An aggressive program should be pursued for demonstrating the process feasibility of technologies for solidification of RH-TRU sludges and associated LLLW to ensure a viable design basis for solidification.

- Consolidation of all WHPP facilities should be examined for minimizing the WHPP TEC.

3.3 STRATEGY FOR ACCOMPLISHING GOAL 3

The ultimate goal of this program plan is to provide an overall strategy and definition of specific tasks sufficient for development of a waste management system for future collection and treatment of LW and disposal of the bulk of this waste as LLWDDD Class II solid waste, while minimizing the volume of RH-TRU waste or LLWDDD Class IV waste. The disposition of TRU waste is a key aspect of this long-term management strategy. Segregation of the bulk of the TRU waste at its source is expected to render the LW concentrate as less than TRU, although TRU waste constituents would likely still be present at low concentrations from operation of active facilities and from decommissioning of inactive facilities. The bulk of the LW would be treated to produce a waste form that would qualify for disposal under LLWDDD as Class II waste. The long-term strategy is shaped largely by the requirement for a waste form that meets the LLWDDD Class II WAC. Implementation of this strategy will minimize the long-term dependence of ORNL on off-site disposal (disposal units over which ORNL has little control) for all LW.

Waste streams are currently being generated for which ORNL has no disposal mechanism; this practice is unacceptable for long-term LW management. This program plan outlines work required for development of a disposal method for each of the likely future waste streams associated with LW management (LLWDDD Class II, LLWDDD Class IV, and TRU). Off-site disposal of RH-TRU and contact-handled-TRU (CH-TRU) wastes is expected to continue through at least the period of operation at WIPP (1988 through 2013).

Elements of the strategic planning approach to accomplish Goal 3 are as follows:

- Evaluate modification of LW sources and the LW collection system to identify changes needed for practical collection, treatment, and storage of LW and incidental quantities of associated TRU elements.

- Evaluate LW solidification options having the capability to meet WAC applicable to the waste types necessary for LW management.

- Evaluate storage/disposal options for the resulting solidified wastes.

Evaluation of the solidification options should include an examination of the technical and economical feasibility of solidification processes, as well as an evaluation of the resulting solidified waste forms. The solidified waste forms must meet the appropriate WAC, either WIPP or LLWDDD. The waste forms must be capable of being delisted from a hazardous waste to a nonhazardous waste in the event that the solidified waste should be disposed of in an LLWDDD facility and the waste stream should be characterized as hazardous prior to solidification.

The evaluation of storage/disposal options should include an assessment of the options of LLWDDD (Classes II and IV), WIPP, and alternatives to WIPP. The evaluation of alternatives to shipping solid wastes to WIPP should include consideration of the impact of potential WIPP WAC revisions, examination of potential changes to the transportation requirements and the associated impacts, and evaluation of the impact of WIPP nonavailability (e.g., WIPP not available when needed or not equipped to handle mixed waste streams).

The elements of the strategic-planning approach are highly related; progress relative to one element will affect requirements for another element. For example, progress in evaluating and eliminating problem LW sources will reduce the requirements for storage/disposal capacity. These relationships must be analyzed via a continuing LW systems analysis, which should be used to guide future LW management planning and operational execution.

Each component of the general strategic-planning approach is subject to criteria and constraints, as shown in Fig. 3.3; these constraints and criteria are discussed in more detail in Sect. 4.4. Based on these and other considerations, it is recommended that:

- A continuing systems analysis should be conducted to guide strategic planning and operational execution of all aspects of LW management and disposal.

- An aggressive research, development, and demonstration program should be pursued for development and demonstration of processes for treating future newly generated LW to produce a waste form that will allow disposal of the bulk of the waste as LLWDDD Class II solid waste. The program should also address other waste types that may be produced in smaller quantities by the processing of newly generated LW (TRU waste and LLWDDD Class IV solid waste).

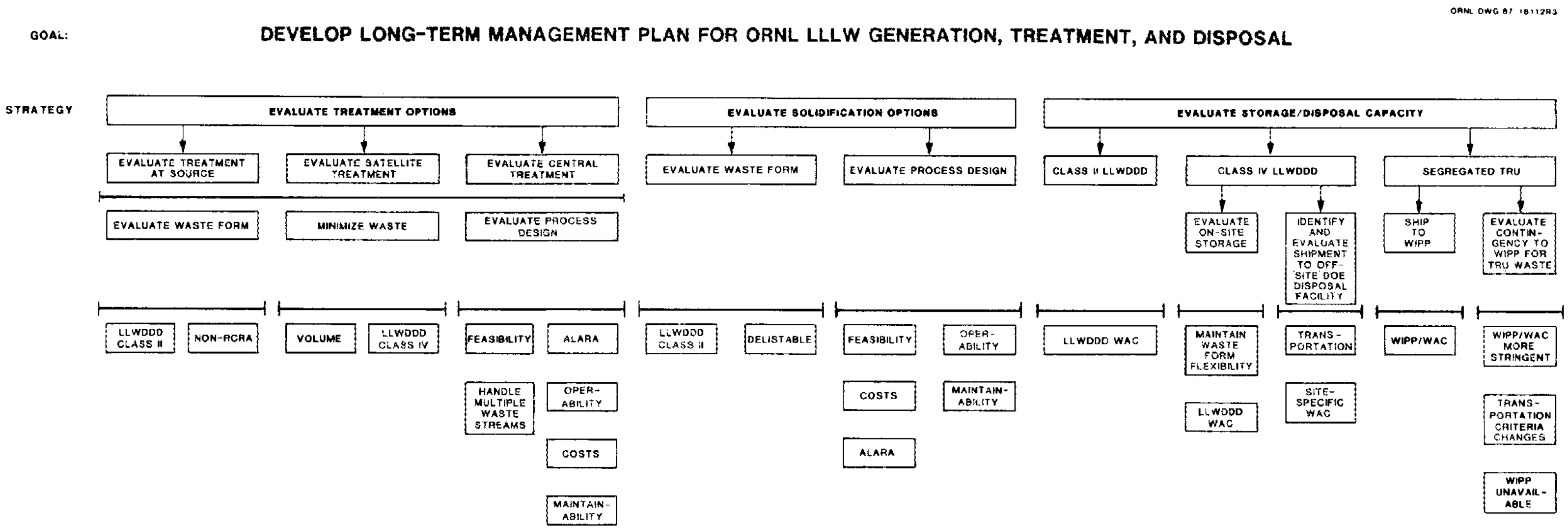

Fig. 3.3. Overall streategy for development of long-term managemnt plans for ORNL liquid waste collection, treatment, and disposal.

4. BASIS FOR GENERAL STRATEGY AND RECOMMENDED APPROACH

An overview of the general strategy and approach recommended for increasing the operational flexibility of the LW system and providing for the long-term management of LW was presented in Sect. 3. More-detailed information is discussed in this section concerning the basis for the recommended general strategy and approach.

In Sect. 4.1, Present LW System Status, information is presented on the current and recent-past LW generation rates, operational status, inventories, and compositions of liquids and sludges in the active and inactive LW tanks, uncertainties in information, and plans for additional sampling and analyses of the tank contents.

In Sect. 4.2, Near-Term Options for Increasing Available Storage Volume, information is provided on in-tank evaporation of water from the active LW tanks and the predicted effect on free tank volume during the near and intermediate terms, as well as summary information for the initial and potential follow-on EASCs.

In Sect. 4.3, Treatment and Disposal of ORNL TRU Wastes, information is presented on the national TRU Program's plans and schedule for disposal of TRU wastes at the WIPP repository, on the WAC for disposal of TRU waste at WIPP, on plans for the ORNL WHPP for solidifying TRU wastes presently contained within the LW system, and on the intermediate-term effects of removal of the bulk of the TRU wastes from the LW system.

In Sect. 4.4, Long-Term Management of ORNL LW, information is presented concerning potential improvements to the LW system that will allow practical long-term management of LW, the projected characteristics of future LW after completion of system reconfiguration, the WAC for disposal of solidified LLLW on the ORR, and projected processes for treatment and solidification of LW.

4.1 PRESENT LW SYSTEM STATUS

Contaminated LW is generated by a number of activities at various sites within ORNL. Most of these activities generate LW that contains relatively low concentrations of radioactive elements. However, the experimental operations used for processing spent power reactor fuel or irradiated isotopes generate waste liquids containing highly radioactive fission products, fissile isotopes, and TRU materials. Such wastes contain high levels of alpha, beta, gamma, and neutron emitters.

These waste streams are collected, transferred, and concentrated by the ORNL LW CAT system, which also contains an evaporator facility. Following concentration by the LW evaporator, the waste stream has relatively high radioactivity levels and can be safely processed only in well-contained, heavily shielded hot-cell facilities. Treatment of process wastewater at the PWTP also produces an LW concentrate. Prior to 1984, both the PWTP concentrate and the concentrate produced by the evaporator were disposed of by the hydrofracture process, and since that time both have been stored in one of three 50,000-gal storage tanks located adjacent to the Low-Level Waste Evaporator Facility (Building 2531) or transferred to one of the eight 50,000-gal tanks located in the MVST vaults near the New Hydrofracture Facility. Since the LW concentrates can no longer be disposed of via the hydrofracture process, they are steadily filling the working volume of the 11 active storage tanks. The stored inventory of concentrate has now reached a level that has reduced the operational flexibility of the ORNL LW system. Projection of the current generation rate into the future indicates total depletion of the active storage capacity in the fourth quarter of FY 1989.

In addition to the inventory of LW concentrate in the active tanks, radioactive liquid and sludges are also stored in inactive LW tanks at ORNL. These tanks were used for varied periods throughout the history of ORNL to collect radioactive waste. Inactive LW tanks are now being managed by the ORNL Remedial Action Program (RAP), and plans have been developed for characterizing the contents of each tank to determine their regulatory status [e.g., Resource Conservation and Recovery Act of 1979 (RCRA) or non-RCRA materials].

The following two subsections describe the active and inactive LW tanks at ORNL, the available information on composition and volumes of stored material, and plans for additional characterization.

4.1.1 Active Tanks

The Evaporator Facility in Bethel Valley was designed with two 50,000-gal feed tanks (W-21 and W-22) and one 50,000-gal concentrate collection tank (W-23). Also in Bethel Valley, located adjacent to the Evaporator Facility, are two 50,000-gal tanks (C-1 and C-2), which were installed to store ORNL's high-level radioactive waste. Due to the need for additional storage capacity for LW concentrate and the lack of high-level waste at ORNL, tanks W-21, C-1, and C-2 were converted for storage of LW concentrate. These three tanks provide the nominal 150,000 gal of Bethel Valley LW storage capacity at ORNL.

In addition to the Bethel Valley storage tanks, eight 50,000-gal tanks are being used to store LW in Melton Valley. These tanks are located in the MVST vaults near the New Hydrofracture Facility and were installed to provide storage for waste awaiting disposal via hydrofracture.

Information on the location, function, and capacity of each of the active LW tanks described previously is summarized in Table 4.1. The total capacity of the 11 storage tanks is ~520,000 gal. Since the last

Table 4.1. Volumes and locations of active concentrate tanks

Location	Function	Tank designation	Actual storage capacity (gal)
Evaporator Facility	Storage	C-1	47,000
Evaporator Facility	Storage	C-2	47,000
Evaporator Facility	Storage	W-21	47,000
Evaporator Facility	Processing	W-23	None[a]
MVST[b]	Storage	W-24	47,000
MVST	Storage	W-25	47,000
MVST	Storage	W-26	47,000
MVST	Storage	W-27	47,000
MVST	Storage	W-28	47,000
MVST	Storage	W-29	47,000
MVST	Storage	W-30	47,000
MVST	Storage	W-31	47,000
		TOTAL	520,000

[a]Processing tank for evaporator and safety reserve.
[b]MVST vault near the New Hydrofracture Facility.

hydrofracture injection in January 1984, LW concentrate has been accumulated in the active tanks at the rate at which it has been generated. Information on the present inventory of stored concentrate is summarized in Table 4.2. The total volume of stored material (liquid and sludge) was 468,900 gal as of November 1, 1987. Also included in Table 4.2 are crude estimates of the volume of settled sludge in the MVSTs as of November 1985. In addition to the settled sludge, a significant quantity of dissolved solids is present in the stored solutions. The volume of additional solids that would be produced via precipitation of dissolved solids was calculated assuming these solids would have a settled specific gravity of 1.5 (Table 4.2). The total estimated volume of solids of both types in the present inventory is 195,300 gal.

The material currently stored is largely the high-activity LW concentrate and PWTP concentrate generated since 1984, with the exception of the sludges in the MVSTs. These sludges are largely heels from the last hydrofracture injection in 1984 and contain materials sluiced from the ORNL gunite tanks.

Most of the existing chemical and radionuclide data on the stored inventory are summarized in a report entitled *Characterization of Low-Level Liquid Waste at Oak Ridge National Laboratory*, ORNL/TM-10218, published in December 1986, and most of the solution characteristics summarized in this report were taken from that source.[1] Generally, the stored material is a highly basic, concentrated sodium nitrate solution that also contains lower concentrations of calcium and magnesium cations and hydroxide, carbonate, bicarbonate, chloride, phosphate, and sulfate anions. The tanks contain significant quantities of alpha-, beta-, and gamma-emitting radioisotopes. In addition to the high concentrations of neutralized salts and excess hydroxides and carbonates, the wastes contain smaller (but significant) amounts of a wide variety of chemical reagents, complexing agents, and other material. Thus, the potential waste treatment and solidification processes for application to these waste liquids will involve complex and unique chemistry. Other radiochemical facilities, such as those at Savannah River, Hanford, and Idaho, generate wastes that are similar, in general, but contain notably different chemicals and concentration levels. Future processing of this unique waste stream will be further complicated by the need for well-contained, heavily shielded hot-cell facilities due to the presence of significant quantities of alpha-, beta-, and gamma-emitting radioisotopes.

The alpha emitters include several TRU-waste isotopes. All settled sludge samples taken from the tanks had TRU-waste isotope concentrations >100 nCi/g. The highest concentration of TRU-waste isotopes (1200 nCi/g) was found in tanks W-29 and W-23 during investigations conducted in November 1985. Most samples taken from the upper regions of the tank indicated a concentration of TRU-waste isotopes <100 nCi/mL. The data indicate that the TRU-waste isotopes are concentrated in the settled sludge and that the concentration is above the limit required to classify

Table 4.2. Current inventory of concentrate in active tanks

Tank designation	Total volume[a] (gal)	Settled sludge[b] (gal)	Dissolved solids[c] (gal)	Total solids[d] (gal)
C-1	10,300	ND[e]	4,000	4,000
C-2	40,600	ND	15,600	15,600
W-21	21,900	ND	10,100	10,100
W-23	26,900	ND	10,300	10,300
W-24	46,000	3,600	14,200	17,800
W-25	46,700	14,600	10,700	25,300
W-26	46,300	7,500	14,600	22,100
W-27	47,000	7,500	9,100	16,600
W-28	45,800	1,100	14,600	15,700
W-29	46,000	3,600	13,400	17,000
W-30	45,600	3,600	14,000	17,600
W-31	45,800	9,800	13,400	23,200
TOTALS	468,900	51,300	144,000	195,300

[a]Volumes as of November 1, 1987, from Waste Management Operation Monthly Concentrate Report.

[b]Based on November 1985 investigations. Volumes may have increased due to additional precipitation and sedimentation.

[c]Calculated volume of dissolved solids, assuming precipitated solids would have a specific gravity of 1.5.

[d]Sum of calculated volumes of precipitated dissolved solids and measured settled solids.

[e]No data available.

the sludge as TRU waste (>100 nCi/g). Assuming all water present in the LW was evaporated in processing, it is estimated that the resulting solid waste would contain ~250 nCi of TRU-waste isotopes per gram of solids.

In addition to the alpha emitters, a number of beta and gamma emitters are present in the stored LW concentrate inventory. The beta emitter found in the tanks at the highest concentration is ^{90}Sr, and the highest concentrations of this radionuclide are present in the settled sludge. The second most abundant radioactive isotope is ^{137}Cs, which is present primarily in the supernate. In addition to ^{137}Cs, there are significant quantities of ^{60}Co and the europium isotopes. Some of the tanks have also been found to contain significant concentrations of ^{106}Ru and ^{95}Zr. In general, data on the radionuclide content within the tanks are more nearly complete than corresponding data on the chemical constituents.

Significant gaps exist in the present data on the tank contents. It is essential that these gaps be filled by additional sampling before a processing approach is selected, treatability studies are conducted, and processing facilities are designed. Additional data are needed in the following areas for each of the tanks:

- chemical composition (anions and cations),
- organic screening to determine quantities and types of organics,
- concentrations of RCRA materials,
- inventory of radionuclides, and
- physical characteristics of the settled sludge as related to sludge mobilization.

A sampling effort to support the EASC has included analyses of the contents of tanks W-29 and W-30 and should provide some of the needed data for these two tanks during FY 1988. In addition to the sampling of the existing waste inventory, analyses of newly generated LW concentrate and PWTP concentrate will be required to determine the effect of volume-reduction efforts on the characteristics of the concentrates.

In summary, the active tanks at ORNL are being filled steadily with LW concentrate, and no acceptable disposal method for the material is currently available. Major efforts have been undertaken in the last several years to reduce the rate of accumulation of LW concentrates. These efforts have significantly reduced the rate of LW generation; however, even with the present reduced generation rate of 26,000 gal/year, very little time is available for the implementation of LW concentrate processing options. Projection of the current generation rate into the future suggests total depletion of the active storage capacity in the fourth quarter of FY 1989. This projection, which assumes no action to further reduce generation rate or inventory, is illustrated in Fig. 4.1. Actions that are currently planned and additional ones that are proposed

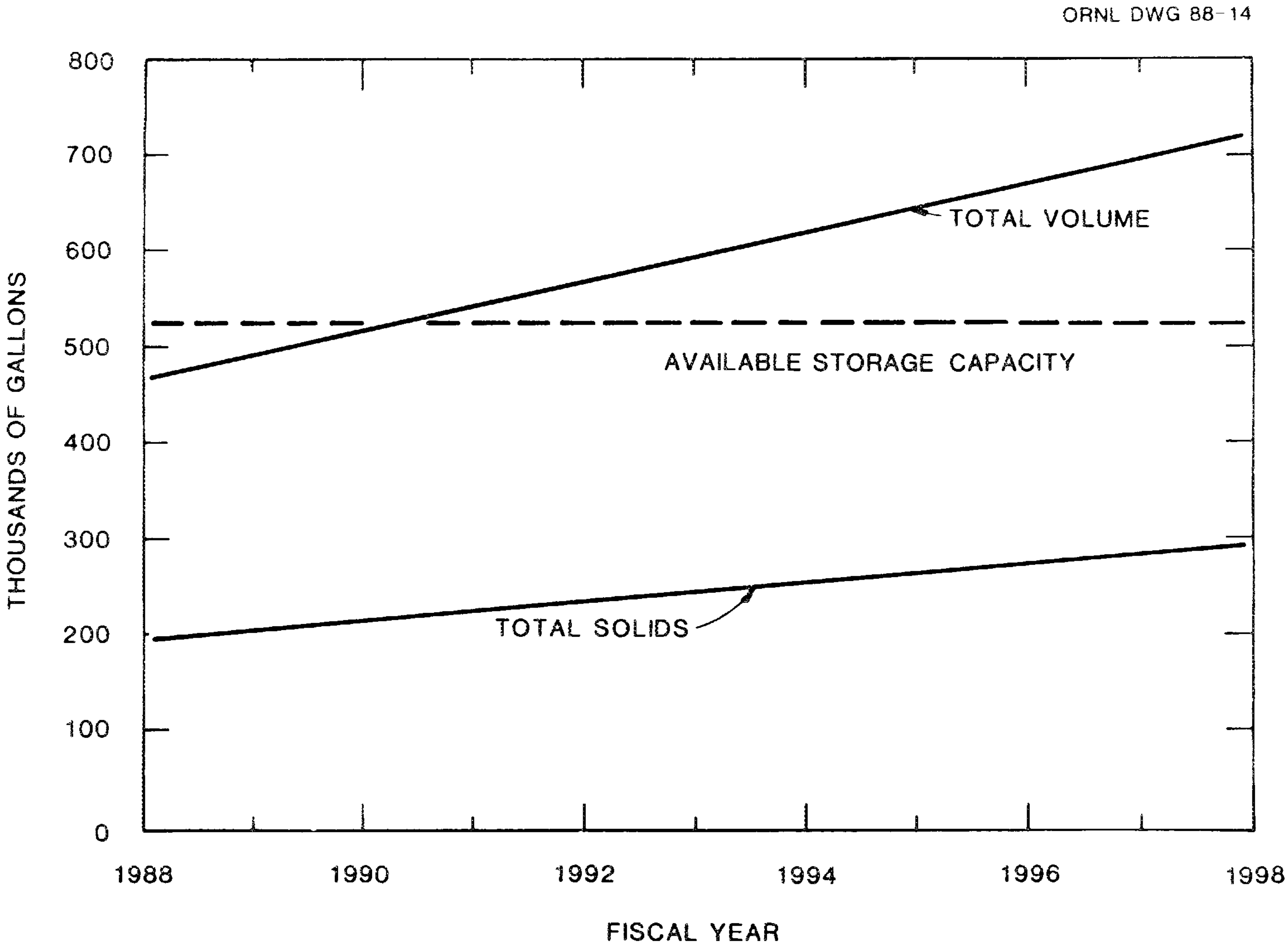

Fig. 4.1. Projection of concentrate volume in active tanks (no action).

in this document would reduce the projected future volume of stored LW. The impact of specific actions on the projected waste inventory will be illustrated in subsequent sections of this chapter via figures similar to Fig. 4.1.

4.1.2 Inactive Tanks

Thirty-three inactive underground LW storage tanks currently exist at ORNL and are being managed by the ORNL RAP. These tanks were used to collect and neutralize LW between 1943 and the time when they were taken out of service. Waste sources included radioactive sinks and drains located in R&D laboratories, radiochemical pilot plants, and nuclear reactors. In many cases the wastes contained within the tanks originated as nitrate solutions, although some contained acidic chlorides or other corrosives. To prevent tank corrosion, the acidic solutions were neutralized by the addition of sodium hydroxide (NaOH), which resulted in precipitation of some constituents. Sedimentation of the precipitate is assumed to have resulted in substantial decontamination of the liquid as well as accumulation of additional solid sludges within the tanks. Over the years, the 33 LW tanks were removed from service because of leaks that developed in the service pipelines leading to the tanks or in the tanks, because of groundwater infiltration, or because the tanks were no longer needed.

Generally, when a tank was no longer needed, the waste inventory was pumped out, leaving only residual quantities of solid, sludge, and liquid that exhibited varying levels of radioactivity. Precise information is not available regarding the chemical composition of materials remaining in the inactive tanks, and at least some of the tanks are suspected to contain small quantities of hazardous chemicals.

A documented sampling effort was performed on 27 of the inactive tanks in 1984 to identify and characterize the environment at each tank site and to estimate the radiological content and radiation levels in each tank. Results indicated that contaminated liquids and sludges remained in some of the tanks. A summary of existing information on the volumes of residual material in eachinactive tank is given in Table 4.3. The present total estimate of residual material in the inactive tanks is ~360,000 gal, which includes 27,000 gal of settled sludge. Assuming values for the concentrations of dissolved solids in the liquid phase based on past usage of each tank, an estimate of the total dissolved solids was calculated to be 15,000 gal on the basis of a specific gravity of 1.5 for the dissolved solids after these materials have been precipitated. Thus, the present crude estimate of the total solids (dissolved and settled) in the inactive tanks is 42,000 gal.

The estimated inventories of radionuclides in each tank range from <0.1 GBq to 310 TBq (several millicuries to several hundred curies). The contaminants are mainly ^{137}Cs and ^{90}Sr, with minor amounts of TRU elements. Radiation fields measured at the surface of the tank contents ranged from 0.15 to 6500 mR/h in 1984.

Table 4.3. Inventory of materials in ORNL inactive tanks

Tank designation	Sampling date	Liquid (gal)	Sludge (gal)
W-1A	1987	1,200	a
W-1	1984	1,025	0
W-2	1984	800	525
W-3	1984	22,000	4,200
W-4	1984	11,500	5,800
W-5	1986		2,550
	1987	8,150	a
W-6	1984		5,000[b]
	1987	74,500	
W-7	1984		2,050[b]
	1987	18,450	
W-8	1984		1,025[b]
	1987	32,100	
W-9	1984		0
	1987	24,700	
W-10	1984		0
	1987	95,300	
W-11	1984	265	45
W-13	1984	450	0
W-14	1984	125	0
W-15		a	a
W-19		c	
W-20		c	
TH-1	1984	475	0
TH-2		d	d
TH-3	1984	700	0
TH-4	1984	9,000	5,000
WC-1		d	
WC-15		a	a
WC-17	1984	950[e]	400
T-30		d	
7560	1987	0	f
7562	1987	Residual	g
T1	1987	9,750[h]	i
T2	1987	9,500[h]	i
T3	1987	1,800[h]	i
T4	1987	9,400[h]	i
T9	1987	2,100[h]	i
7860A	1987	0[e]	[a]
	Totals	334,640	26,595

[a]No data available.

[b]High-density sludge. Low-density sludge volumes are included with liquid volumes.

[c]No data available; believed to contain no liquid.

[d]No data available; assumed to contain liquid and sludge.

[e]Oil present.

[f]Believed to be none.

[g]Volume unknown.

[h]Liquid and sludge.

[i]Sludge depth unknown.

The ORNL inactive tanks have no immediate- or long-term reuse potential and will be decontaminated and brought to the status of regulatory closure. The preliminary plan for closure of tanks has been prepared. The draft plan includes several options for final closure. Removal of residual liquid and sludge from the tanks may be required as a part of closure activity. It would be desirable to handle the waste sludges and liquids from tank-closure activity in existing and planned ORNL waste management facilities to produce a solidified waste form adequate for final disposal.

The preliminary schedule for closure actions for the inactive tanks is illustrated in Fig. 4.2. The schedule indicates that the removal of residual material from the tanks would be initiated in FY 1991 and completed in mid-FY 1997. Due to lack of additional information, it was assumed that the total inventory in the inactive tanks would be removed at a constant rate during the 6.5 years between FY 1991 and mid-FY 1997. It was also assumed that the liquid from the tanks (groundwater in many cases) would be fed to the LW system and concentrated prior to being added to the concentrate inventory. This projected generation of LW concentrate from the tank closures (gal) has been added to the projected active tank inventory, and the resulting minor incremental effect is shown in Fig. 4.3. This figure includes consideration of all known ORNL sources of LW and sludges and assumes no further action to reduce waste generation or to process existing inventory. This projection obviously exceeds the ORNL capacity to store this material but provides a baseline against which the effects of proposed actions for reducing stored waste inventory can be compared.

The existing data on chemical and radionuclide characteristics of the residual material in the inactive tanks are not adequate to allow detailed evaluation of solidification options. It will be desirable to coprocess this material with material from the active tanks if the characteristics of the two streams are compatible, and this has been assumed to be the case during this study.

The RAP plans to conduct a sampling effort during FY 1988 to determine waste volumes and approximate waste characteristics for the inactive tanks to allow decisions on processing options. Solidification of the residual materials in the inactive tanks will be included in long-term management plans for LW and sludges.

4.2 NEAR-TERM OPTIONS FOR INCREASING AVAILABLE STORAGE VOLUME

4.2.1 In-Tank Evaporation

Past transfers of LW concentrate from the Evaporator Facility collection tanks to the MVSTs used a significant quantity of water for line rinsing to prevent solids buildup and possible line plugging. Thus, the concentrations of dissolved solids in the waste presently contained

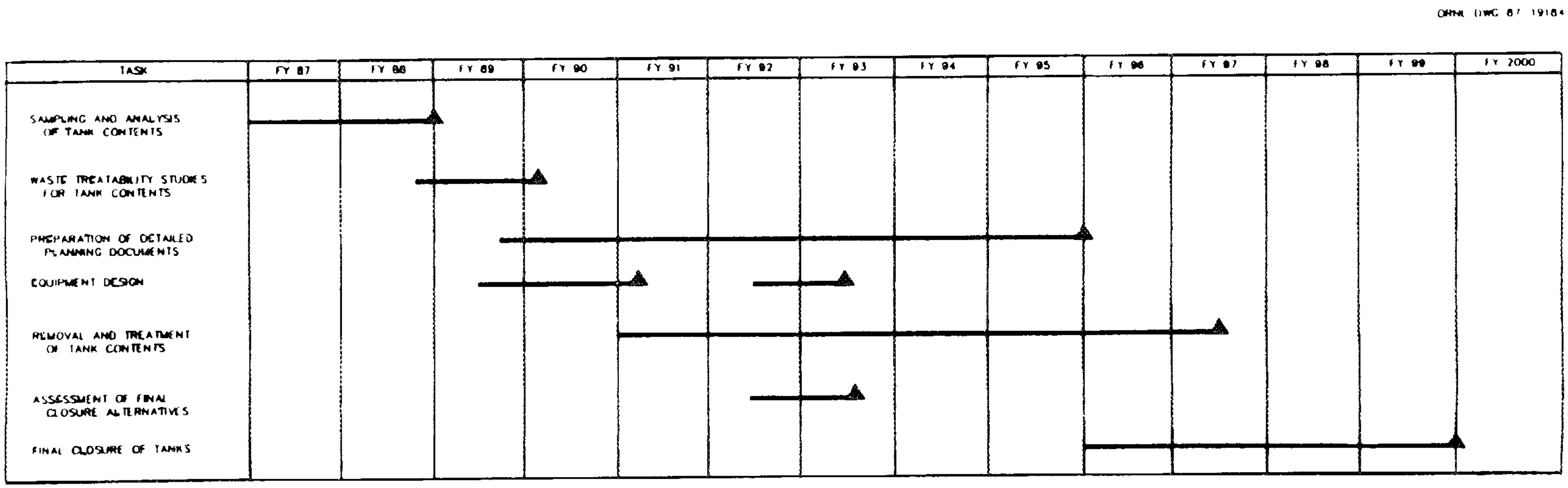

Fig. 4.2. Preliminary schedule for removal of contents of inactive tanks and final closure of tanks.

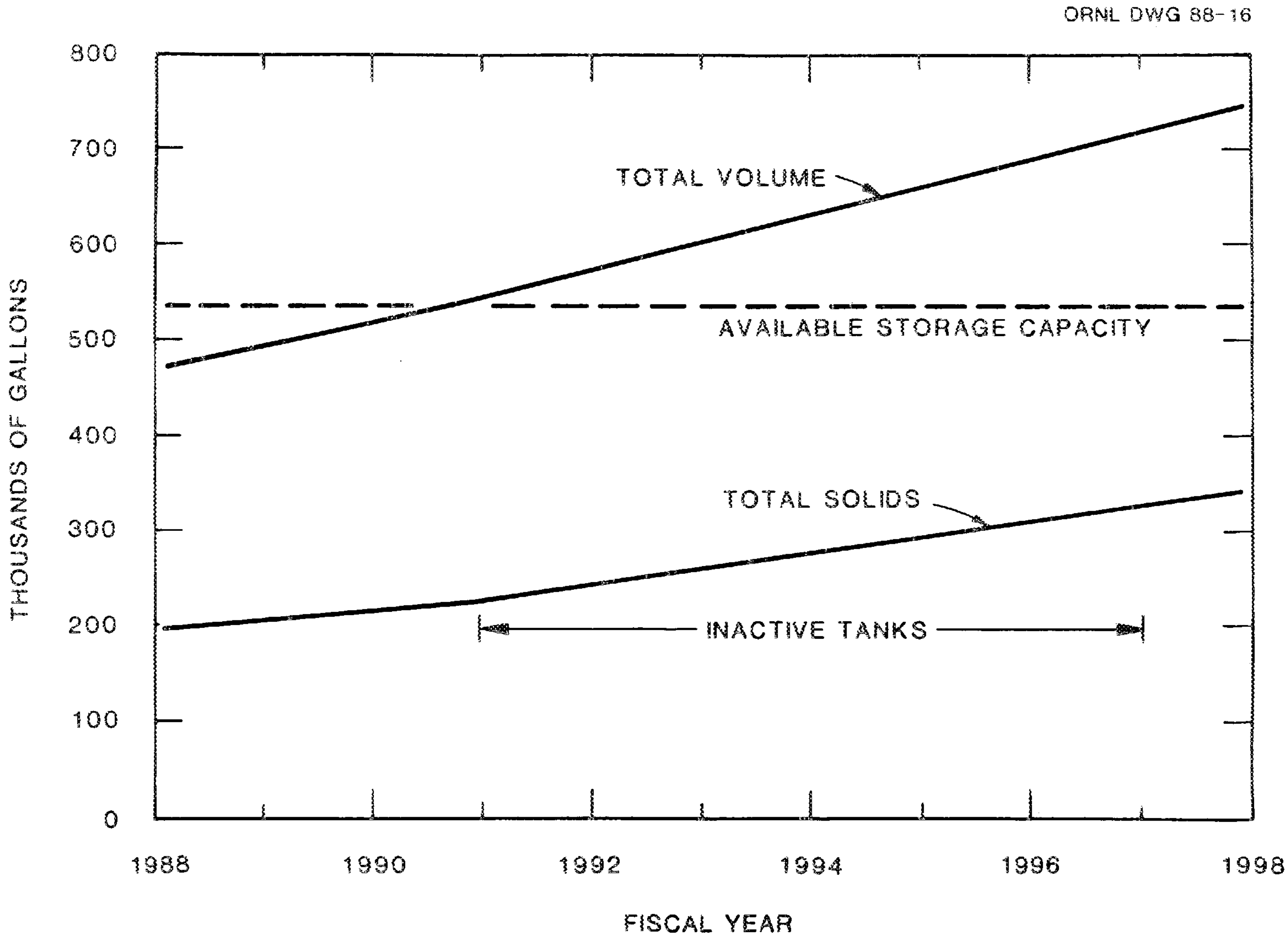

Fig. 4.3. Projection of concentrate volumes in active and inactive tanks (no action).

in the MVSTs are lower than the initial concentrations resulting from evaporation. Also, the evaporation limit is presently dictated by the maximum density of concentrate that can be removed by the jet transfer system. This density restriction limits the maximum dissolved solids content of the concentrate to a value well below the solubility of the dissolved solids. The concentration of dissolved solids presently in the tanks varies from ~250 to 550 g/L. A recent boildown experiment using the supernate from W-29 indicated that solids did not form until the dissolved solids concentration was increased to about ~900 g/L. Hence, evaporation of water from the MVSTs appears to be a viable short-term option for increasing the available LW storage volume without the precipitation of dissolved solids. Additional evaporation of water may be possible in the intermediate term if studies on the characteristics of the precipitate formed after the solubility limit is reached are favorable and if other considerations allow removal of additional water.

The MVSTs were designed with a tank ventilation system for purging radiolytic gases from the tanks. The purge air sweeps across the void space at the top of each tank at the rate of 100 ft^3/min. Each tank also has an alternate system for introducing an air sparge into the tanks for mixing the tank contents. The sparge system consists of five draft tubes into which air is introduced. The design rate of sparge air flow for tank mixing is also 100 ft^3/min and is subdivided to 20 ft^3/min per draft tube. The tank mixing system was operated continuously during the period when waste disposal via hydrofracture was being conducted. However, the capacity of the air compressors limits the sparge rate to less than ~20% of the design rate when all of the eight tanks are sparged simultaneously. The in-tank air sparging system has not been since the termination of hydrofracture operations, except during brief periods prior to taking samples from the tanks.

If the tank sparging system were operated on a continuous basis at the design rate of 100 ft^3/min, water could theoretically be evaporated from the tanks at an appreciable rate. An estimate of the maximum quantity of water that can be removed from a tank due to evaporation can be made by assuming that dry air enters the draft tubes and that this air is saturated when it leaves a given tank. At a saturation temperature of 50°F, 100 ft^3/min of air would remove ~3,000 gal of water from a tank over a period of 1 year, assuming an 80% on-stream time. At a saturation temperature of 90°F, the quantity of water removed increases to >10,000 gal per year per tank. Thus, if one considers air sparging of multiple tanks, then it is theoretically possible to evaporate water from the tanks at a rate equal to, or greater than, the presently estimated generation rate of LW concentrate being fed to these tanks (26,000 gal/year). Figure 4.4 shows the relationship between the predicted number of tanks that would have to be sparged to achieve the 26,000 gal/year water removal rate and the saturation temperature of the exit air.[2] Table 4.4 shows the cumulative effect, over time, of evaporation on the volume of waste in the MVSTs as a function of temperature and the number of tanks undergoing air sparging.

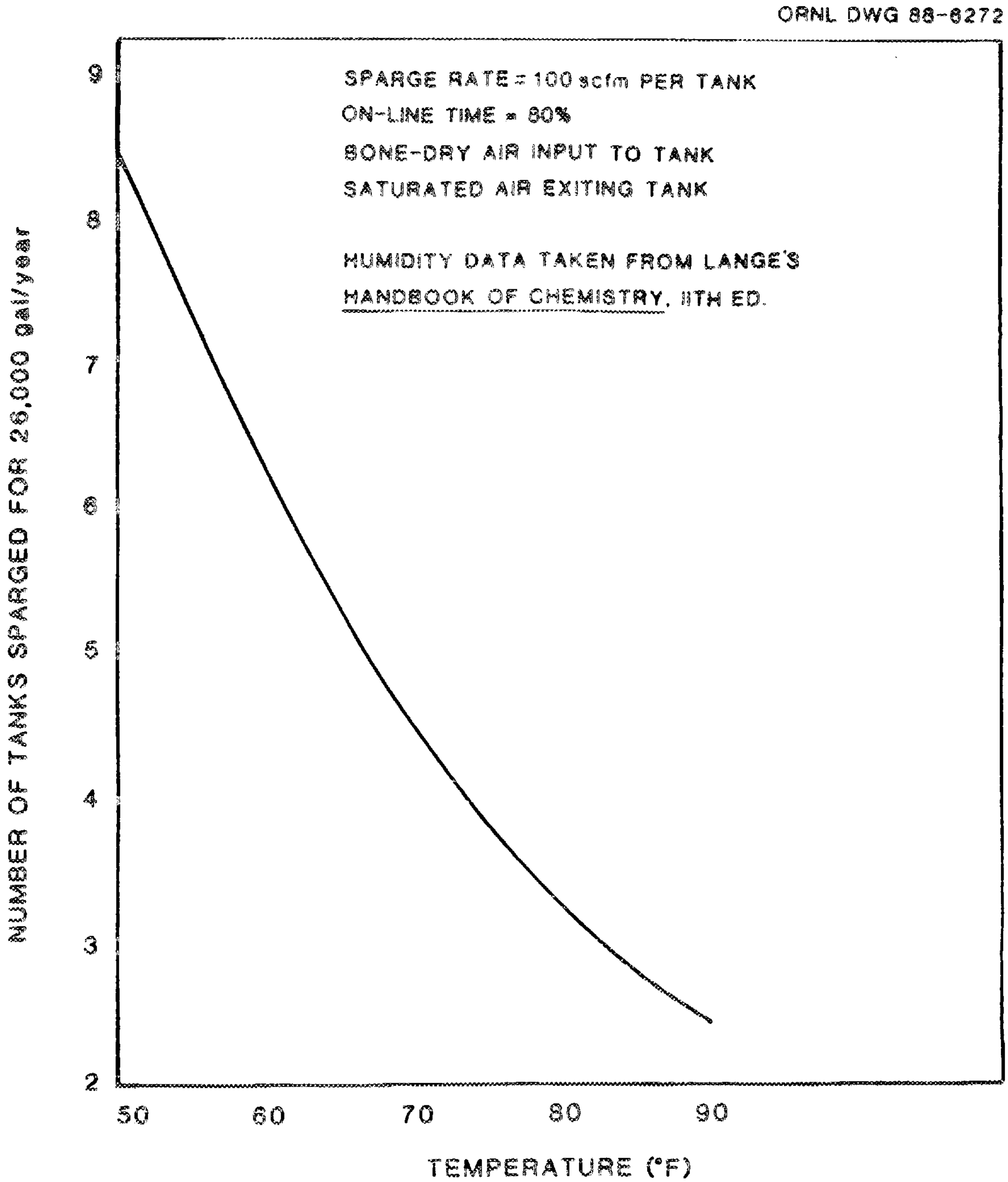

Fig. 4.4. Number of tanks requiring sparging as a function of temperature.

Table 4.4. **Cumulative waste volume as a function of the number of tanks undergoing evaporation and the temperature of evaporation**[a]

Year	Temp. (F)	Cumulative waste volume (gal) based on number of tanks undergoing evaporation				
		0	2	4	6	8
0	50	468900				
1	50	494900	488740	482580	476420	470260
2	50	520900	508580	496260	483940	471620
3	50	546900	528420	509940	491460	472980
4	50	572900	548260	523620	498980	474340
5	50	598900	568100	537300	506500	475700
6	50	624900	587940	550980	514020	477060
0	60	468900				
1	60	494900	486540	478180	469820	461460
2	60	520900	504180	487460	470740	454020
3	60	546900	521820	496740	471660	446580
4	60	572900	539460	506020	472580	439140
5	60	598900	557100	515300	473500	431700
6	60	624900	574740	524580	474420	424260
0	70	468900				
1	70	494900	483280	471660	460040	448420
2	70	520900	497660	474420	451180	427940
3	70	546900	512040	477180	442320	407460
4	70	572900	526420	479940	433460	386980
5	70	598900	540800	482700	424600	366500
6	70	624900	555180	485460	415740	346020
0	80	468900				
1	80	494900	478960	463020	447080	431140
2	80	520900	489020	457140	425260	393380
3	80	546900	499080	445380	403440	355620
4	80	572900	509140	445380	381620	317860
5	80	598900	519200	439500	359800	280100
6	80	624900	529260	433620	337980	242340
0	90	468900				
1	90	494900	473340	451780	430220	408660
2	90	520900	477780	434660	391540	348420
3	90	546900	482220	417540	352860	288180
4	90	572900	486660	400420	314180	227940
5	90	598900	491100	383300	275500	167700
6	90	624900	495540	366180	236820	107460

[a]Assumes 468,900 gal of waste at year zero and 26,000 gal of waste per year added to the system.

The eight MVSTs are located in two vaults. Each vault has a ventilation system that moves 1400 ft^3/min of air through it. The average temperature of the vault and tanks relative to the adiabatic saturation temperature of the incoming atmospheric air results in condensation in the vault sump for a significant fraction of the year. The same phenomenon of condensation collection occurs within the tanks as they are presently operated because the tank sparge air is not dried before being fed to the system.

The present tank off-gas system consists of the exit piping, a demister, a heater, filters, an exhauster, and a local stack as shown in Fig. 4.5. The purpose of the demister is to remove entrained liquids and return them to one of the waste storage tanks. The piping arrangement of the return line for this liquid does not contain a sample point, and no sample has ever been collected. Radiation readings indicating fields of ~20 to 30 mR/h have, on occasion, been detected at the exterior surface of the demister. The off-gas heater is required to prevent condensation from interfering with the operation of the high-efficiency particulate air (HEPA) filters. To achieve the desired reduction in the tank volumes by evaporation, it will be necessary to increase the temperature of the tanks and vaults from 50°F to about 90°F and to insulate the off-gas piping external to the vaults. The air-compression capability will need to be increased sufficiently to permit operation of all of the spargers at the design rate. Additionally, an air-drying system(s) may be required to lower the humidity of the air fed to the void space of the tanks to maximize the rate of evaporation of water.

Assuming a staged implementation of systems to enhance the evaporation rate, we estimated the effect of in-tank evaporation (shown in Fig. 4.6). This preliminary estimate indicates that a significant inventory reduction could be obtained using in-tank evaporation. The evaporation scenario in Fig. 4.6 represents a "likely" case and is based on theoretical calculations and estimates of evaporation limits that require experimental verification. It appears that in-tank evaporation can maintain the waste volume in the tanks at roughly the present volume until about the beginning of FY 1995, assuming that LW concentrate continues to be generated at the rate of 26,000 gal/year.

4.2.2 Emergency Avoidance Solidification Campaign

In October 1985, ORNL informed DOE-Oak Ridge Operations (ORO) management that obtaining a permit to operate the ORNL Hydrofracture Facility would not be possible in the time frame required to prevent total depletion of storage space in existing LW storage tanks. Contingency planning was initiated, and several alternatives were considered, including construction of additional LW storage tanks. In October 1986, ORNL and DOE-ORO management selected both a "reference" and a "backup" flow sheet for processing the accumulating LW in the nearly full storage tanks.

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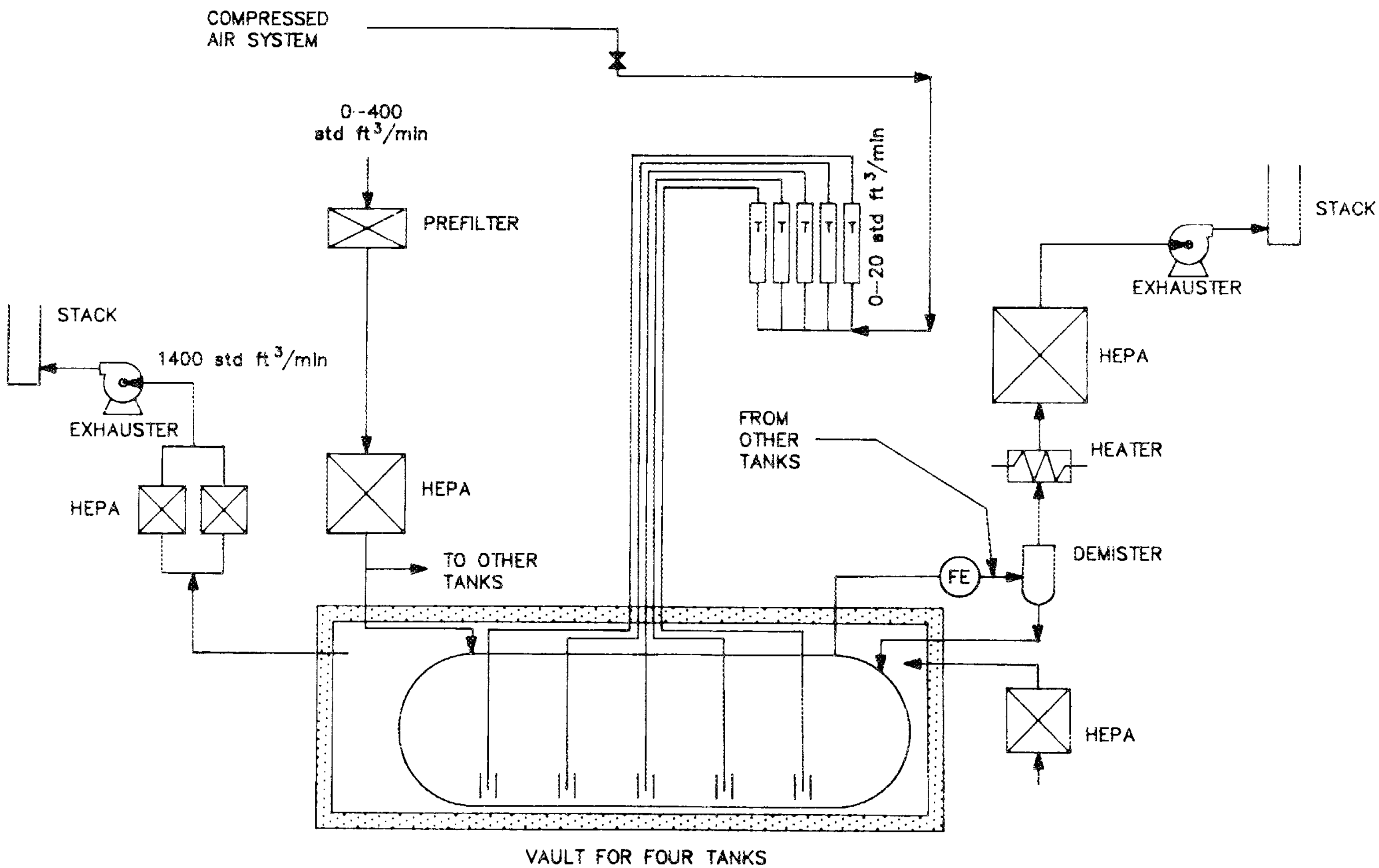

Fig. 4.5. Schematic of present Melton Valley Storage Tank off-gas system.

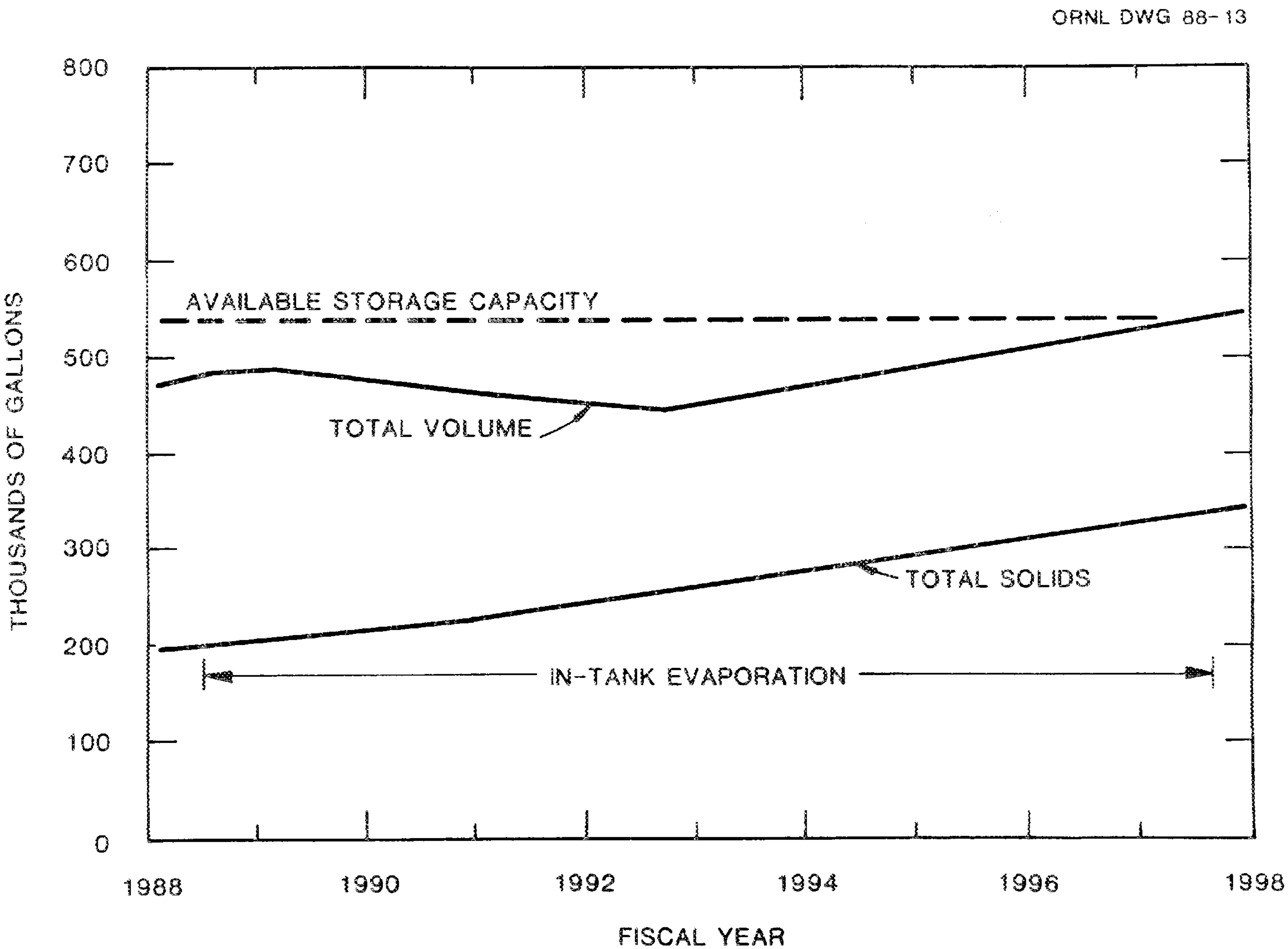

Fig. 4.6. Effect of in-tank evaporation on total inventory.

The reference flow sheet is mainly a three-step process consisting of cross-flow filtration and zeolite decontamination followed by a suitable immobilization process. Cross-flow filtration would provide a positive means of ensuring that any TRU sludges were removed, and zeolite decontamination would remove most of the soluble cesium and strontium. The resulting CH waste would have been immobilized in either bitumen or cement by a commercial firm using mobile systems. Subsequently, it was decided that immobilization via bitumen would not be utilized.

When the reference flow sheet was selected, it was recognized that system constraints, namely funding and technology applications work, could yield a situation whereby the reference flow sheet could not be deployed soon enough. Accordingly, a backup flow sheet was defined which is based on decanting liquid from the tanks and immobilizing the high-activity liquid in cement without the benefit of cross-flow filtration or supernate decontamination to reduce the activity of the waste being solidified. Decanting the liquid was judged to be available technology that required no additional development effort. In addition, the backup approach was judged to have lower capital costs relative to the reference process and, therefore, could be deployed in the near term.

The EASC is a project that will utilize the backup flow sheet for the immobilization of 50,000 gal of waste from the MVSTs. The project elements for the EASC include (1) the services of a commercial subcontractor who will immobilize the decanted liquid in a cement-based matrix after individual batches of the decanted liquid have been analyzed to ensure that the supernate is LLLW rather than TRU waste; (2) facilities for decanting the liquid from one of two of the MVSTs (W-29 and W-30) and for transfer of the liquid to the vendor's system, a structure for containment of the vendor's system during liquid processing, and disposal units for the cement-based waste forms; and (3) supporting documentation for regulatory, environmental, quality, safety, and operational aspects.

LN Technologies has been selected as the primary qualified source for the on-site solidification of the waste, and Chem-Nuclear has been selected as the alternate should the primary source be unable to respond in time. Both firms have demonstrated experience with the in-container solidification of typical nuclear power station radwaste in cement and have Nuclear Regulatory Commission-approved topical reports covering their mobile solidification system. Contracts have been signed with both the primary and the alternate solidification sources to proceed with waste-form demonstration work to certify that their waste form meets the performance requirements of 10 CFR 61 and that the waste form will yield a minimum leach index of eight for nitrates.

Following certification of the surrogate waste forms from the primary and alternate vendors, the primary vendor's system may be mobilized and may undergo cold checkout operations at ORNL, provided it is available. Should the primary source not be able to respond, the secondary source's solidification system will be brought in. During the cold checkout of the project, the vendor would supply the full complement of actual equipment and produce two liners (~6-ft-diam and 6-ft-tall right cylinders made of carbon steel and in which the waste is solidified) of nonradioactive waste forms using a surrogate LW that approximates the chemical composition of the actual waste. Hot operations would follow the successful completion of cold checkout operations.

Construction of the needed capital facilities via two General Plant Projects (GPPs) has been completed at the MVST facility to support the EASC-LLLW Solidification Facilities (FY 1986 Waste Management GPP) and the MVST Decant System (FY 1987 Waste Management GPP). Construction and checkout of the capital facilities were completed on schedule in April 1988.

The first of these GPPs (LLLW Solidification Facilities, total estimated cost of $830 thousand) provides a containment structure and supporting utility services for the vendor's mobile solidification process. The structure is a preengineered metal building ~3 ft wide by 60 ft long by 33 ft tall. It is insulated and well sealed to provide for negative pressure operations with a HEPA filtration system. The building floor is 1-ft-thick reinforced continuously poured concrete, which is sealed with an epoxy coating. Electrical services were extended to the building, and a new distribution system was provided for pumps, fans, monitoring equipment, lights, and outlets. A new dry-pipe sprinkler system was installed for fire protection. Process water was provided from existing services in the general area.

The second GPP (MVST Decant System, total estimated cost of $510 thousand) provides a pumping and piping system from the MVST facility to decant the LW from the tanks and transfer it to the vendor's system. The decant system consists of a pump module (a shielded stainless steel box containing the transfer pump and associated process valving) that is located above the MVST, dip pipes extending to the centerline of tanks W-29 and W-30 (well above the sludge region of the tanks), ~200 ft of 1-in.-diam stainless steel pipe contained inside a 2-in.-diam stainless steel pipe, a pressurized-annulus leak-detection system for the double-walled piping system, new liquid-level monitors, and instrumentation.

The immobilized waste from the solidification facilities will be transported from the containment structure at the MVSTs inside a DOT-approved shipping cask to a suitable interim storage facility. A number of storage options are being pursued. Many of the options would entail emplacement of each liner of solidified waste in a concrete shielded cask. The exact number of liners produced during the EASC will depend on the vendor's particular cement-based formula, which may yield from 60 to 80 liners, depending on the final waste loading.

The costs for solidification of 50,000 gal of LW via the first EASC and possible follow-on campaigns are presented in Table 4.5.

Table 4.5. **Estimated costs for solidification of 50,000 gal of LW via the first EASC**

Activity	Costs ($1000) First campaign	Costs ($1000) Follow-on campaigns
Solidification		
Waste-form certification	200	100
Solidification (O&M)	1500	1500
	1700	1600
Interim storage		
casks (70 @$6500 ea)	460	0
O&M	480	400
	940	400
Transportation (@$10,000/round trip to NTS)	700	700
Disposal (@$40/CF)	470	470
Project planning		
Permit-by-rule	200	200
Test plans and procedures	120	20
Safety	150	30
Quality plan	40	10
Operating procedures	140	30
As-built drawings	70	10
Supporting systems	300	100
Project management	280	140
Storage plans	280	
	1580	540
Capital facilities		
LW solidification facilities	830	
MVST decant system	510	
General plant equipment	300	100
	1640	100
TOTAL	7030	3810

While EASC will solidify 50,000 gal of LW, the net reduction in system concentrate inventory is the difference in the quantity solidified or removed by other means and the quantity of LW concentrate generated during the period. Assuming that EASC requires 6 months for solidification and that concentrate generation is ~26,000 gal/year, the net reduction in total tank inventory from conduct of the EASC will be ~37,000 gal. The effect of conducting the initial EASC, in addition to the previously discussed effect of in-tank evaporation on the total waste inventory, is illustrated in Fig. 4.7.

4.3 TREATMENT AND DISPOSAL OF ORNL TRU WASTES

4.3.1 National TRU Program Activities

The goal of the DOE TRU Waste Program, as stated in the *Long-Range Master Plan for the Defense Transuranic Waste Program*, DOE-JIO-023, is to end interim storage and to achieve permanent disposal of TRU waste.[3] To reach this goal, the WIPP has been developed as a geologic repository for TRU wastes in a salt formation ~2000 ft underground near Carlsbad, New Mexico. WIPP is scheduled to start initial operations with actual waste in October 1988. The first 5 years of operation is scheduled as a demonstration period, during which all the waste emplaced at WIPP will be fully retrievable. At the end of that period (September 1993), assuming that the concept of disposal via the geologic repository has been demonstrated satisfactorily, WIPP will be converted to a permanent disposal repository and TRU waste will be permanently emplaced for the remaining planned operational life of the project (through 2013). TRU waste is defined as radioactive waste that is contaminated with alpha-emitting transuranium radionuclides having half-lives >20 years in concentrations >100 nCi/g. CH-TRU waste is defined as having a surface dose rate no greater than 200 mR/h. RH-TRU waste is defined as having a surface dose rate >200 mR/h.

The underground layout at WIPP consists of a large number of rooms that have been constructed via excavation of salt from the geologic salt deposit. The rooms are about 33 ft wide, 300 ft long, and 14 ft high and are separated from each other by a 100-ft wall of virgin salt. The RH-TRU will be emplaced in cavities to be drilled into the walls of the rooms, and CH-TRU waste will be stacked in the middle of the rooms in 55-gal drums and boxes. The number of rooms and the planned capacity of WIPP are determined by the volume of CH-TRU waste in storage at various DOE sites and currently being generated within the DOE system. During the demonstration phase of WIPP operation, RH-TRU waste will be emplaced within WIPP in sealed canisters having a waste volume of 1 m^3. Because WIPP will have the capability to handle RH-TRU waste only in canisters during the demonstration phase and because RH-TRU waste would be transported to WIPP in canisters during this period, many planning and operational aspects of the RH-TRU Program currently use the RH-TRU canister as the reference unit of RH-TRU waste volume. Three 55-gal

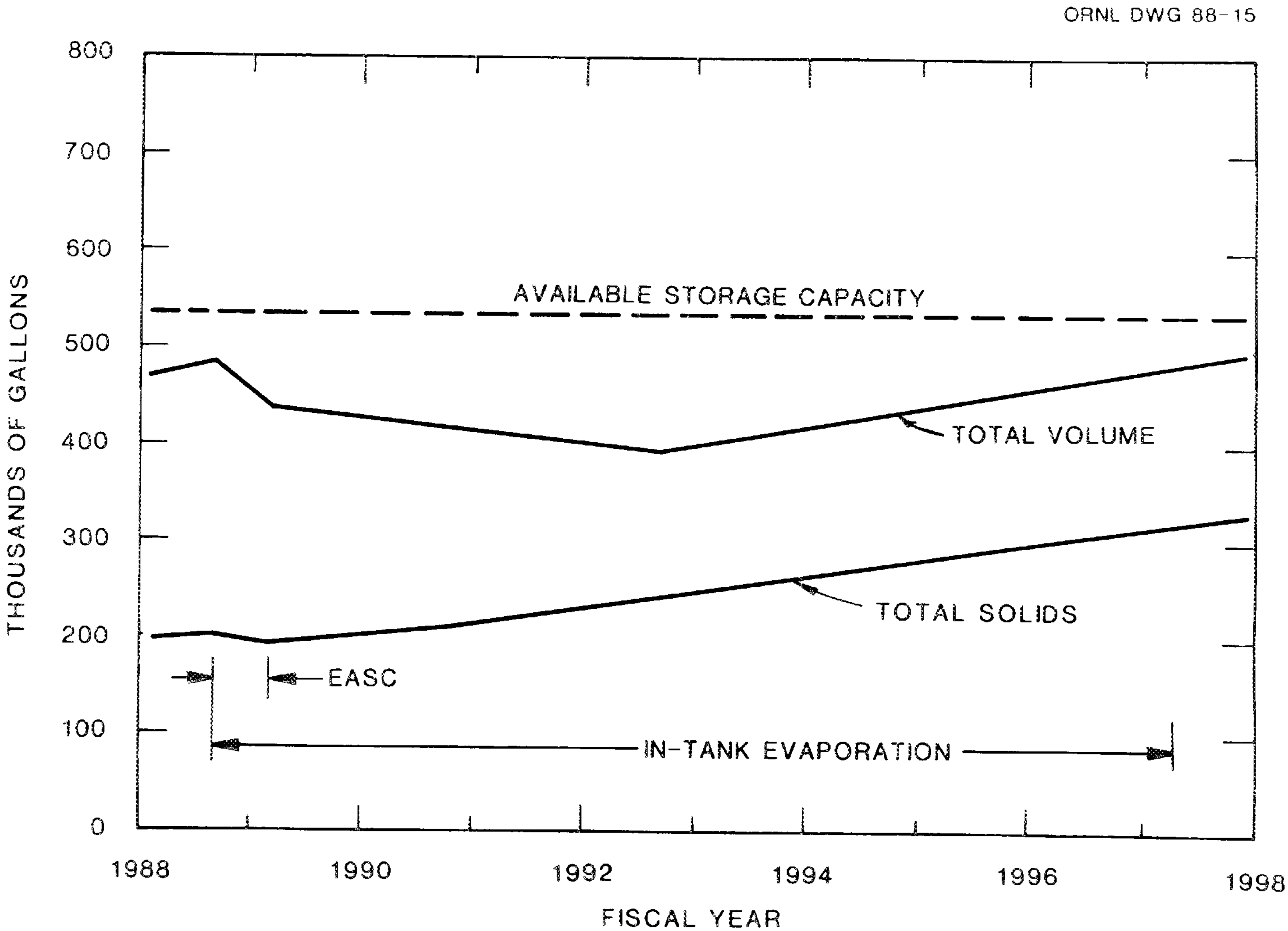

Fig. 4.7. Effects of Emergency Avoidance Solidification Campaign and in-tank evaporation on total inventory.

drums can be placed within an RH-TRU canister. As documented in the *Defense Remote-Handled Transuranic Waste Cost/Schedule Optimization Study*, DOE-JIO-017, the planned capacity of WIPP provides space for ~5000 canisters of RH-TRU waste.[4] The planned receiving rate for RH-TRU waste at WIPP during permanent disposal operations is 250 canisters per year for 20 years. Of this capacity, about 3300 canisters are projected to be used by the RH-TRU wastes currently in storage or to be generated at ORNL through the year 2013. Of these 3300 canisters, 1526 were projected to result from solidification of the RH-TRU sludges stored in active and inactive LW tanks at ORNL. Because three 55-gal drums can be loaded into one RH-TRU canister, this is equivalent to 4578 drums of solidified sludges. The remaining 1474 canisters of ORNL RH-TRU wastes are projected to result from repackaging other RH-TRU solid hot-cell waste that is currently stored at ORNL.

To be accepted at WIPP, TRU waste must be certified as meeting the WIPP-WAC, which is documented in WIPP-DOE-069.[5] The WIPP-WAC can be summarized as requiring that the TRU waste must be in approved containers; it must contain no free liquids, no explosives, or compressed gases; particles having a diameter <10 microns must be less than 1 wt % of the waste; and particles <200 microns in diameter must be <15 wt %. There are also limits on weight, surface contamination, thermal power, fissile content, and Pu equivalent activity. The presence of organics and RCRA hazardous wastes must be identified and quantified, but these materials are not prohibited. The total quantity of radioactivity that is allowed is 23 Ci/L, which is ~5000 Ci per 55-gal RH-TRU waste drum. Previous studies by the DOE TRU Program have shown that decontamination of RH-TRU wastes relative to associated fission products is not cost-effective and this practice would not, in general, be funded by the DOE TRU Program.

The transportation cost for shipping RH-TRU waste by truck from ORNL to WIPP is projected to be ~$5300 per trip, according to DOE-JIO-017. It is proposed that the waste generator pay this operational cost. A shipping cask that will transport one RH-TRU canister is currently being designed and should be operational by January 1989. The cost of acquiring the shipping casks and managing the transportation network that will route and maintain the fleet of RH-TRU and CH-TRU casks will be borne by the national DOE TRU Program. It is proposed that, after the demonstration period is completed, WIPP will accept RH-TRU waste in 55-gal drums, similar to CH-TRU, because previous studies have shown this approach to be much more cost-effective than continued use of RH-TRU canisters. An RH-TRU drum cask has been proposed that would contain 14 RH-TRU waste drums and would be available in 1994. In this case, the freight cost of $5300 would be the same per shipment; however, the payload would be 14 drums rather than the 3 that will fit in an RH-TRU canister. This increase in efficiency is one of the reasons that the RH-TRU drum cask is being pursued, as well as the fact that some DOE sites do not have the facilities to load and weld the RH-TRU canisters. The operational cost of emplacing one RH-TRU canister at WIPP is projected to be ~$1000, and this cost will be borne by the TRU Program.

In summary, it is particularly important to note the following aspect of WIPP-WAC and expected mode of operation:

> The present and envisioned WAC place no leach-resistance requirements on the RH-TRU waste form in contrast to the stringent leach criteria associated with disposal of high-level waste. This results largely from the fact that the bulk of the DOE Defense Program TRU wastes to be disposed at WIPP are already in existence and from the recognition that it would be impractical to convert these wastes to a form having high leach resistance.

4.3.2 ORNL Waste Handling and Packaging Plant

The ORNL WHPP is proposed as an FY 1991 capital-line item that would retrieve, process, repackage, and certify RH-TRU waste and special-case (SC) TRU wastes for shipment to WIPP. The WHPP would process all RH-TRU wastes stored at ORNL as well as newly generated RH-TRU waste from ORNL and small amounts of RH-TRU waste from other DOE sites such as Argonne National Laboratory, Idaho National Engineering Laboratory, and the Hanford Reservation. WHPP would be the only facility of its kind within the DOE system for processing RH-TRU and SC TRU wastes that can be shipped but require certification or repackaging before shipment to WIPP. The conceptual design of the WHPP began in FY 1988, and Title II design will be initiated in FY 1991. Construction is scheduled to start in FY 1992, and operations are scheduled to begin in FY 1996.

The projected impact of waste processing by WHPP on the total inventory of liquid contaminated waste is shown in Fig. 4.8. The WHPP would complete solidification of the inventory of the active and inactive tanks during FY 1996 through FY 2012. It was assumed that systems modifications would be implemented by the end of FY 1997 to render the "newly" generated LW non-TRU, one LW tank would have been emptied via WHPP operation, and modifications would have been completed to collect newly generated LW separate from the inventory containing RH-TRU materials such that the newly generated LW would not be disposed of at WIPP via WHPP. Further discussions of systems modifications and non-TRU LW are presented in Sect. 4.4.

4.4 LONG-TERM MANAGEMENT OF ORNL LW

The LW system (Fig. 4.9) at ORNL is used to collect, neutralize, concentrate, and store aqueous radioactive waste solutions from various sources. Waste solutions from facilities discussed in Sect. 4.4.1 are transferred to one of two evaporators in which the aqueous solution is concentrated. The volume of the solution in the evaporator is reduced until a predetermined specific gravity, which ranges from 1.25 to 1.5 (depending on current system capacity), is reached. The concentrate is then transferred to a 50,000-gal stainless steel storage tank. As discussed previously, there is limited storage capacity in the active LW

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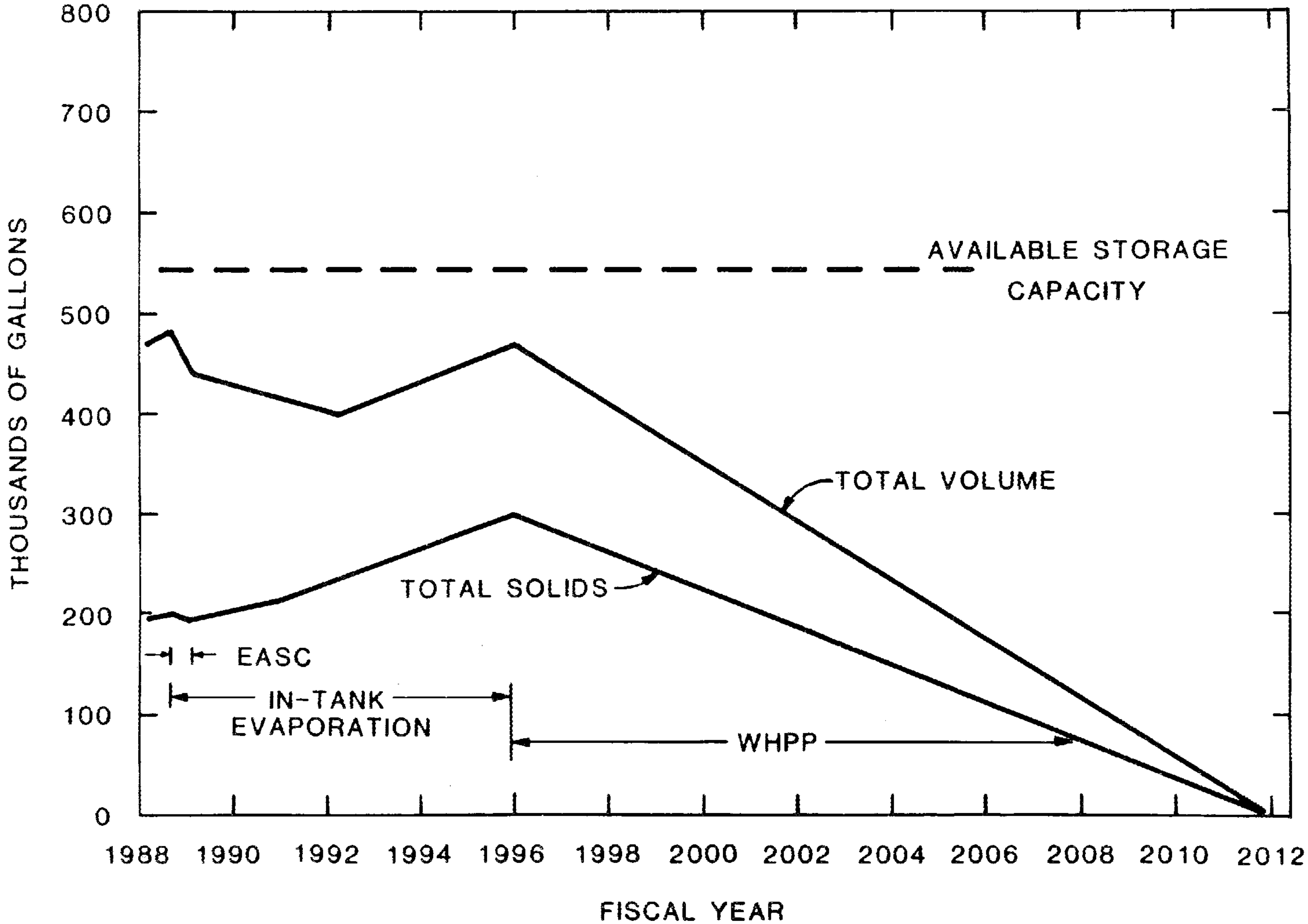

Fig. 4.8. Effects of Emergency Avoidance Solidification Campaign, in-tank evaporation, and WHPP processing on total inventory.

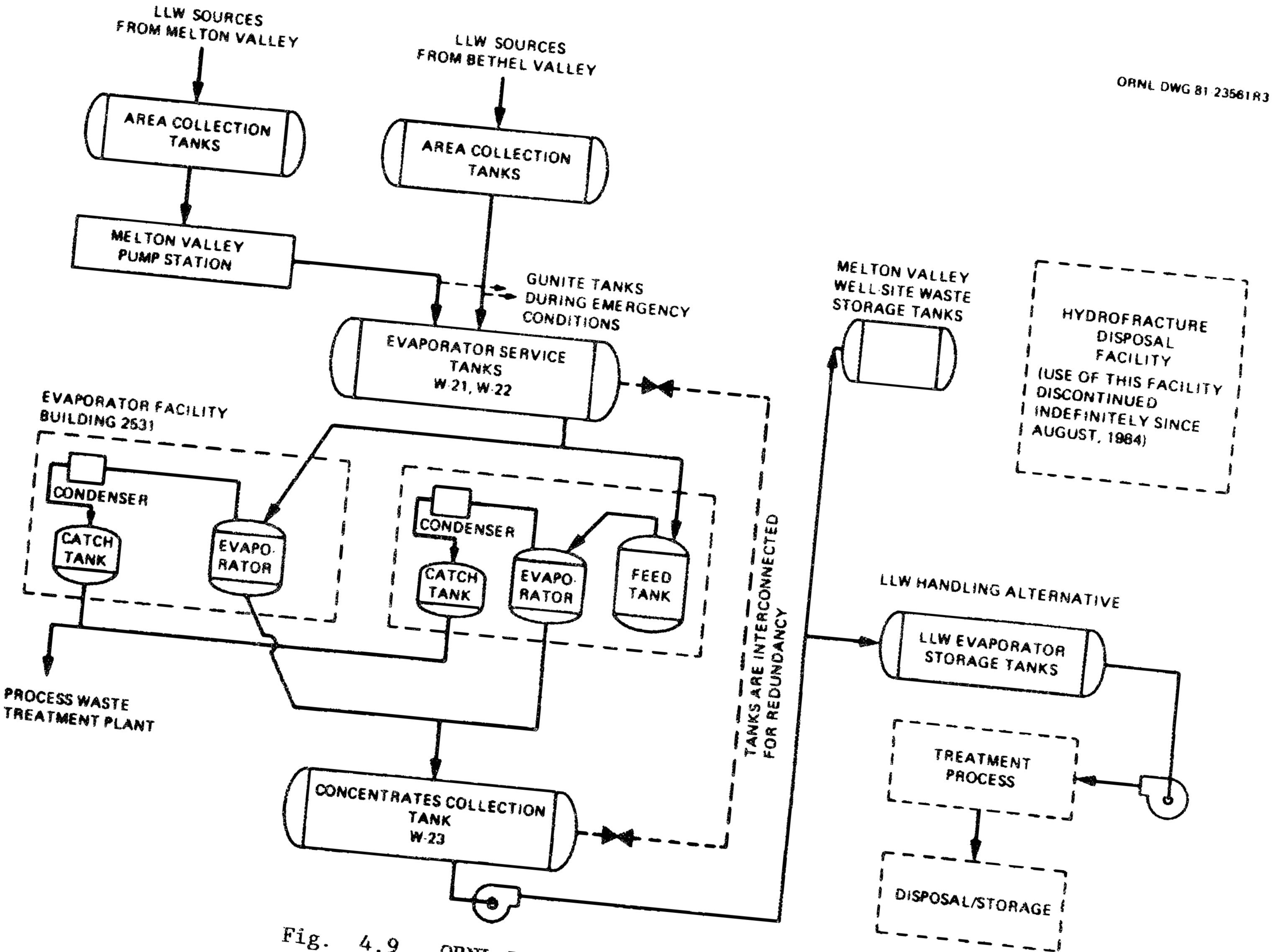

Fig. 4.9. ORNL liquid waste system.

tanks. The cumulative effect of various system modifications is described in terms of the estimated reduction in LW concentrate-generation rate in the remainder of this section.

Long-term management of LW will be guided by a continuing systems analysis that will integrate the effects of all aspects of the strategy and program plan. The analysis will include consideration of the effects of achieving each of the goals of the program plan: (1) near-term options to improve operational flexibility of the LW system; (2) options to remove the legacy of LW liquids and sludges from the active and inactive tanks; and (3) options for long-term management of LW generation, treatment, and disposal so that waste streams are properly segregated and a legacy for future management is not created.

Modification of LW sources and the subsequent manner of LW collection provides the means for affecting significantly the future LW generation rate and waste composition as discussed in Sects. 4.4.1 and 4.4.2. Two long-term options have been compared: (1) segregating waste streams according to WAC and (2) operating a system with combined waste streams and treating the waste to achieve compliance with WAC for solidified waste (see Sects. 4.4.3 and 4.4.4).

4.4.1 Potential Improvements to LW System

The volume and composition of dilute LW vary by waste generator as shown in Table 4.6. An initial systems analysis was conducted to determine the effects of the 1984 waste minimization program; these effects are reflected in the 1987 generation rates. Waste management practices have been changed in areas where the cost of change has been low and the resulting gains have been large. In contrast, a continuing systems analysis will be conducted to analyze costs, benefits, and risks in order to identify process changes that will require capital funds. Modification of LW sources and collection is a significant aspect of long-term LW management because the strategy to use WHPP as the primary means for implementing LW treatment and disposal requires confidence in ORNL's ability to further reduce the generation rate of LW prior to WHPP becoming operational.

The present systems analysis is being conducted with the following constraints and criteria in mind:

1. Waste minimization will be most effective when the solids content, nitrate content, and TRU constituents of LW are reduced at the source.

2. The effect of reducing LW volumes is important.

3. Capital projects that have been initiated will be continued, and the impact of these projects on waste generation rate and composition will be included in the systems analysis.

Table 4.6. LW generation rates

Building area	Generation rate (gal/week) 1984	1987	1987 (%)
3039 Stack area		822	12
Oak Ridge Reactor/Bulk Shielding Reactor (BSR)	3277	808	12
Fission Products Development Laboratory (Bldg. 3517)	2930	797	12
High Flux Isotope Reactor (HFIR)	3000	654	10
Building 3019		461	7
Radioisotope production lab. B (Bldg. 3026-C)		416	6
High-radiation-level examination lab. (Bldg. 3525)	831	406	6
Isotopes area	1754	324	5
Abandoned tank W1A	1938	261	4
Transuranium Processing Plant (TPP) (Bldg. 7920)	571	240	4
Examination hot cells (Bldg. 3026-D)		152	2
High-radiation-level engineering lab. (Bldg. 3025)		118	2
Solid state lab./hot cells		117	2
PWTP dilute (Bldg. 3544)		113	2
PWTP concentrate (Bldg. 3544)	6877	91	1
Pump pit		87	1
Nuclear Safety Pilot Plant (Bldg. 3074)		51	1
Interim Manipulator Repair Facility (Bldg. 3074)		48	1
FPDL annex (Bldg. 3505)		33	1
High-radiation-level analytical lab. (Bldg. 3508)		31	0
Chemical Technology alpha lab. Bldg. 3508)		30	0
Radioisotope production lab. A (Bldg. 3028)		20	0
Geosciences lab. (Bldg. 3504)		13	0
4500 Complex			
Chem Tech (WC-11)		218	3
Chem Tech (WC-12)		47	1
Chem Tech (WC-14)		35	1
ACD, M&C, Chem[a] (WC-13)		246	4
Totals	**21278**	**6639**	**100**

[a]ACD = Analytical Chemistry Division; M&C = Metals and Ceramics Division; Chem = Chemistry Division.

4. Waste minimization will be most effective when the impact on the downstream waste form is considered.

5. The R&D capabilities of ORNL will not be affected by waste minimization projects.

6. No new storage tanks for concentrated LW will be constructed.

The present major LW generators and the fraction of the total waste generation they represent are as follows:

3039 Stack off-gas scrubber (12%),
Fission Products Development Laboratory (FPDL), Bldg. 3517 (12%),
HFIR (10%),
Oak Ridge Research Reactor/Bulk Shielding Reactor (BSR) (12%), and PWTP (3%).

The Transuranium Processing Plant (TPP), Building 7920, is the major potential generator of LW which contains TRU isotopes, and steps should be taken to minimize the discharge of TRU isotopes from TPP into the LW system. Each of these facilities will be discussed with regard to improvements that have the potential to reduce waste volume or make the waste more manageable due to resultant changes in composition of LW concentrate.

4.4.1.1 3039 Stack Off-Gas Scrubber

Process off-gas streams generated within process or R&D equipment are vented directly to the central off-gas collection system for the removal of radioactive iodine. Off-gases potentially contain radioactive, toxic, acidic, or flammable vapors. Because acidic vapors can react with HEPA filter media and seriously degrade the efficiency of the HEPA filter, the off-gas is passed through a caustic scrubber to neutralize acidic vapors. A demister and a heater are located downstream from the scrubber to eliminate entrained moisture and prevent subsequent plugging and filter media deterioration.

The existing operation produces a low-activity waste consisting of a 3% solution of caustic in water (pH 8.3). The caustic solution is circulated through the scrubber at a rate of 400 gal/min at ambient temperature. The solution is recycled for one week and is then discharged to the LW system. An FY 1988 line-item project, Bethel Valley Liquid LLW Collection and Transfer System Upgrade, involves installation of a monitored collection tank at the existing scrubber. The tank will replace the caustic sump which is currently used as surge for the scrubber. Two alternative options for handling the off-gas scrubber solution have been proposed:

1. Discharge of spent scrubber solution to the process waste system. The discharge would be direct or after pretreatment, depending on the activity levels of the spent solution.
2. Change the scrubber solution or type of scrubber to minimize the volume of LW concentrate produced by the spent solution discharge to the LW system.

Recent samples of the spent scrubber solution indicate that the concentration of gross alpha and ^{60}Co are too high to allow direct discharge of this stream to the process waste system. Concentration studies were conducted with the solution to determine its actual contribution to the LW concentrate generation rate. These studies indicate that the total concentrate produced from this source is <50 gal/year. Since the volume of LW concentrate produced from this source is low and the stream cannot be discharged directly to the process waste system, changes in handling this stream are not warranted at this time. Recent information collected on this stream will be incorporated into future systems analysis activities.

4.4.1.2 Fission Products Development Laboratory, Bldg. 3517

Three major activities produce LW at the FPDL: (1) hot cell operations, (2) hot cell decontamination, and (3) groundwater inleakage to the local tank vault. Each of these waste streams contains varying concentrations of ^{90}Sr and ^{137}Cs; the waste streams are not analyzed routinely. A sample of groundwater inleakage to the tank vault was taken during the 1984 waste minimization campaign. The gross beta-gamma activity was 4×10^5 Bq/L. This activity level is significantly higher than that of typical process waste ($\sim 10^3$ Bq/L) but is about an order of magnitude below the normal activity level of dilute LLLW (10^6 to 10^9 Bq/L). Prior to the ^{90}Sr release from a construction site in the 3517 area, the Radioactive Liquid and Gaseous Waste Disposal Operations and Effluent Monitoring monthly reports included a footnote on the Building 3517 LW volume which indicated that the storage tank pit has an inleakage problem from groundwater and that this volume of water is jetted from the pit during the month. The pit can only be jetted to the LW system because it was designed in this fashion. The feasibility of implementing local treatment has not been investigated. The potential for source treatment is recognized as a candidate for further research, and alternative means for disposing of the liquid waste generated at Building 3517 should be investigated. Options include (1) a local pretreatment system for removal of ^{90}Sr and ^{137}Cs with discharge to the process waste or LW system, depending on activity levels; and (2) piping to route LW to the process waste or LW system, depending on activity levels.

4.4.1.3 High Flux Isotope Reactor

LW collected from the HFIR originates at the following sources: (1) regeneration and backwashing of primary and pool demineralizer systems,

(2) waste from sampling, (3) head tank overflow, (4) gaseous waste filter pit, (5) 7911 stack drainage, and (6) off-gas condensate collection pit. The most significant LW generation source is the regeneration and backwashing of primary and pool demineralizer systems. Other waste streams were reduced during the previous waste minimization campaign by recycling head tank overflow and resealing the filter pit plug.

The regeneration and backwashing of primary and pool demineralizer systems accounted for an estimated one-third of the volume of HFIR LW. This stream, which contains nitric acid and a high concentration of total dissolved solids (~2 g/L) and is the primary source of ^{60}Co at ORNL. The volume of waste produced during 1987 is approximately one-half the 1986 volume due to waste minimization efforts and the shutdown of reactor operations. Demineralizer systems were regenerated during 1987, but on a less frequent basis. The quantity of LW is expected to increase when reactor operation is resumed.

The following three options for disposal of HFIR demineralizer waste should be investigated because the high salt content that results in the concentrated LW (due primarily to nitric acid) constrains the technical options for centralized waste treatment and increases the complexity of long-term, centralized waste treatment process flow sheets. Further, treatment of regenerant and backwash solutions at the source may have the secondary benefit of reducing or eliminating a difficult-to-handle process waste stream that contains ^{60}Co.

1. During the 1985 LW systems analysis, the possibility was investigated of disposing of demineralizer resins by sluicing the resins from the columns, placing the resins in a high-integrity container (HIC), and dewatering the container. Central disposal of demineralizer regenerant waste via the LW system was selected by the HFIR staff as the preferred method for handling HFIR demineralizer waste at that time. This option should be reconsidered. Major components of piping used to connect demineralizers to a HIC (provided by a vendor) were installed at the HFIR when the reactor was constructed. Disposal of the HIC presents a significant hurdle to accomplishing this option because the HIC may be considered to be an LLWDDD Class IV waste, which would require off-site disposal.

2. A process analysis of HFIR demineralizer regeneration and backwashing operations may reveal that installation of an in-plant evaporator for recovery of nitric acid with subsequent centralized disposal of LW is more economical than direct disposal of resin.

3. A process analysis of HFIR operations may indicate that a combination of direct resin disposal and evaporation of backwash solutions is the most cost-effective option.

Implementation of a process to eliminate the HFIR primary demineralizer regeneration stream from centralized LW treatment has not been planned. However, the project appears to be a good candidate for management by the Waste Management Technology Center and LLWDDD Program. To determine the impact on the LW system, it was assumed that the project would be implemented in June 1993 and would eliminate the LW generated due to regeneration and backwashing of primary and pool demineralizer systems. Elimination of this waste stream would reduce the salt content and the concentration of nitrates in LW concentrate. These parameters affect the operation of the LW evaporator and increase the difficulty of preparing LW concentrate for disposal. The estimated effect of either of these modifications is that the rate of LW concentrate generation would be reduced by ~1200 gal/year.

4.4.1.4 Oak Ridge Research Reactor/Bulk Shielding Reactor

The Oak Ridge Research Reactor was shut down permanently during 1987 and will not be restarted. Although the reactor will be decommissioned, radioactivity levels in the reactor pool must be maintained at acceptable levels during decontamination and decommissioning (D&D) activities. Recommendations for reducing the volume of LW generated by the Oak Ridge Research Reactor are limited to a general policy statement that waste minimization should be a principal design parameter in planning D&D activities.

The BSR operates at a low power level (2 MW) and is unique in operation in that primary coolant water is not contained in a closed loop as are the Oak Ridge Research Reactor and HFIR primary coolants. The BSR pool water not only provides shielding but also serves as the primary coolant. The primary water is gravity fed from the 130,000-gal pool basin through the reactor core, which is located 17 ft below the level of the pool. Here it is channeled to the decay tank and pumped through a heat exchanger back to the bottom of the reactor pool. High-radiation alarms are located on the cooling line from the core, at the decay tank, and at the pump house where the heat exchanger is located.

The following options for disposing of BSR LW should be investigated: (1) recycle pool overflow to eliminate a source of liquid waste and to reduce makeup water use; and (2) handle BSR pool water as process waste because discussion with reactor operators has indicated that radioactivity levels are "low."

4.4.1.5 Process Waste Treatment Plant

Operation of the PWTP produces two secondary waste streams of interest: (1) the PWTP evaporator is used to recover nitric acid from ion exchange column regenerate solution and produces a concentrated LW stream; and (2) when the operating conditions require the PWTP evaporator to be bypassed, a dilute LW stream is fed to the LW evaporator.

The volume of each LW stream generated by the PWTP has been reduced by 80% since a clarifier/precipitator was installed in 1986. Reduction or elimination of these LW streams is important because the wastes contain high concentrations of solids and nitrate salts. These parameters affect the operation of the LW evaporator and increase the difficulty of preparing LW concentrate for disposal. LW generated by treatment of process waste could be significantly reduced or completely eliminated if further modifications to the PWTP are made. A proposed FY 1989 GPP, LLW Volume Reduction - PWTP, would reduce both solid and liquid waste generated by the PWTP by an additional 50% because zeolites would be used to decontaminate the wastewater. Installation of zeolite columns at the PWTP is scheduled for June 1991 and will result in a total elimination of the PWTP concentrate and bypass waste streams. The reduction in LW concentrate generation rate is estimated to be 3200 gal/year.

Initial results from the systems analysis indicate that the proposed GPP should be pursued to minimize waste generation and to reduce PWTP operating costs. Continuing to operate the PWTP without modifications will have cost ~$22.5 million by the year 2004. Operating the modified plant will have cost between $8.3 million and $20.8 million (depending on the selected process modification) in capital and operating costs by the year 2004.

4.4.1.6 Lining of Process Waste Piping

An extensive underground piping system collects process waste throughout ORNL and transfers the waste to the PWTP for removal of radionuclides. An investigation of process waste piping integrity in Bethel and Melton Valleys was conducted during FY 1986. The study included smoke testing of selected process waste lines, televising 1500 m (5000 ft) of pipe, and determining the volume of inleakage to the process waste system. The inspection indicated that inappropriate connections exist, some pipes are crushed, a majority of pipes are cracked, joints are offset, and inleakage of groundwater is prevalent.

Construction is scheduled for completion in 1988 on two capital projects that will modify or replace sections of process waste piping to reduce surface water inflow and groundwater infiltration. These projects will result in the lining, replacement, or rehabilitation of underground piping sections. Environmental contamination will be reduced due to eliminating the potential for process waste outleakage. The hydraulic load on the PWTP will be reduced by an estimated 1,000,000 gal/month. The estimated effect of these projects is that the rate of generation of LW concentrate will be reduced by ~1000 gal/year.

4.4.1.7 Transuranium Processing Plant

The TPP is a significant potential generator of LW that contains TRU isotopes. One aspect of the ultimate goal of the LW Program Plan is to segregate TRU and non-TRU waste streams. TPP waste includes (1) waste from processing, which includes solvents and TRU components; and (2) off-gas scrubber solution that may have lower activity than waste from processing and may not be classified as TRU. Long-range planning should be initiated to provide a method for transferring TPP TRU waste to the WHPP without using the central LW collection system and to segregate the off-gas scrubber solution from processing wastes. The principal effect of implementing these options is that the TRU content of the LW concentrate will be reduced.

4.4.2 Projected Future LW Characteristics

The cumulative effect of system modifications described in Sect. 4.4.1 can be described quantitatively in terms of the reduction in LW concentrate generation. The average concentrate generation rate during 1987 (26,000 gal) has been used as the basis for comparing the effect of process modifications. The cumulative impact of the system modifications discussed in Sect. 4.4.1 on concentrate-generation rate has been included in Fig. 4.10. The combined reduction in the generation rate of LW concentrate is estimated to be 5400 gal/year, or approximately 21 vol % of the assumed present rate of 26,000 gal/year.

The timing and effect on concentrate generation rate and composition for individual system modifications are shown in Table 4.7. It is projected that the "newly" generated LW will be rendered non-TRU by 1996.

The effects of pretreating wastes generated by operating the FPDL and the TPP have not been included in projected reductions in concentrate-generation rates since the feasibility of implementing local treatment has not been investigated.

4.4.3 Required Class II Waste Characteristics

The LLWDDD WAC for any solidified waste generated by operation of the LW system will include a number of criteria such as concentration limits for numerous constituents based on waste form and package. The current preliminary WAC are based on as-generated waste forms and assumptions which did not take credit for engineered features, and the draft concentration limits for each of the LLWDDD Classes I through III are summarized in Tables 4.8 through 4.10, respectively. These radionuclide concentration limits will increase as improvements are made to the waste form and/or package, thus improving the leach-resistance characteristics of the waste to be placed in the disposal unit. The final set of WAC will not be available until the record of decision for the environmental impact statement (EIS) is published. A draft set of WAC will be available October 1, 1988. The evaluations being conducted for the ORNL LW system will consider the latest available LLWDDD WAC.

The LLWDDD WAC will also require that the waste form not have hazardous waste characteristics as defined by 40 CFR 264. Any mixed-waste streams that will be placed in LLWDDD disposal facilities or demonstrations will be required to be put into a waste form that will not be characteristically hazardous, or the mixed-waste stream must be delistable.

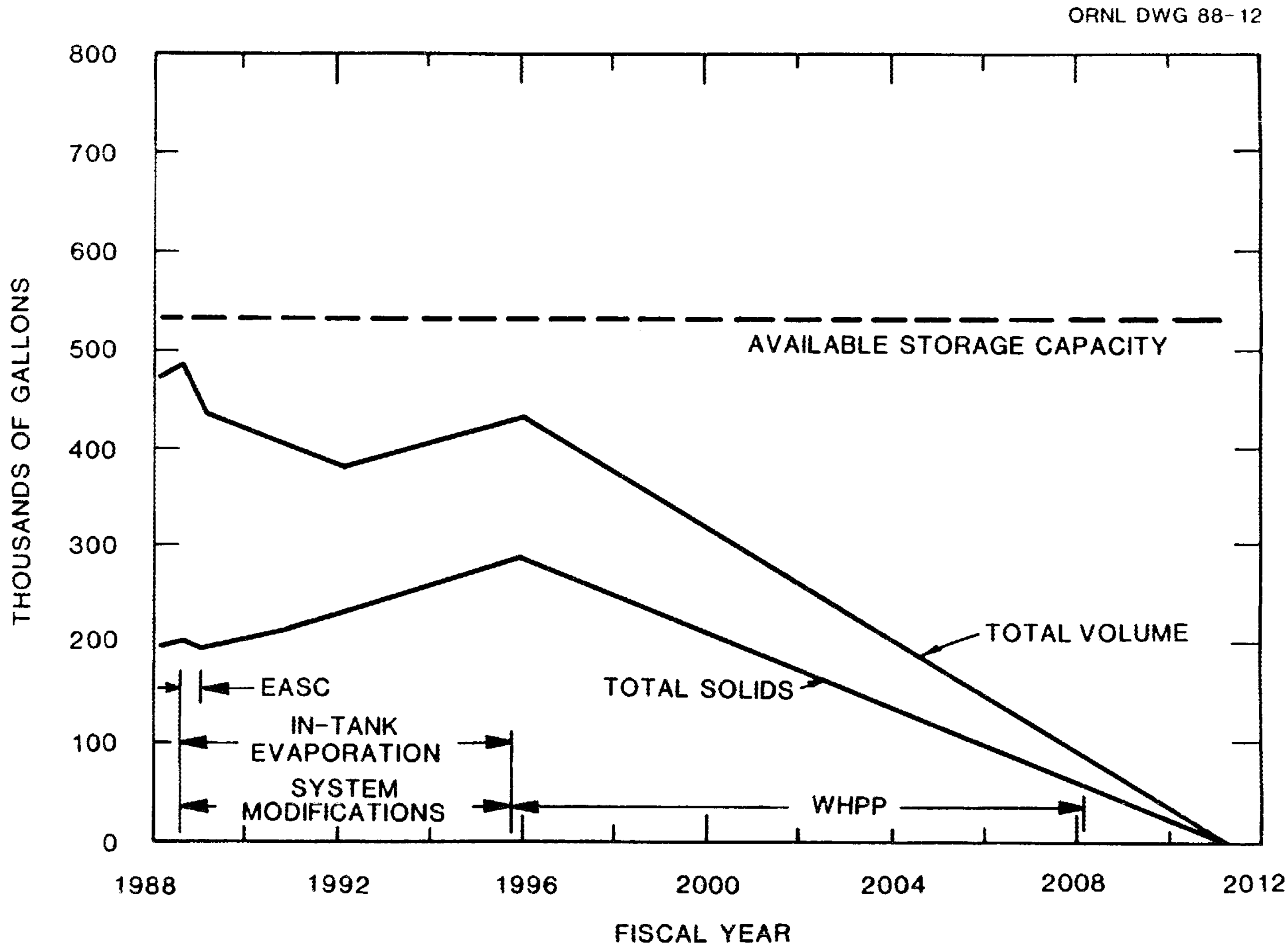

Fig. 4.10. Effects of Emergency Avoidance Solidification Campaign, in-tank evaporation, WHPP processing, and system modifications on total inventory.

Table 4.7. **Projected effects of system modifications on present liquid waste generation rate**

System modification	Volume reduction (gal/year)	Percent of baseline
Lining of process waste piping (implemented in December 1988)	1000	3.8
PWTP upgrade/installation of zeolite columns (implemented in June 1991)	3200	12.3
Elimination of HFIR regeneration stream (implemented in June 1992)	1200	4.6
Total	5400	20.7

Table 4.8. Class I waste concentration limits calculated according to LLWDDD strategy using preliminary site and waste characterization data for West Chestnut Ridge site

Isotope	Half-life (years)	Water pathway (μCi/m^3)	Intruder pathway (μCi/m^3)	Intruder/ water pathway (μCi/m^3)
^{3}H	1.23E+01	4.18E+05	3.43E+05	1.88E+05
^{10}Be	1.60E+06	3.20E+06	3.64E+03	3.63E+03
^{14}C	5.73E+03	1.06E+05	7.32E+04	4.32E+04
^{22}Na	2.60E+00	*a*	*a*	*a*
^{55}Fe	2.70E+00	*a*	*a*	*a*
^{60}Co	5.30E+00	3.87E+08	1.49E+04	1.49E+04
^{63}Ni	1.00E+02	4.53E+07	4.71E+04	4.71E+04
^{90}Sr	2.86E+01	3.96E+05	9.27E+02	9.24E+02
^{93}Zr	1.53E+06	6.70E+07	1.95E+05	1.95E+05
^{99}Tc	2.13E+05	1.38E+04	8.51E+02	8.02E+02
^{106}Ru	1.00E+00	*a*	*a*	*a*
^{113m}Cd	1.37E+01	2.04E+04	3.04E+03	2.65E+03
^{121m}Sn	5.50E+01	1.75E+07	2.09E+02	1.86E+06
^{134}Cs	2.06E+00	*a*	*a*	*a*
^{137}Cs	3.02E+01	1.30E+07	3.07E+02	3.07E+02
^{147}Pm	2.62E+00	*a*	*a*	*a*
^{151}Sm	9.00E+01	7.06E+07	4.05E+06	3.83E+06
^{152}Eu	1.36E+01	3.58E+07	6.39E+02	6.39E+02
^{154}Eu	8.80E+00	9.83E+07	2.28E+03	2.28E+03
^{155}Eu	4.96E+05	1.28E+10	2.98E+06	2.98E+06
^{232}Th	1.41E+05	5.96E+04	1.78E+01	1.78E+01
^{233}U	1.59E+05	8.01E+01	6.67E+03	7.92E+01
^{235}U	7.00E+08	8.99E+01	5.71E+02	7.77E+01
^{238}U	4.40E+09	8.90E+01	2.29E+03	8.57E+01
^{237}Np	2.14E+06	6.90E+01	1.86E+01	1.45E+01
^{238}Pu	8.78E+01	1.14E+05	1.95E+03	1.91E+03
^{239}Pu	2.41E+04	6.71E+04	1.16E+03	1.14E+03
^{241}Am	4.32E+02	4.55E+03	1.24E+03	9.74E+02
^{243}Am	7.38E+03	4.22E+03	3.49E+02	3.23E+02
^{242}Cm	4.50E-01	*a*	*a*	*a*
^{244}Cm	1.81E+01	9.33E+04	1.60E+04	1.36E+04
^{249}Bk	8.80E-01	*a*	*a*	*a*
^{252}Cf	2.64E+00	*a*	*a*	*a*

[a]Indicates that a dose-conversion factor was not developed for this isotope. Further analysis will be necessary to determine the waste concentration limit.

Table 4.9. Class II waste concentration limits calculated according to LLWDDD strategy using preliminary site and waste characterization data for Bear Creek Valley site

Isotope	Half-life (years)	Water pathway ($\mu Ci/m^3$)	Intruder pathway ($\mu Ci/m^3$)	Intruder/ water pathway ($\mu Ci/m^3$)
^{3}H	1.23E+01	5.48E+14	7.30E+11	7.29E+11
^{10}Be	1.60E+06	3.81E+05	5.91E+03	5.82E+03
^{14}C	5.73E+03	8.92E+05	1.23E+04	1.08E+05
^{22}Na	2.60E+00	*a*	*a*	*a*
^{55}Fe	2.70E+00	*a*	*a*	*a*
^{60}Co	5.30E+00	7.24E+21	3.82E+18	3.81E+18
^{63}Ni	1.00E+02	3.05E+07	4.33E+05	4.27E+04
^{90}Sr	2.86E+01	2.01E+07	6.43E+05	6.24E+52
^{93}Zr	1.53E+06	5.00E+05	3.17E+05	1.94E+05
^{99}Tc	2.13E+05	1.25E+06	1.38E+03	1.38E+03
^{106}Ru	1.00E+00	*a*	*a*	*a*
^{113m}Cd	1.37E+01	5.19E+10	1.53E+09	1.49E+09
^{121m}Sn	5.50E+01	4.87E+07	7.91E+07	3.01E+07
^{134}Cs	2.06E+00	*a*	*a*	*a*
^{137}Cs	3.02E+01	3.01E+07	1.57E+05	1.54E+05
^{147}Pm	2.62E+00	*a*	*a*	*a*
^{151}Sm	9.00E+01	5.76E+07	4.52E+07	2.53E+07
^{152}Eu	1.36E+01	1.45E+12	3.54E+08	3.54E+08
^{154}Eu	8.80E+00	4.16E+15	1318E+03	1.13E+12
^{155}Eu	4.96E+05	2.24E+24	7.16E+21	7.14E+21
^{232}Th	1.41E+05	4.45E+02	2.89E+01	2.72E+01
^{233}U	1.59E+05	7.28E+03	1.08E+04	4.36E+03
^{235}U	7.00E+08	8.16E+03	9.29E+02	8.34E+02
^{238}U	4.40E+09	8.08E+03	3.71E+03	2.54E+03
^{237}Np	2.14E+06	5.33E+02	3.02E+01	2.86E+01
^{238}Pu	8.78E+01	6.10E+03	2.27E+04	4.81E+03
^{239}Pu	2.41E+04	5.04E+02	1.90E+03	3.99E+02
^{241}Am	4.32E+02	8.09E+02	3.01E+03	6.37E+02
^{243}Am	7.38E+03	5.14E+02	5.81E+02	2.73E+02
^{242}Cm	4.50E-01	*a*	*a*	*a*
^{244}Cm	1.81E+01	9.16E+07	3.72E+08	7.35E+07
^{249}Bk	8.80E-01	*a*	*a*	*a*
^{252}Cf	2.64E+00	*a*	*a*	*a*

[a]Indicates that the decay of the isotope is sufficient to allow for any concentation in the waste for that particular isotope.

Table 4.10. Class III waste concentration limits calculated according to LLWDDD strategy using preliminary site and waste characterization data for Bear Creek Valley site

Isotope	Half-life (years)	Water pathway (μCi/m^3)	Intruder pathway (μCi/m^3)	Intruder/water pathway (μCi/m^3)
^{10}B	1.60E+06	4.57E+05	1.40E+06	3.45E+05
^{14}C	5.73E+03	1.07E+06	1.09E+06	5.40E+05
^{93}Zr	1.53E+06	6.00E+05	4.53E+08	5.99E+05
^{99}Tc	2.13E+06	1.50E+06	7.51E+05	5.00E+05
^{232}U	1.41E+05	5.34E+02	1.10E+04	5.09E+05
^{233}U	1.59E+05	8.74E+03	1.81E+06	8.70E+03
^{235}U	7.00E+08	9.80E+03	2.80E+05	9.46E+03
^{238}Pu	4.40E+09	9.70E+03	1.03E+06	9.61E+03
^{237}Pu	2.41E+04	6.40E+02	2.80E+03	5.21E+02
^{239}Am	2.41E+05	6.05E+02	6.09E+05	6.05E+02
^{241}Am	4.32E+02	9 71E+02	7.40E+04	9.58E+02
^{243}Am	7.38E+03	6.17E+02	2.58E+04	6.03E+02

The most probable waste forms that will meet the LLWDDD WAC and be delistable, if applicable, will be those that provide minimum leachate concentrations. An evaluation of highly promising waste forms using actual waste should be pursued to provide a comprehensive evaluation of the alternatives based on the available technology.

4.4.4 Projected Collection, Treatment, and Solidification Processes for Radioactively Contaminated LW

The LW Planning Team recognizes the need for centralized LW treatment in addition to the capability for solidification of RH-TRU sludges that will be provided by WHPP. Assuming that RH-TRU sludges will be processed via WHPP beginning in 1996, approximately 2 years will be required to empty one waste storage tank, which would then allow separate collection of newly generated LW. The accumulation rate of "newly" generated LW at ORNL is depicted in Fig. 4.11. As indicated in this figure, LW generation will be significant; therefore a treatment system will be needed. This treatment system will provide for long-term management of LW and will include three long-term strategy components: (1) segregation and treatment of LW at its source where cost-effective, (2) conversion of the bulk (volume and weight) of the waste to either reusable materials or LLWDDD Class II solid low-level waste (SLLW), and (3) concentration of radionuclides (both TRU and beta-gamma) into a volume that will optimize preparation for disposal. The optimal disposal volume is dependent on the method of disposal and is strongly influenced by the results of the ongoing LLWDDD pathways analysis. Each of these components affects the specific steps that may be required for treatment of LW.

Changes in LW generation that have the potential to simplify central treatment requirements will be pursued vigorously. Major components of the collection system will be upgraded by three line-item projects and will reduce the solids content of LW by more accurately controlling reagents added for waste neutralization. The actual control point for neutralization may be a function of downstream processing because some processes may require a lower pH than is currently used in the waste collection and transfer system. Centralized treatment will be needed through the twenty-first century because the mission of the Laboratory includes research in the nuclear energy field. Facility D&D is also expected to add additional waste to the system. The success of implementing waste segregation projects outlined in Sect. 4.4.1 will affect significantly the composition of dilute LW.

Overall, the major chemical constituents of the dilute LW are not expected to change (e.g., $NaNO_3$). Further, the removal of TRU constituents at their source to a level that renders the resultant concentrate non-TRU will be exacerbated by the indigenous TRU contamination within the LW system. Nevertheless, long-range planning includes introducing segregated waste streams into the reconfigured treatment system at the appropriate

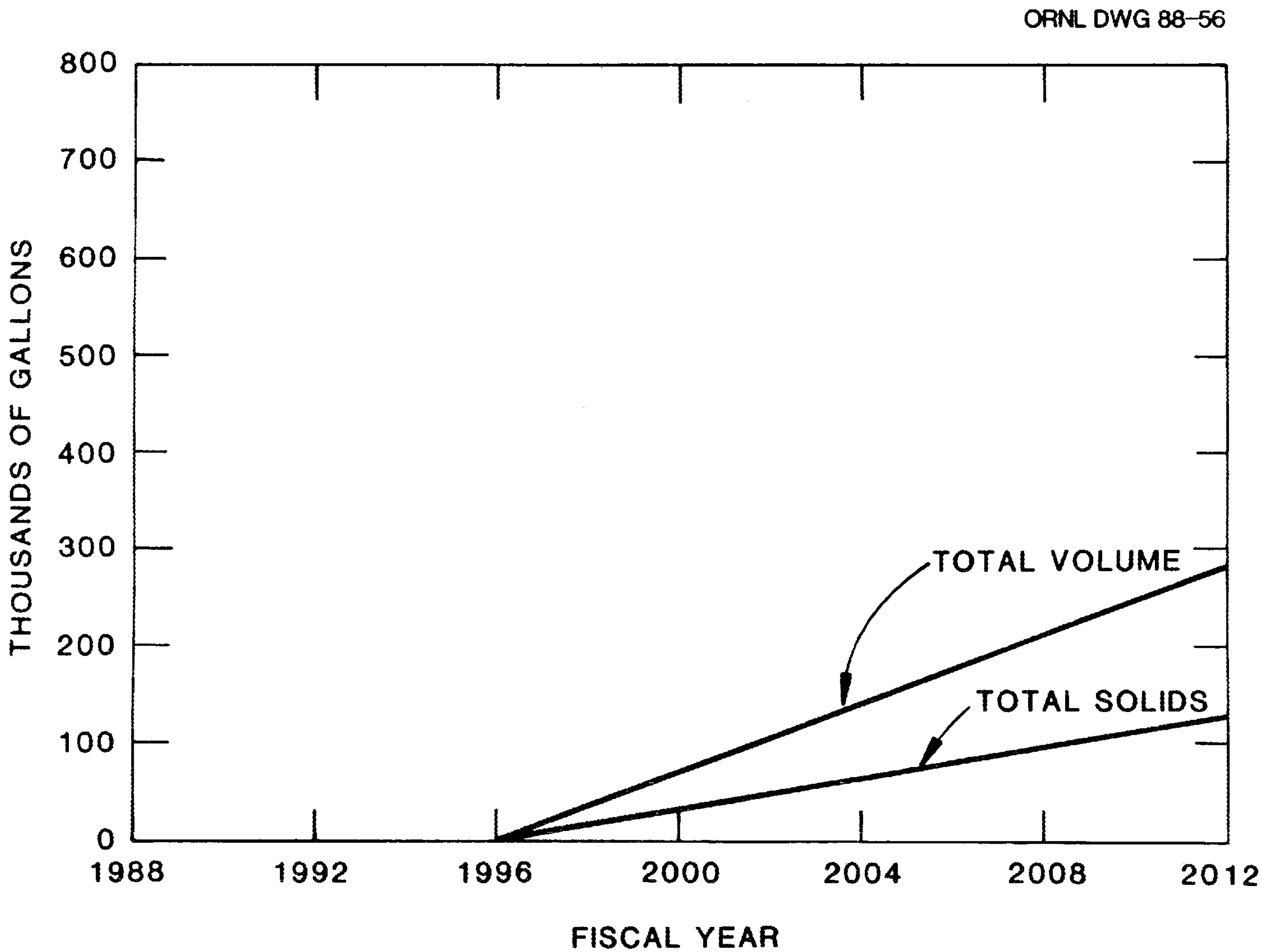

Fig. 4.11. Accumulation of newly generated liquid waste.

processing step. LW that has been concentrated at its source will not be allowed to mix with less concentrated waste; dilute LW will not be mixed with LW that has a high solids or high radionuclide concentration.

Contaminated LW will continue to be collected in large tanks and fed to the treatment process. At this point, the LW will have been treated by the addition of alkali metal hydroxides or carbonates to ensure that the liquid is not acidic. Under these conditions, practically all radionuclides except cesium, technetium, iodine, and a small portion of the strontium and cobalt will have been precipitated in the form of hydroxides or carbonates. The dissolved solids will be predominantly sodium, potassium, lithium, and aluminum compounds such as nitrates, chlorides, carbonates, and hydroxides. Of these water-soluble compounds, sodium nitrate will be the most predominant.

The flow sheet shown in Fig. 4.12 illustrates the projected treatment and solidification processes for the central collection system. The processing steps shown on the flow sheet are discussed below.

Treatment of supernate or dilute LW will convert the bulk of LW to reusable material or LLWDDD Class II SLLW. Treatment of concentrated LW will also result in production of a smaller volume of RH-TRU waste or LLWDDD Class IV SLLW. Parameters that will be considered during the selection of unit operations include shielding requirements and use of existing or planned facilities. Shielding requirements will determine the need for remote operations and maintenance. The activity level and volume of the concentrated LW can be varied, depending on the severity of treatment. This activity level and volume will be traded off against shielding and handling requirements. Self-shielding, which will be a greater influence in larger volumes, will be included in the overall shielding analysis. Use of existing equipment will be proposed where the anticipated equipment life meets the projected life of the new treatment system. The ORNL Evaporator (Building 2531), the 3039 Stack system, the PWTP, and the WHPP are among the existing or proposed facilities that have potential for use in long-term LW treatment. Use of this equipment will be considered for processing steps labeled "volume reduction" (ORNL Evaporator), "prepare concentrate for disposal" (WHPP), and "polishing" (PWTP and 3039 Stack).

The "solids/liquids separation" step may include decantation-filtration equipment located within the collection tanks (preferably as a floating suction line) and a nearby (preferably within Building 2531) shielded-filter module, which could be cleaned periodically by nitric acid flush-back into the collection tank.

The supernate decontamination process would probably use an ion exchanger to retain cesium and strontium, which would periodically be eluted and returned to the evaporator. The decontamination equipment will require shielding and must be located within a contained facility. This equipment and the evaporator system, which will likely be needed for

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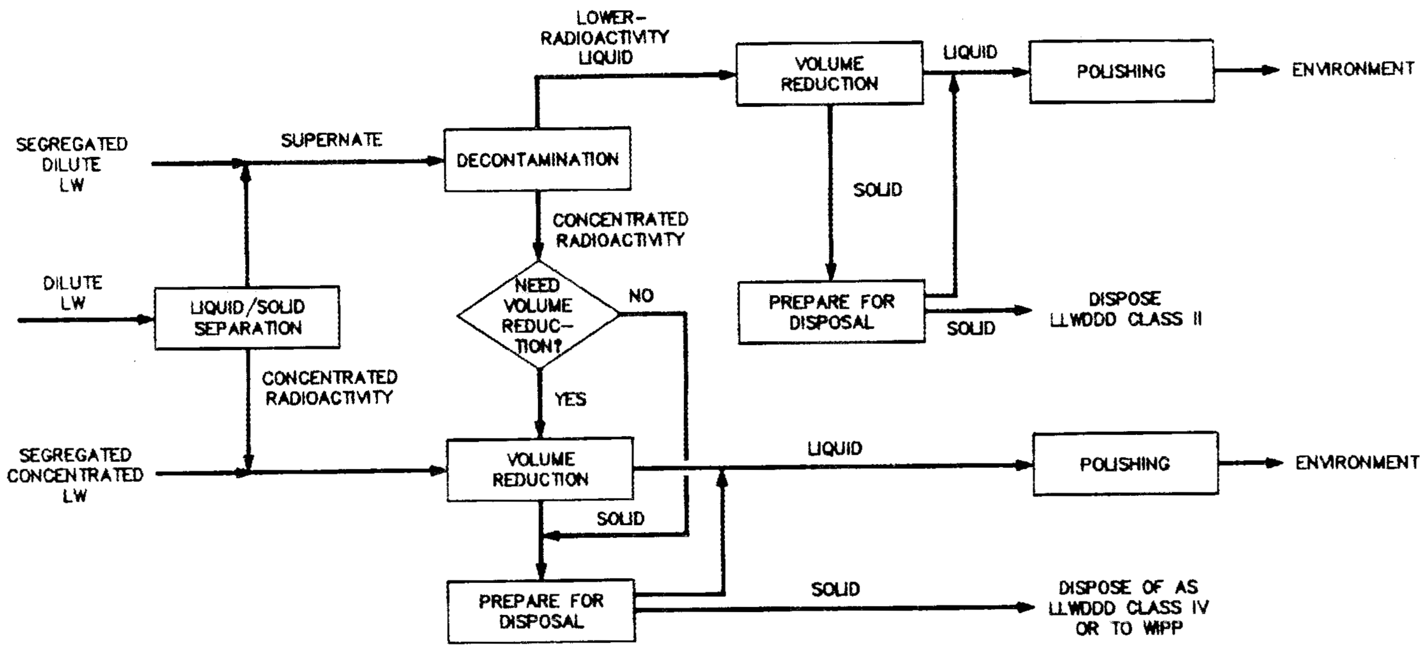

Fig. 4.12 Projected treatment of ORNL liquid waste.

volume reduction, could be located in existing buildings. For example, Building 3517 previously contained equipment of this type and is currently used for cesium and strontium processing.

The process used to "prepare material for disposal" may include denitration and will definitely include solidification. The equipment needed for "preparing solids for disposal" from the supernate stream may not need to be located within a shielded hot cell if sufficient decontamination is achieved which would allow a lesser degree of containment to be used.

In practice, supernate treatment would be carried out on a continuous basis, allowing the volume of hydroxide/carbonate sludge to accumulate in the collection tank (settling time will be considered in determining the frequency of operation). Periodically, most of the supernate would be removed, and then concentrate treatment would be carried out. The sludge would be transferred and flushed with water to the evaporator and solidification system. After the chloride concentration has been reduced sufficiently to prevent corrosion of the collection tank, a dilute acid flush may be used to enable more efficient transfer of TRU wastes from the tank to the solidification system.

Several variations of the treatment and solidification processes could be used. An R&D program is needed to support process development and testing. The specific R&D needs are discussed in Sect. 5.4.2.

An expanded discussion of R&D conducted to date and observations about appropriate areas to study during the planning phase of the R&D program follows. These thoughts are grouped according to processing area in Fig. 4.12.

4.4.4.1 Pretreatment

Although not shown explicitly in Fig. 4.12, pretreatment and process modification at the generation source are ways in which major impacts can be made on both the volume and the nature of future LW generated at ORNL. An example of this impact is the dramatic reduction in LW production seen at the PWTP as a result of process modifications. Further areas where it is obvious that improvement can be made are the demineralizers for contaminated water streams, the 3517 facility, and the TPP at Building 7920. In each of these areas, process modification could be performed to either drastically reduce, eliminate, and/or significantly change the nature of the LW generated.

4.4.4.2 Solids/Liquid Separation

Any process envisioned for LW treatment will have to include a step for eliminating suspended solids. With the current chemistry of the waste, this step can also be used to eliminate the TRU constituents. This is effective because the waste is at high pH, and under these conditions, most of the alpha emitters will have been precipitated. A significant amount of work has been done in looking at one possible method for performing this step. Cross-flow filtration has been evaluated with both simulated and actual waste for removal of suspended solids. The initial test results indicate that the cross-flow filter can effectively remove alpha contamination from the MVST waste (W-29). If cyclic backpulsing of the filter is employed, then filter flux can be maintained for extended operating periods before filter cleaning or replacement is required. Other types of filtration have been studied with mixed success. Dead-end filters of porous-metal and wound-fiber design have been investigated briefly with simulated waste. These filters are effective if the solids loading is extremely low. Other types of solids/liquid separators have not been investigated but should be included in the initial screening exercise for process development. These include centrifugal devices such as cyclones and centrifuges. When implemented, it would obviously be advantageous to employ gravitational forces to improve process efficiency. This can most easily be done by removing supernate from the top of the tank through a mechanism that imparts the minimum amount of turbulence and thus does not agitate solids.

In the previous discussion, it has been assumed that the solids/liquid separation step would be conducted on the raw waste. It is possible that by judicious chemical pretreatment (possibly pH adjustment), a major fraction of the solid phase could be solubilized without placing the TRU constituents into solution. The net effect would be to drastically reduce the volume of TRU-waste. Some very preliminary work suggests that the solution pH can be lowered to ~7 without significant transfer of alpha activity to the supernate. However, data are not available that indicate whether any of the bulk sludge is solubilized at this pH. A more detailed study would indicate how this technique might fit into the overall flow sheet. It might be more appropriate to perform sludge dissolution on the concentrate produced by solids/liquid separation.

Another possible amendment to simple filtration is the use of additives to the feed solution, such as coagulants to augment either fission product or actinide removal. Addition of nonradioactive strontium in solution followed by precipitation and filtration to reduce the radioactive strontium fraction in the filtrate is another option.

4.4.4.3 Decontamination

There are several options for decontaminating the solids-free solution. Ion exchange is one of the prime candidates. Variables that must be considered include the type of exchanger (organic-inorganic), the decision on whether or not to regenerate, pretreatment (pH adjustment, dilution), and posttreatment (further concentration of the regenerant stream to make the final waste package even smaller). Other process alternatives to ion exchange include solvent extraction, biological absorption, precipitation, and crystallization. All of these options should be included in the initial screening of process alternatives.

4.4.4.4 Volume Reduction and Polishing

Volume reduction and polishing can be attained conceptually through combinations of evaporation and decontamination (via techniques described above) and through treatment for nitrate removal. Denitration could be achieved through several different methods, which include biological, chemical, thermal, and electrochemical denitration. The chemical and electrochemical techniques provide the opportunity for caustic recycle, an attractive method for potential volume reduction and cost savings.

4.4.4.5 Segregated Concentrated LW

Depending on the physical characteristics and the ultimate disposal of the waste, the feed might be processed for volume reduction. In the simplest form, this could be evaporation to reduce liquid content. One option that will be considered is drying through the application of microwave energy. There are other options, and these should also be evaluated. The microwave drying technique is most effective for wastes that will be disposed of at the WIPP in New Mexico. This technique could be coupled with immobilization techniques such as solidification in a grout matrix. As previously noted, it might also be possible to greatly reduce the TRU sludge volume without solubilizing the TRU isotopes through the application of a mild acid leach. The concentrate from this kind of process would then be a candidate for fixation. The leachate would be cycled to the dilute LW front end of the flow sheet. A more severe leach with strong acid could produce a feed stream that would be amenable to TRU separation by a solvent-extraction technique such as the TRUEX process. This would result in a TRU waste of minimum volume.

4.5 SUMMARY

Clearly, there are many combinations of treatment options to be evaluated in order to determine the best long-term approach to LW handling at ORNL. The selection of the "best" treatment and solidification processes would be supported by the proposed R&D program. This program represents a systematic evaluation of process development options. As discussed in Sect. 5.4.2, the evaluation (and the entire R&D program) would be performed within an organization having a centralized planning and analysis function. The ultimate direction taken would be based on systematic evaluation of technical merit, experience of others, experimental testing, regulatory constraints, and institutional and fiscal constraints.

5. ACTIVITIES NEEDED FOR STRATEGY IMPLEMENTATION

A detailed discussion of the basis for each of the primary elements that support the general strategy and approach for management of LW at ORNL was prosented in Sect. 4. Information is provided in this chapter on the following specific activities needed for implementation of the general strategy:

- Characterization of the contents of the active and inactive LW tanks.
- System modifications and R&D necessary for conduct of in-tank evaporation.
- Completion of the initial EASC.
- Further development and evaluation of processes for removing the RH-TRU wastes from the LW tanks and solidifying these wastes.
- Potential improvements to the LW system.
- R&D needed to provide the capability for treating and solidifying future LW.

Information is also presented on the anticipated timing for initiation and completion of the required activities and estimated budget requirements.

5.1 CHARACTERIZATION OF TANK CONTENTS

It is essential to the process of developing flow sheets, conducting treatability tests, and designing processing facilities to first establish the characteristics of the material to be processed. The existing information on the contents of the active and inactive tanks was presented in Sects. 4.1 and 4.2. Additional characterization is required to adequately evaluate processing options for the contents of active and inactive tanks.

Currently, the radiochemical description of the wastes in the active tanks is much more complete than the knowledge of bulk chemical composition, and the distribution between true insolubles and dissolved (or soluble) constituents in the sludge is uncertain. The extent to which the TRU isotopes are isolated in the settled sludge is a very important parameter. Chemical components (cations, anions, and others) were determined in 1985 for tanks W-24 through W-28; but since completion of that sampling work, W-28 has been practically emptied and the liquid has been added to the other seven MVSTs. Tank W-28 was later filled with concentrate from the Bethel Valley LW storage tanks. These tank transfers have introduced uncertainty in information on individual tank characteristics.

It is important that all significant species be determined in fractions representative of the final materials that might be processed. These are the pure liquid phase and the truly insoluble constituents; from these, various mixtures can be calculated. The following considerations are of particular importance:

1. Sludge analysis methods should be reexamined to ensure determination of the composition of both the supernate and the insoluble solids free of supernate.

2. Analyses should be carried out for all "key" constituents. These include some of the more difficult radioactive species and also some likely bulk components, notably carbonate and bicarbonate. For evaluation of ion-exchange processes, it is useful to know the stable cesium and strontium concentrations and also organic complexing agents [generally anionic ones such as disodium ethylenediaminetetraacetate (EDTA), and others]. Elements that interfere with cement hardening (boron, silicon, and others) are also of interest because concrete waste generated from sludges has been known to remain paste-like and not set properly.

Accurate determination of the RCRA metals is needed to provide information concerning whether the waste will be classified as RCRA hazardous material. In conjunction with this RCRA-related interest, organic screening analyses should be performed to verify that significant quantities of RCRA hazardous organics are not present.

A sampling effort has been conducted to support the EASC. This sampling of tanks W-29 and W-30 will provide information on the liquid supernate for these two tanks. The sampling of tanks W-29 and W-30 was funded in conjunction with the EASC efforts. The liquid and sludge sampling of tanks W-24 through W-28 and sludge sampling of tanks W-29 and W-30 are not currently funded. This currently unfunded effort should include the development of a sampling plan in FY 1988 to be followed with conduct of the actual sampling to be done in the first quarter of FY 1989. The development of the sampling plan will build on the experience in FY 1988 of sampling tanks W-29, W-30, and the inactive tanks. Development of the plan is estimated to cost $30,000 (FY 1988).

The actual sampling will be delayed until FY 1989 because the ORNL capability for analyzing these highly radioactive samples will be consumed in FY 1988 by the efforts to characterize the other tanks. Analyzing this kind of radioactive material is very expensive, and it is estimated that $450,000 will be required in FY 1989 to collect samples and complete characterization of the supernate and the sludge in the MVSTs. In addition to the characterization of MVSTs, sampling in other parts of the active LW system will be needed to support systems analysis and strategy development. The cost for sampling the newly generated waste in other parts of the LW system is estimated at $200,000 in FY 1990 and $100,000 in FY 1991.

Available information on the contents of the inactive tanks is very limited. Even the volumes of liquid and sludges in many of the tanks are not well established. No chemical parameters (cations, anions, and others) have been determined, and the information on radioisotopes is sparse. The RAP has planned a sampling effort, which will be conducted in FY 1988, to sample the inactive tanks. The plans for this effort will be reviewed with regard to options for future processing and solidification of the contents. No sampling in addition to that funded by RAP is necessary at this time for the inactive tanks.

5.2 NEAR-TERM ACTIONS

5.2.1 In-Tank Evaporation

As a means for obtaining additional storage capacity at the MVSTs, it is recommended that in-tank evaporation be undertaken in a phased approach beginning immediately with a low rate of liquid removal from the tanks. As each phase is completed, the water-removal rate would be increased.

There are two methods for handling the evaporated water from the MVSTs. The first method consists of system improvements that will result in the release of the evaporated water via the local stack. The second method consists of intercepting the demister liquid (condensate plus entrained liquid) and transferring it to Bethel Valley for treatment and release in either the Evaporator Facility or the PWTP, depending on the level of radioactivity. System improvements for increasing the evaporation rate of water from the tanks will be necessary for either or both of these methods to be effective. The suggested phased approach will use both methods at various times to varying degrees.

The proposed approach for removing water from the MVSTs would be undertaken in six phases, which are as follows: (1) The first phase consists of piping modifications to the demister drain system that will allow sampling of the demister liquid. (2) The second phase consists of actions which will allow operation of the in-tank spargers at the presently obtainable rate to remove water from the tanks. (3) The third phase consists of actions required to increase the in-tank sparge rate to the design value of 100 ft^3/min per tank. (4) The fourth phase consists of actions that will require some modifications of the present system and will allow the transfer of the demister liquid to Bethel Valley for treatment and release. (5) The fifth phase consists of actions that will require design and procurement of significant items. (6) The sixth and last phase involves major modifications that should only be undertaken after development results are available. Figure 5.1 is a schematic representation of the system with the various phases highlighted.

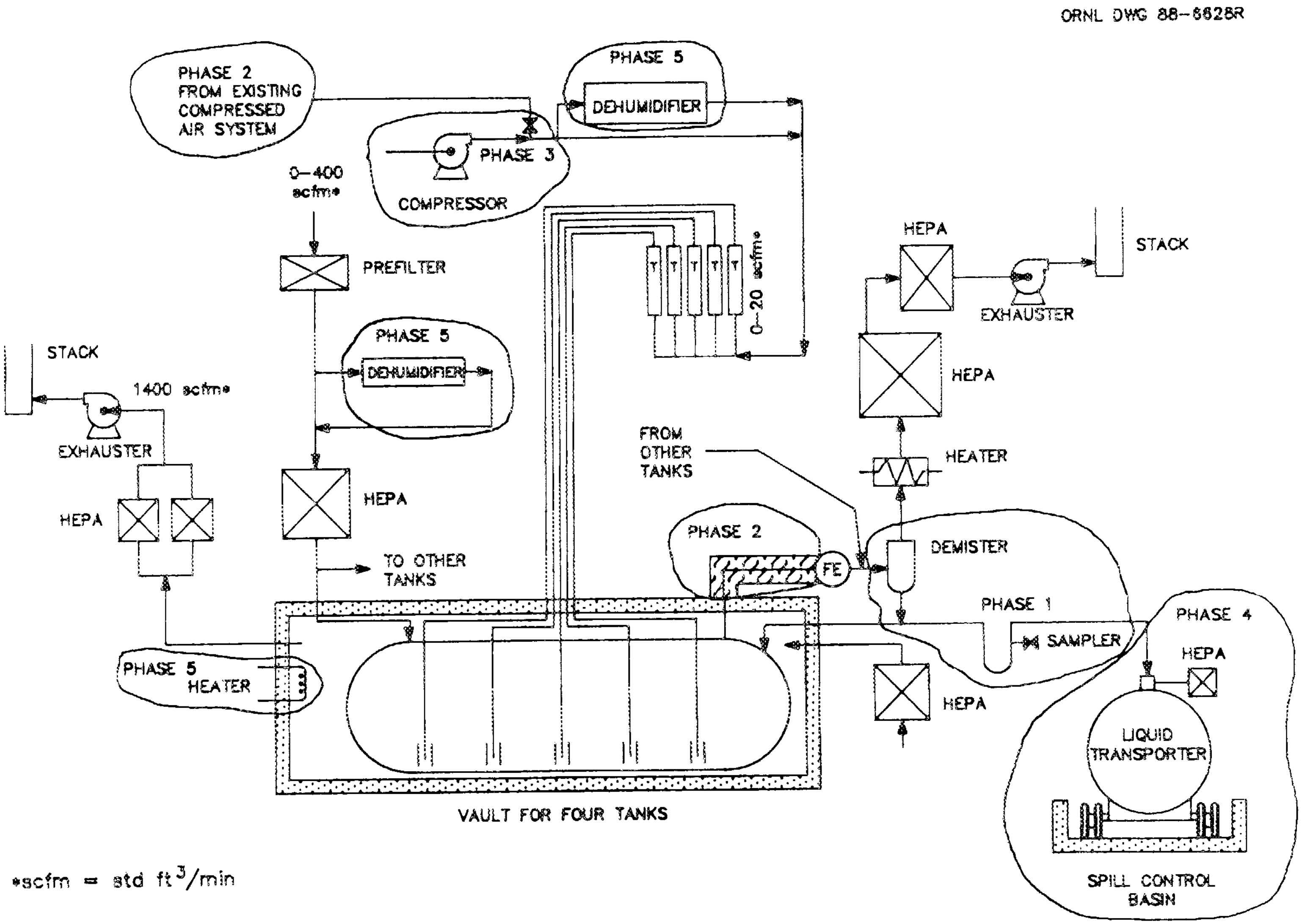

Fig. 5.1. Schematic of an Melton Valley Storage Tank vault and tank highlighting the phased modifications.

5.2.1.1 Phase 1

Phase 1 consists of making the appropriate piping modifications that will allow sampling of the demister liquids. The piping that returns the liquid from the demister to the tanks would be modified to permit sampling and flow-rate measurements of this liquid, which has never been sampled due to the existing piping arrangement. Chemical and radiological information about this stream is needed for implementation of later phases of this approach. Also, flow-rate measurements on this stream are needed for further evaluation of the effects of various sparging conditions. While the system is down for piping modifications, a spray nozzle would be installed in the top flange of the demister. This nozzle can be used to back-flush and decontaminate the demister, if required, during later phases of in-tank evaporation.

The suggested demister piping modification would be designed so that piping attachments can be made later for diverting this liquid to another location. Once this demister drain piping modification has been completed, Phase 2 would be initiated.

5.2.1.2 Phase 2

Phase 2 consists of sparging four of the tanks at the air sparge rate that is obtainable with the existing compressor. This sparging will be similar to that performed when the New Hydrofracture Facility was being operated. Four tanks, W-24 through W-27, would be considered for sparging during Phase 2 operations. Tanks W-29 and W-30, plus the other tanks in the same vault, would not be sparged until the EASC has been completed.

The off-gas ducts external to the vault would be insulated, and electrical heat tracing would be installed to minimize refluxing. Procurement of the heat tracing and insulation can proceed while operation of the spargers is occurring; however, sparging will need to cease during the installation phase.

5.2.1.3 Phase 3

Phase 3 involves the installation of additional air-compression capacity which will allow for in-tank sparging at the design rate of 100 ft^3/min per tank. An air compressor would be leased until one can be purchased and installed permanently. The compressor should have the capability of delivering at least 900 ft/min at 100 psig, which is the present pressure prior to air pressure reduction. This compressor capacity will ensure that adequate air is available for both sparging and instrumentation needs.

5.2.1.4 Phase 4

Phase 4 involves the removal of the demister liquid from the system. This will result in the collection of the demister liquid and its subsequent transfer to Bethel Valley for treatment and release. The elevation of the demister is ~16 ft higher than the area north of the vaults. This elevation difference will allow gravity drainage of the demister liquid into a transfer vessel. The tasks required for this phase are (1) installation of a spill basin for the transporter north of the vaults; (2) modification of the demister piping to permit liquid routing to the liquid transporter, which will be located ~100 ft from the vault; and (3) modification of the fill nozzle of the transporter to provide suitable piping connections and to provide a HEPA-filtered vent connection.

5.2.1.5 Phase 5

Phase 5 consists of system modifications necessary for increasing the evaporation rate from the tanks. The tasks to be done during this phase involve installation of (1) electric heaters having a total capacity of ~20 kW through the roof plugs located in one corner of each vault, (2) heaters in the vault inlet air supply, (3) a dehumidifier on the tank ventilation air supply to lower the humidity of the tank vent air, and (4) a dehumidifier on the compressed air system to lower the humidity of the purge air. It should be noted that compression of air to 100 psig will lower the water vapor content by about 86%.

An alternative design for in-tank electrical heating that could be inserted into a tank through the 20-in. manhole (nozzle C) should be evaluated. Information on the extent of insulation of the heater element via solids formation is needed for this evaluation. This alternative heating method requires breaching the integrity of the tanks, whereas the above steps do not. The design temperature of the tanks is 150°F.

5.2.1.6 Phase 6

Phase 6 consists of operations whose need can only be determined after experiments have been performed using actual tank solutions. For example, if the level of radioactivity in the demister liquid is too high for shipping via the available liquid transporter, then a local collection tank for the demister liquid with appropriate piping connections for underground transfer to the Bethel Valley evaporator feed tanks may be required. This modification would use the existing underground line for transfer to the Bethel Valley evaporator. Some components of the off-gas system may require local shielding.

There are several experimental results that are needed but can only be obtained using actual tank solutions. While the initial phases of in-tank evaporation can be deployed without the experimental results obtained from existing tank solutions, implementation cannot proceed for an extended period of time without this information. The complexity of the existing tank solutions makes theoretical prediction of the precipitation behavior of dissolved solids of little value. Information on the solids concentration at which crystallization or precipitation occurs initially, the nature of the crystals formed, and the allowable dissolved solids concentration at which evaporation must cease or may become inoperative because of lowered equilibrium partial pressure of water above the concentrated waste solution are several of the more important experimental results required.

The effect of atmospheric carbon dioxide on the buildup of carbonates in the tank and the consequences of carbonates on later waste-processing steps need to be evaluated using existing waste solutions. The removal of atmospheric carbon dioxide from 100 ft^3/min of air and its conversion to carbonate ions will produce about 2800 lb of carbonate ions per year. However, once the calcium has been converted to $CaCO_3$, further CO_2 absorption will cease and the liquids will remain saturated with CO_2.

A preliminary schedule for implementing the first five phases of in-tank evaporation is given in Fig. 5.2. The estimated costs for implementing the tasks described in this section (on the schedule given in Fig. 5.2) are shown in Table 5.1.

5.2.1.7 Experimental Testing

Laboratory-scale scouting tests performed thus far give a good indication of the crystallization behavior as a function of volume reduction factor that can be obtained by boiling supernate samples from MVST tank W-29. Future laboratory-scale tests will focus on sparging dry air through supernatant solutions to determine air flow rates and temperatures needed to reduce liquid volumes in the MVST via offsetting addition of LW at the present LW generation rate. The experiments will provide information needed to determine the effect of volume reduction (i.e., increased salt concentration) on the equilibrium partial pressure of water above the solutions and the impact that the nonideal salt solution behavior will have on the preliminary humidification calculations. The quantity and composition of the crystals that form as a function of volume reduction and temperature will be determined. The nature of precipitates, their tendency to plug sparge tubes, and the ease with which they can be redissolved will be determined. The effect of the presence of CO_2 in the sparge air will also be examined.

An experimental apparatus will be designed and fabricated to meter known amounts of dry air into MVST supernate samples that will be maintained at a constant temperature. The system will have the capability to cool the concentrate to 50°F (approximate ambient temperature of the MVST vaults) in order to determine the amount of precipitation that will occur during operation at that temperature.

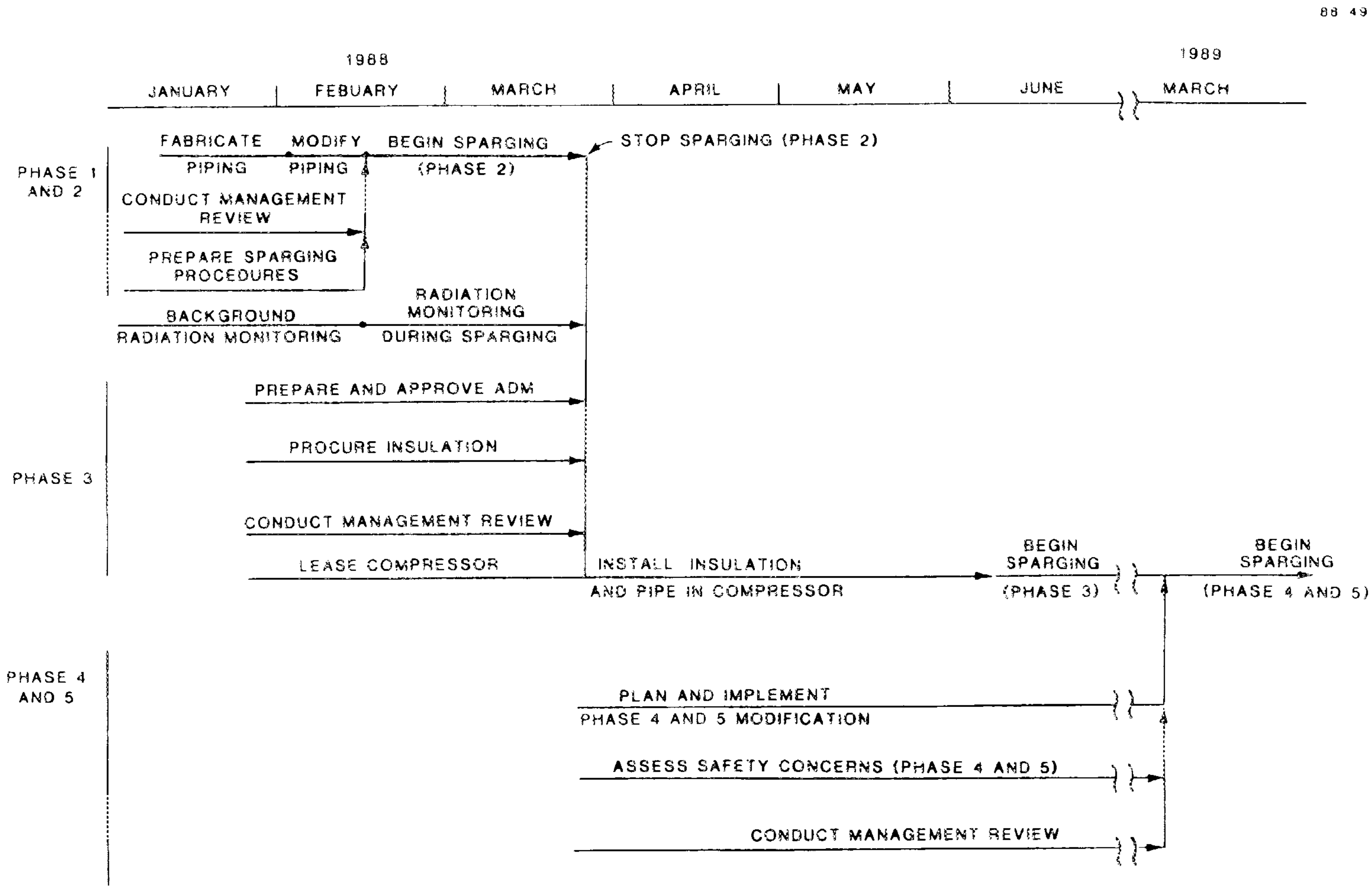

Fig. 5.2. In-tank evaporation implementation schedule.

Table 5.1. Costs for implementing in-tank evaporation (Phases 1-5)

Task	1988 ($1000) Expense	1988 ($1000) Capital	1989 ($1000) Expense	1989 ($1000) Capital
Obtain approvals and coordinate efforts	40			
Purchase and install equipment (Phases 1, 2, and 3)	60			200[a]
Implement enhanced evaporation (Phases 4 and 5)	50			300[b]

[a]Capital equipment.

[b]General Plant Project.

The humidity of the feed and exit air will be monitored, along with the temperature of the liquid and vapor. The vapors will be condensed and collected incrementally to assess potential contamination problems. Therefore, particulate and activated carbon filters will also be installed in the off-gas lines and monitored for radioactivity. Data from the MVST filtration/stack system indicate that few, or no, radioactive particulates are being entrained by the present air sweep through the tanks above the liquid surface. Air-monitoring data should be analyzed to determine the effects of sparging on the off-gas composition.

The compositions of wastes in the MVSTs vary widely and have been characterized to varying degrees, with the predominant data available being radioisotopic. Tanks W-24 through W-27, located in one of the two underground vaults, have been characterized more thoroughly than tanks W-28 through W-31, which are located in the other vault. Therefore, it is deemed necessary to conduct tests with a minimum of four tanks in these evaporation studies. Minimum analytical requirements for each test will include major anion and cation analyses of the liquid feed and concentrate and the chemical composition of the precipitate. Radiochemical analyses of both the liquid and solid phases will also be required.

Tanks W-29 and W-30 are currently being characterized in detail for the EASC, and supernate samples obtained from the midpoints above the sludge levels are available for immediate evaporation tests. Scouting tests will begin with currently available samples from tank W-29. Experiments will be conducted at two temperatures, 50°F (the average temperature of the vaults) and 90°F. The air sparge rate will be set at a level sufficiently low to saturate the air with water vapor. The effects of CO_2 in the inlet air on precipitation will be observed.

The initial tests will be followed with tests using supernate samples from tanks W-30, W-24, and W-27 at one temperature and air sparge rate. Current analytical data indicate that, of the more thoroughly characterized tanks, W-24 and W-27 have the highest and lowest amounts of dissolved solids and salts, respectively. If the results from testing these samples are predictable, the study will be discontinued; otherwise, it may be necessary to test samples from the other four tanks to determine individually their volume-reduction potentials.

5.2.1.8 Schedule and Costs for In-Tank Evaporation

Activity	Time or Cost
Equipment fabrication and installation	2 months
Experimental tests on indicated tanks:	
W-19	2 months
W-30, W-24, and W-27	2 months
Total costs	$150,000 (FY 1988)
Total time	6 months from time personnel are available

Additional testing of the remaining four tanks should require approximately 2 months and cost an additional $60,000 in FY 1989.

5.2.2 Emergency Avoidance Solidification Campaign

The addition of filtration to the backup process has been suggested as a way to physically ensure that no TRU waste is inadvertently solidified. The backup process relies on gravity settling of the TRU waste sludge to separate it from the supernate, which is a low-level waste, and on decantation to remove supernate from the tanks. One technical view is that the flow sheet has no dedicated in-line unit operation for precluding the withdrawal of TRU waste sludge from the tanks. Technically, this is correct; however, there are two factors which indicate that the probability of entraining sludge is low.

First, based on two sampling campaigns, it appears that it is difficult to mix the sludge with the supernate in the tanks. In the July 1985 sampling of the MVST, the objective was to homogenize the contents of the tanks prior to taking samples of the sludge-supernate mixture. The contents of the tanks were both aerated and circulated externally to mix the contents and minimize settling of hard deposits. During the second sampling campaign, which was conducted in November 1985, the objective was to homogenize the supernate. This was to have been accomplished via aeration using the air spargers. In both the July and November 1985 sampling campaigns, the results indicate that a sludge phase was still present and that homogenization of sludge and supernate had not been achieved. More importantly, the supernate was a non-TRU liquid after the rigorous attempt to mix the contents of the tanks.

The second factor is associated with the design of the decanting system. The dip tube design is such that the tube extends only to the midpoint of the tanks. This location is ~4.5 ft above the sludge-supernate interface. At the planned low flow rates to be utilized

(5 to 10 gpm), it is highly unlikely that a significant quantity of sludge would be withdrawn.

The EASC will rely on the following administrative control measures to ensure that no TRU LW is solidified:

1. The supernate will be withdrawn from either tank W-29 or W-30 through a fixed-depth dip pipe positioned at the midpoint of the tanks using a pump located in a module atop the vault.

2. The supernate will be transferred from the decantation pump module to a vendor connection point inside the containment structure through a double-walled piping system.

3. The supernate being pumped through the piping system will be transferred through hose to one of two liners positioned inside the containment structure in casks on "lowboy" trailers.

4. The transfer will be made at a rate of 5 to 10 gpm.

5. Following the batch transfer of ~700 gal of supernate to the liner, the liquid will be mixed by rotating the mixing blade inside the liner while liquid is recirculated from the liner back to the plant connection skid and returned to the liner.

6. During the recirculation mode, a liquid sample will be withdrawn. Prior to the addition of cement, an aliquot of the sample will be analyzed for gross alpha content. Previous samplings show that ~25% of the gross alpha content is attributed to TRU elements; thus, if the gross alpha is <400 nCi/g, there is reasonable assurance that the liquid is a non-TRU waste.

7. Should the quick check for gross alpha indicate that the liquid is potentially TRU waste, then the liquid in the liner will be removed by the recirculation tube and returned to the tank. Should this happen, solidification of supernate from that tank would cease until a non-TRU supernate could be withdrawn.

The backup process approach for the EASC and the reference flow sheet differ mainly in the unit operations that precede solidification. The reference flow sheet includes cross-flow filtration and decontamination ahead of solidification. Cross-flow filtration is intended to remove sludge from the supernate and yield a non-TRU liquid. The proposed decontamination step is intended to remove soluble radioisotopes, mainly cesium, from the supernate and yield a liquid suitable for CH solidification. There is a possibility that the backup flow sheet might be enhanced technically by the addition of filtration in the transfer system.

From the standpoint of implementation, cross-flow filtration would probably work over a wide range of sludge-to-supernate ratios. At one time, consideration was given to procuring a cross-flow filter for installation in the pipe tunnel of the MVST for use in the solidification flow sheet. The principal advantage of locating a filtration system in the pipe tunnel is the short lengths of piping necessary for installation. However, the radiation level measured recently in the pipe tunnel (300 mR/h) indicates that worker exposure during installation of such a system negates the apparent benefits of the close proximity for the necessary tie-ins. In general, it has been concluded that the installation of a cross-flow filter system would cost more than $1,200,000. Therefore, it would require line-item funding and cannot be implemented for the near term.

Another possibility would be to use a cartridge-type filter system in conjunction with decantation in the backup flow sheet. The main limitation of a cartridge filter is that it plugs at a relative low solids loading. Thus, from the standpoint of its utility, it would be passive in the system as long as the decanting system withdrew no sludge from the tanks. If solids should become entrained in the supernate, then the cartridge filter would plug immediately, which would be detectable by pressure drop across the filter element. The merit of a cartridge filter would be its use as an early-warning device system that solids were being entrained rather than its capacity as a continuous separator of solids and liquid. Installation of a disposable cask containing cartridge filters is estimated to cost less than $1.1 million.

5.3 SOLIDIFICATION OF RH-TRU SLUDGES

5.3.1 *Process Evaluations*

For the updated Feasibility Study for WHPP, several assumptions were made, including utilization of a dedicated facility for the stored hot cell waste and a separate dedicated facility for the sludges. It was assumed that the solid hot cell waste would be handled in the facility (WHPP-Solids) to be located near the Melton Valley complex about 500 ft west of the HFIR. Since the TRU sludges to be solidified result from processing in the reference LW solidification facility, it was assumed that the sludge solidification facility (WHPP-Sludges) would have to be closely coordinated, both physically and technically, with the LW decontamination and solidification facilities adjacent to the MVST facility. It was also assumed that the construction of an underground transfer line to move the sludges from the MVST to the WHPP-Solids site (about one-half mile) would be difficult. Further, it was evident that the timing of the two activities might have to proceed on different schedules. For the sludge solidification facility, vitrification was assumed as the reference solidification process because it is well developed and is being used on wastes of a similar nature elsewhere in the DOE system. The Feasibility Study update, as was issued in January 1988, provides revised cost estimates for the WHPP-Solids and WHPP-Sludges facilities.

In addition to the Feasibility Study, a Sludge Solidification Alternative Study was completed in February 1988. The purpose of this study was to evaluate alternative solidification processes based on cementation and thermally driven evaporation for solidification of the ORNL RH-TRU sludges. Starting from the reference vitrification approach, preliminary information on cement-based solidification and thermally driven evaporation solidification was used in preparing modified facility layouts and cost estimates. Additionally, the operating, transportation, and disposal costs were projected for each of the three processes so that a comparison of total life cycle could be performed. Results of this study indicate that thermally driven evaporation is the most cost-effective approach.

Solidification tests based on the thermally driven evaporation approach will be conducted in late FY 1988 with simulated waste. Additional solidification tests using actual ORNL sludges are being proposed in FY 1989 and are discussed in more detail in the following section.

5.3.2 R&D to Support Process Selection and Design Basis for RH-TRU Sludge Solidification

Radioactively contaminated LW from the MVSTs can be separated into a dilute, lower-activity liquid and a concentrated, higher-activity sludge. The strategy for long-term management of contaminated liquids includes (1) decontamination and conversion of the bulk constituents into LLWDDD Class II SLLW and (2) concentration of the radionuclides (both TRU and beta-gamma) into a volume that will optimize preparation for disposal (see Sect. 4.4.4). Solidified radioactive waste will be required to meet WIPP or LLWDDD Class IV WAC.

R&D will be conducted to support process and design-basis selection for RH-TRU sludge solidification. This effort will be conducted concurrently and in parallel with R&D to support other steps necessary for the long-term treatment process and design-basis selection and will be coordinated through the "Analysis and Planning" function discussed in Sect. 5.4.2. The WHPP will contain unit operations for handling TRU sludge. Analyses of alternative unit operations have indicated that microwave drying or some other thermal treatment is promising for solidifying MVST TRU sludge for shipment to WIPP. [Vitrification was assumed as the reference solidification process for the WHPP feasibility study (see Sect. 5.3.1)]. The following discussion outlines R&D tasks, schedule, and costs needed to determine whether microwave drying or other thermal treatment is cost-effective and whether this approach should replace vitrification in the design basis for the WHPP.

Sludge-removal, solidification, and packaging for shipment to WIPP are three major steps required to solidify the waste as shown in Fig. 5.3.

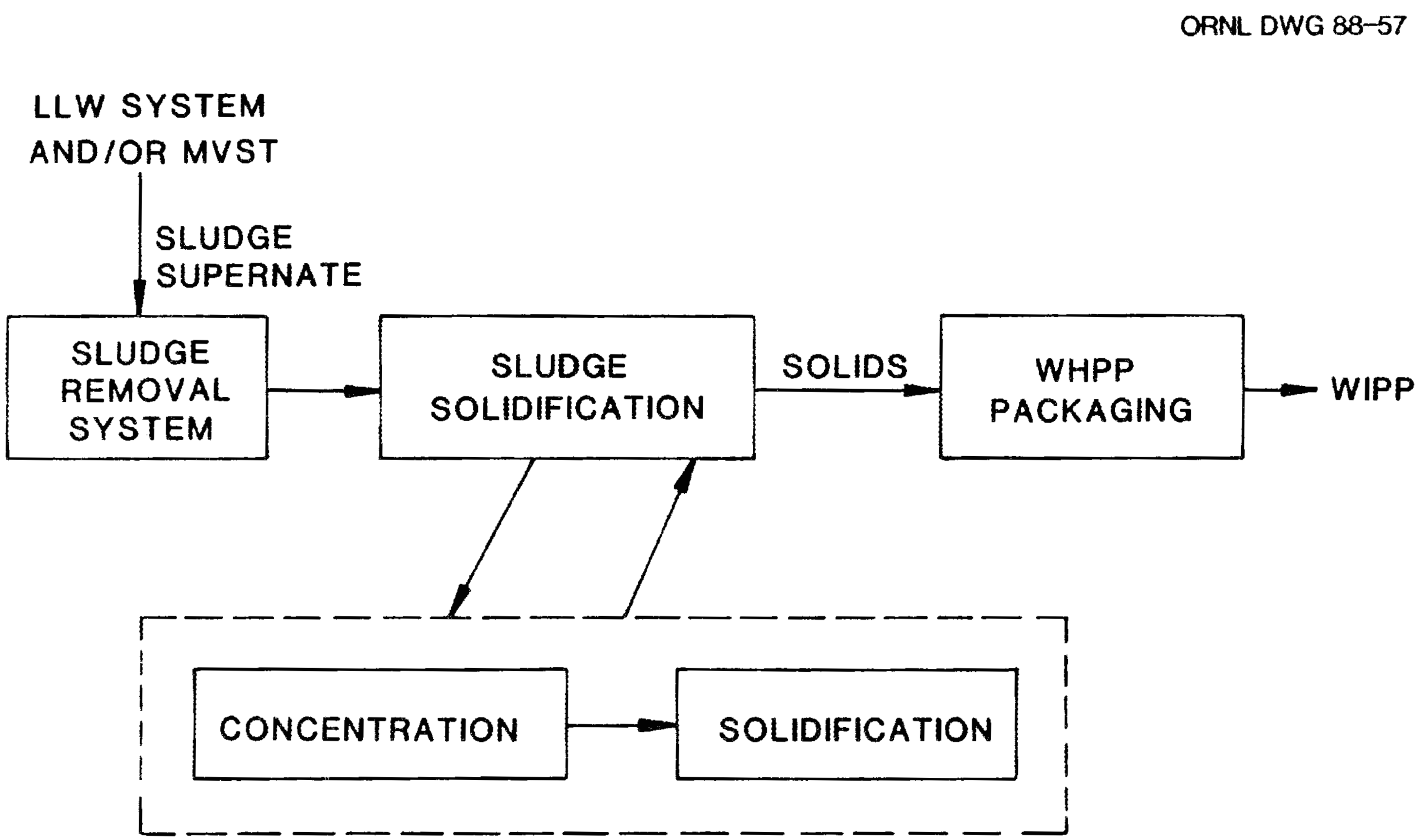

Fig. 5.3. Major steps required for management of remote-handled transuranic sludges.

The first step in the R&D effort will be a literature review to assess the viability of alternative solidification techniques. Experimental evaluation of alternative processes will follow the literature review. Testing of methods to concentrate wet sludge and solidify concentrated sludge will be conducted using simulated ORNL waste during FY 1988. The purpose of the cold testing is to demonstrate total direct solidification of ORNL MVST sludge. Process parameters that will be refined in preparation for testing of actual ORNL waste include (1) volume reduction factors, (2) tendencies for foaming, (3) plugging of off-gas lines, (4) off-gas constituents, (5) equipment specifications, and (6) potential problem areas.

The versatility of processes will be investigated to determine their potential for producing solids that meet the WIPP WAC, as well as for examining their capability for meeting more stringent WAC should the criteria be expanded to address leach-resistance characteristics. The ability of a waste form to meet WAC must be measured to determine whether process parameters (such as temperature and waste-to-flux mix ratio) should be modified to improve the waste form. Testing of the concentration/solidification processes using actual ORNL sludge will be conducted at ORNL in hot cell facilities. These hot tests must be conducted early in FY 1989 so that results will be available to support validation of the WHPP project during mid-FY 1989. The design aspects of the project will be integrated by working with Engineering staff and will include consideration of secondary waste stream treatment and production rates.

Tests using actual MVST sludge will be coordinated with R&D on the LW. Alternative methods for removing sludge from the MVST tanks and preparing it for shipment to WIPP will be evaluated (e.g., using a "sludge hog" to remove sludge and vacuum drying in HIC to prepare for shipment to WIPP). This R&D effort could expand into a demonstration project by FY 1991, perhaps through use of an outside subcontractor. Table 5.2 includes funding to implement a technology demonstration.

In addition to engineering applications, information gathered during hot testing will be used to prepare the Preliminary Safety Assessment Report (PSAR), Environmental Assessment (EA), handling and transportation approvals, solidified-material certification, radiation exposure scenarios, gas generation projections, solid waste generation projections, and quality assurance documentation.

5.3.3 Sludge Mobilization

The basic technique for sludge removal from the MVSTs is anticipated to be similar to that utilized in removal of solids from the ORNL gunite tanks. This will consist of a high-pressure recirculating stream that can be remotely directed at the sludge for the purpose of erosion and entrainment of the solids. The basic system will consist of a nozzle that is inserted into a tank through the manhole and remotely directed at

Table 5.2. Cost estimate for RH-TRU sludge solidification R&D

Task	Funding needs by fiscal year ($1000)			
	1988	1989	1990	1991
Literature search and summary (initial funding by TRU Program)		10	10	10
ORNL evaluation of cold tests and procurement of hot test equipment (initial funding by TRU Program, $50K)	40	65	45	45
ORNL hot waste testing and demonstration (additional funding by TRU, $150K FY 1989)	30	350	350	100
Waste-form testing and characterization		150	300	150
Totals	70	575	705	305

the sludge by using a TV camera. A shielded and ventilated enclosure will be located above the manhole, and it will contain the necessary equipment for directing the nozzle and camera. This enclosure will also contain the necessary instrumentation and piping for carrying out the sludge-removal operations necessary to empty a tank. The sludge-removal enclosure will remain in place at a tank position until the residual sludge in that tank is of no concern. At this point in the sludge-removal operation, the enclosure will be relocated to another tank position. The existing tank and vault ventilation system on the northern side of the vaults must be relocated prior to the installation of the sludge-removal enclosure.

The support equipment external to a sludge-removal enclosure will consist of a pump enclosure, a sludge transfer line to the sludge solidification facility, a clarifier-type vessel located within the solidification facility, and a return line from the clarifier back to the pump enclosure. This equipment will have adequate shielding and ventilation. Figure 5.4 is a schematic of the proposed process.

The sequence of operations required to empty a tank is as follows:

1. The supernate from a tank will be used to hydraulically fill the pumps, piping, and clarifier to initiate sludge removal from a tank.

2. The recirculating system will be operated at flow rates up to 150 gpm until the desired quantity of sludge has been transferred to the clarifier.

3. The sludge solidification facility will then be operated to empty the clarifier of sludge and liquid.

4. This procedure will be repeated until the residual sludge remaining in a tank is of no concern as to follow-on operations.

Process water will be used, as needed, in the later stages of this operation once the supernate is depleted. Thus, the solidification facility process equipment must include an evaporator.

Sludge and supernate samples need to be collected and analyzed to determine the shielding requirements for this equipment. Sampling data required for development and design of a sludge system will be gathered as a part of the MVST characterization effort described and costed in Sect. 5.1. A literature search is needed to review past work in sludge mobilization. In addition, a vendor survey is necessary to identify state-of-the-art sluicing and sludge transport systems. Funding needs for the literature search and vendor survey are not defined, and it is estimated that $50 thousand of expense funding will be required in FY 1988 to complete the effort.

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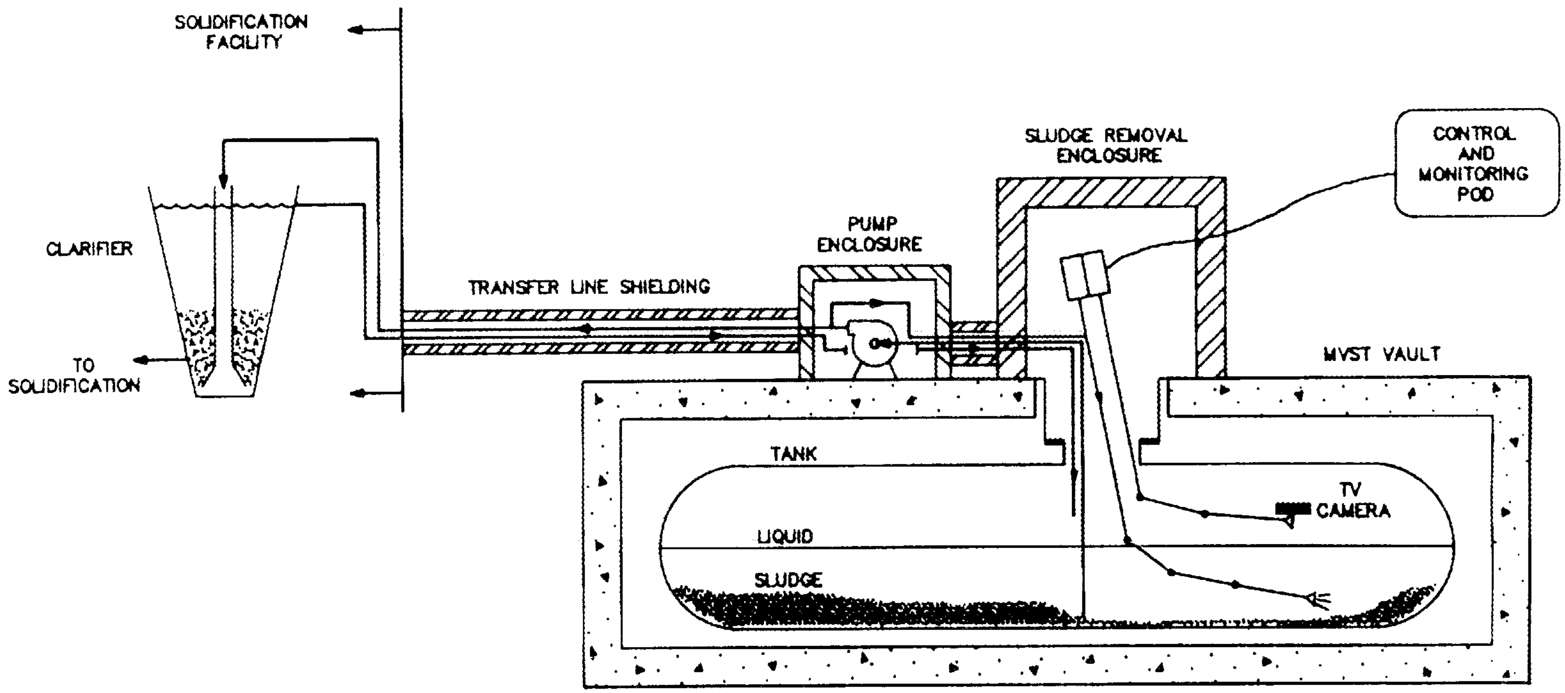

Fig. 5.4. Schematic of proposed sludge-removal process for Melton Valley Storage Tanks, typical for a vault.

After the study to identify mobilization equipment has been completed, mock-up tests will be required to demonstrate equipment and procedures for application in the MVSTs. Additionally, proper procedures for the removal of the manhole and placement of the sludge-removal enclosure need to be demonstrated to ensure acceptable radiation exposures for workers.

Demonstration of sludge-mobilization equipment and tank access is a newly defined task and is not presently funded. To effectively support the WHPP design effort, the demonstrations should be conducted in FY 1989, FY 1990, and FY 1991. Preliminary estimates indicate that the funding required for these efforts would be $100 thousand in FY 1989, $500 thousand in FY 1990, and $100 thousand in FY 1991.

5.4 LONG-TERM MANAGEMENT OF LW

Information is presented in this section for work that is needed in the following areas: (1) potential improvements to the LW system for further minimizing LW concentrate generation and (2) R&D to support process selection and design-basis definition for treatment of contaminated LW.

5.4.1 Potential Improvements to LW System

An initial systems analysis has been completed. A plan for implementing the initial group of improvements identified by this analysis is discussed in the following section. A more complete analysis of the LW system will be a continuing effort for several years. The items discussed in the remainder of this section are the results of the initial analysis. Systems analysis studies to be constructed in the future will include consideration of results from sampling of waste streams at the source and evaluation of source treatment to minimize the LW generated.

5.4.1.1 3039 Stack Off-Gas Scrubber

As previously stated (Sect. 4.4.1.1), no change in the handling of this waste stream is warranted at this time.

5.4.1.2 Lining of Process Waste Piping

The lining of process waste piping is being conducted under two existing capital projects. No additional funding is required for this modification, which should be completed in 1988.

5.4.1.3 Fission Products Development Laboratory, Building 3517

Implementation of changes to the waste-handling practice at Building 3517 would first require sampling of the waste stream for some period to establish its characteristics. Sampling should be followed by bench-scale studies to determine the effect of diversion on the PWTP and/or development of pretreatment at the source prior to discharge to the process waste system.

Cost estimates to modify the Building 3517 waste system are given in Table 5.3. These costs include expense funding in FY 1989 to sample and develop a pretreatment scheme, with capital funding in FY 1989 to design and construct the system. Modifications should be complete in 1991 if FY 1989 funding is approved.

5.4.1.4 High Flux Isotope Reactor

Implementation of improvements proposed in Sect. 4.4.1 for HFIR should begin with radionuclide characterization of the spent primary demineralizer resins. This characterization would be used to request vendor proposals for solidification of the resin to meet LLWDDD Class II WAC. Candidate vendors should then be asked to demonstrate their solidification process on a surrogate loaded resin and submit the waste form for ORNL testing to verify compliance with LLWDDD Class II WAC. If a solidification vendor can be established, the necessary modifications to HFIR facilities should be made to accommodate vendor solidification at HFIR.

If a process cannot be established to produce an LLWDDD Class II waste form, modifications will be defined to minimize the generation of LW at HFIR. As suggested in Sect. 4.4.2, these may include concentration of the regeneration streams by evaporation and fractionation of the overheads to recover nitric acid for recycle.

The preliminary costs for changes to the waste system at HFIR are given in Table 5.3. The expense funding includes spent-resin characterization, vendor evaluation, and proposed waste-form testing. Capital cost includes modifications to the facilities to accommodate a vendor solidification process or recovery and recycle equipment additions. Funding of these activities in FY 1989 should allow for completion in 1993.

5.4.1.5 Oak Ridge Research Reactor/Bulk Shielding Reactor

Modification for minimizing waste generation at the Oak Ridge Research Reactor is being implemented as a part of the activities to put the reactor in a safe shutdown condition. Funding for these activities is provided by the Reactor Division at ORNL.

Table 5.3. Estimated costs and schedule for proposed improvements to the LW system

Facility proposed for improvement	Funding status	Additional funding requirements by FY: Expense $1000	Expense FY	Capital $1000	Capital FY	Estimated completion date
Lining for process waste piping	Funded	-	-	-	-	1988
Fission products development lab., Bldg. 3517	Not funded	25 105 30	1988 1989 1990	500-750	1989 GPP	1991
High-Flux Isotope Reactor	Not funded	230 30 50	1989 1990 1991	500-750	1990 GPP	1993
Oak Ridge Research Reactor	Funded (reactor funds)	-	-	-	-	1998
Process Waste Treatment Plant	Funded	-	-	-	-	1990
TRU Processing Plant	Scope change; WHPP line item (LI) or Melton Valley CAT LI	-	-	-	-	1998

BSR waste-handling changes are being implemented through a planned GPP to upgrade the facilities. Review of this project, as it develops, should be continued to ensure that waste recycle and minimization are included. Additional funding should not be required.

5.4.1.6 Process Waste Treatment Plant

As previously stated, the modifications to the PWTP are to be completed by a FY 1989 GPP; additional funding is not required.

5.4.1.7 Transuranium Processing Plant

Piping changes to segregate LLLW and TRU waste, both within TPP and in the LW collection system, would best be implemented as an addition to the proposed Melton Valley LLLW Collection and Transfer (MV-CAT) line item and/or the WHPP line item. Definition of needed piping changes should be established, and scope changes to MV-CAT and WHPP should be proposed. No additional funding is needed other than the cost increase in the line items, which will be associated with scope changes.

5.4.2 R&D to Support Process Selection and Design-Basis Definition for Treatment of Contaminated LW

An aggressive R&D program will be conducted to select the appropriate processes and to develop the design basis for the processing scheme that is depicted in Fig. 4.12. The goal of the processing is to render the bulk of the ORNL LW acceptable for final disposal as an LLWDDD Class II waste. The approach to this development effort and to the major work elements to ensure its successful completion is discussed in Sect. 5.4.2.1.

5.4.2.1 Generic Research and Development Approach

The organizational approach adopted to perform this process development task is shown schematically in Fig. 5.5. The direction of the work will be determined by the analysis and planning function, which provides the overall definition of the R&D program via an ongoing systems analysis wherein the information from literature surveys, waste characterization, experimental data, and regulatory and institutional constraints are evaluated and balanced to produce the best approach for development of the process. Characterization of the waste slurry, which is extremely important to the process development effort, will be an ongoing effort during process development, as is discussed in Sect. 5.1 of this report.

The generic approach to be taken will involve an iterative evaluation of processes at a progressively greater level of detail. Initially, a screening-level evaluation will be conducted in that all feasible processes for each step will be considered. The processing steps will be configured into potential flow sheets, which will then be

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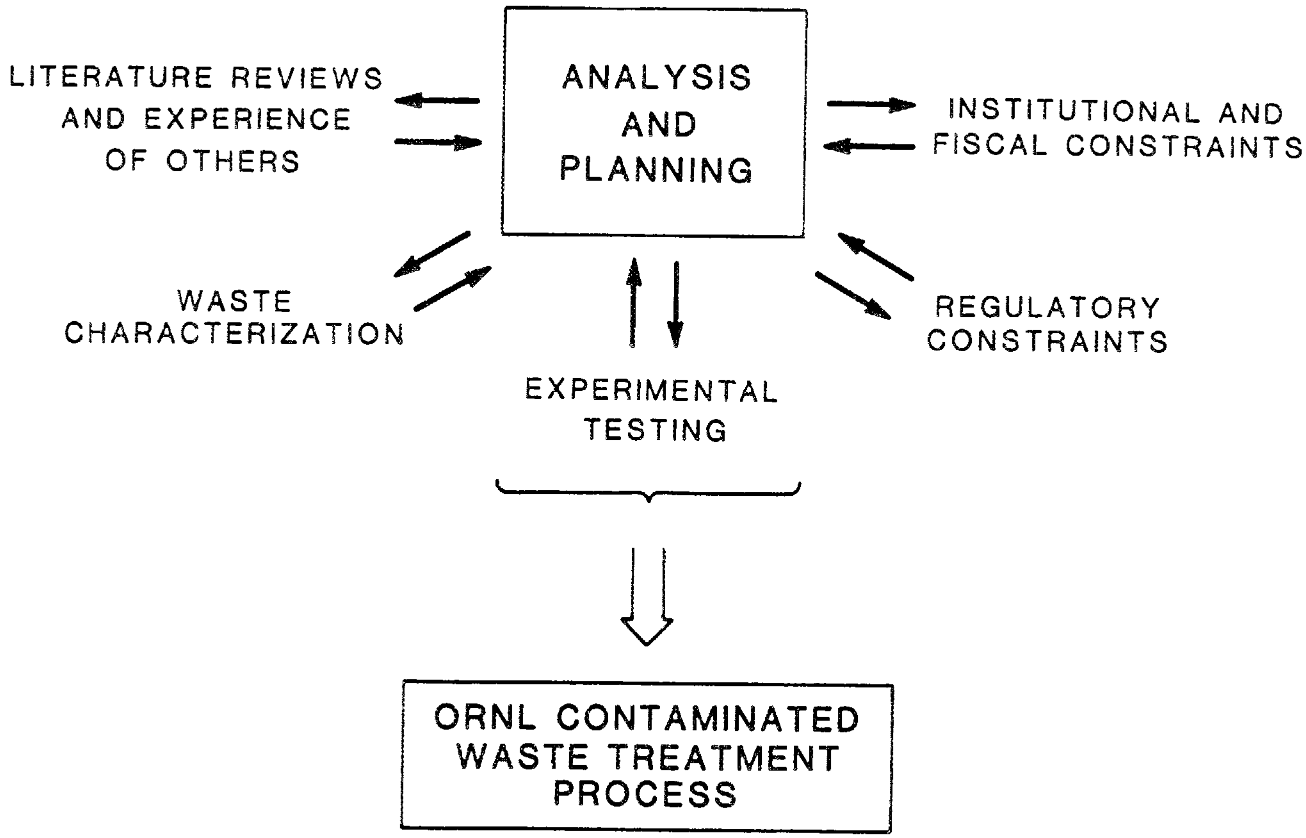

Fig. 5.5. Contaminated waste process development.

evaluated to determine those that have potential for meeting the set of unique constraints. Information regarding needed data with respect to each of the processes will also be produced during this initial evaluation. The next step will be to obtain the needed data by conducting key experiments. It is envisioned that, at this point, the level of process knowledge will be sufficient to select one flow sheet. The level of flow-sheet detail would be such that the unit operations would be known but the type of equipment and mode of operation would not.

After selection of the best flow sheet, an intensive effort will be made through a combination of laboratory evaluations and engineering analysis to select the equipment and operating conditions that appear best for the unit operations. This phase will involve parametric testing of each of the process steps, utilizing both simulated and actual waste. A major emphasis during this phase will be placed on a fundamental understanding of the process mechanisms, which is crucial for process analysis. The costs associated with large-scale testing of treatment processes are prohibitive because most of the work would have to be done remotely in containment facilities designed to handle high levels of beta-gamma and alpha activity. It is unlikely that, without a firm understanding of process fundamentals, processes tested in the laboratory can successfully be scaled to plant scale.

The final development task, and the one that will produce the design-basis information for the plant, will be a pilot demonstration of the flow sheet. This demonstration will be conducted in hot cell or glove box containment. Because operations of this type are costly, the scale of operation would be as small as possible, while retaining the capability to generate the data necessary to design the actual processing plant and demonstrate process feasibility.

5.4.2.2 Specific Approach

One of the key steps of the process illustrated in Fig. 4.12 is the box labeled "prepare for disposal." This step appears in two parts of the flow sheet. One part is the solidification step for decontaminated supernate, and the other part is for solidification of the bulk of the radioactive materials. From a chemical processing standpoint, both of these solidification steps may be similar. Moreover, they are similar to the direct solidification of all solids contained in the LW slurry now stored in the MVSTs. Since the latter method has been proposed previously in this report for use in the WHPP, specific R&D to cover this step will be initiated immediately, as described in Sect. 5.3.2, to provide the necessary input to the WHPP Conceptual Design Report. This R&D will also provide the basic data required for the solidification steps shown in Fig. 4.12.

In previous R&D studies, initial data have been obtained for the liquid/solid separation step shown in Fig. 4.12. While not complete, the data have shown that, if this process step is carried out efficiently, the supernate will not be TRU waste. Further studies will be needed to define pretreatment steps (such as addition of coagulants) and the appropriate equipment. However, this work can be postponed until feasibility of the supernate decontamination has been established.

Supernate decontamination is the process step for which the least is currently known and for which R&D is not already planned (such as for the "prepare for disposal" solidification steps). R&D on supernate decontamination is crucial in determining whether the bulk of the waste liquid can be converted to LLWDDD Class II SLLW. Thus, R&D in this area should be started as soon as possible to determine the extent of decontamination possible and the best method for its accomplishment.

Several methods of decontamination should be examined. These include ion exchange, precipitation, solvent extraction, and biological sorption processes. In addition to determining the attainable decontamination, the available processes must be evaluated according to (1) the volume of waste material generated, (2) the complexity of the process and equipment, and (3) applicability to remote operation and maintenance.

5.4.2.3 Schedule

The proposed schedule for the development program is outlined in Table 5.4. During FY 1988, the major emphasis will be on process screening. A detailed program plan will be developed to guide the process development efforts that will be required, and the resulting detailed program plan will be updated to maintain an up-to-date detailed plan. This planning will be done in conjunction with a systems analysis effort for the existing LW system. Bench-scale testing will be done, as required, to support these planning exercises. As discussed in Sect. 5.2.1, a testing program will be conducted in support of the in-tank evaporation program to be carried out in the MVSTs. This effort will be made in FY 1988.

Pilot-scale work has been initiated on a reference EASC flow sheet as discussed in Sect. 5.2.2. The reference flow sheet was selected after literature review and a preliminary "paper" process evaluation. Cross-flow filtration work has been completed, and additional pilot-scale testing of the reference flow sheet has been suspended pending completion of alternative flow sheet analysis and efforts to fill "data gaps." This pilot-scale test facility will be held in standby until the planning and analysis efforts indicate what should be done next with respect to long-term LW processing. The WHPP will require a direct solidification process to prepare the existing RH-TRU sludges for shipment to WIPP. Time is allotted for following the ongoing cold experimental program and for setting up a program for solidifying actual hot wastes at ORNL. This work is discussed in detail in Sect. 5.3.2.

Table 5.4. Proposed schedule for LW research and process development

Task	Fiscal year 1988	1989	1990	1991
LW process development, program planning, and initial process screening	————X			
Bench-scale testing	————	————	————X	
Characterization	————	————	————X	
Pilot-scale evaluation		——	————	——X

...st estimate for performing the previously described process development work is presented in Table 5.5. The projected costs are estimates and, as such, are to be used for initial program guidance only. Much better cost estimates will be available at the end of FY 1988 when the process development program planning exercise is complete. These costs do not include allowances for major equipment items or for the development work related to solidification that is proposed in Sect. 5.3.2.

Table 5.5. Cost estimate for LW process development

	Funding requirements ($1000)			
	FY 1988	FY 1989	FY 1990	FY 1991
Planning and analysis	50	110	120	120
Bench-scale testing	40	300	400	110
Pilot-scale evaluation		150	575	200
Analytical support		100	150	75
Cross-flow filtration	100			
Flow sheet evaluation and feasibility study (process engineering)	20	40	300	500
Solidification development and demonstration		300	1800	3000
System analysis	40	40	40	40
Total	250	1040	3385	4045

6. PROJECTED FUNDING REQUIREMENTS

This section compiles and summarizes the estimated costs for implementing the activities outlined in Sect. 5. The estimated costs are compared with the existing baseline budget based on current DOE budget guidance, and additional funding requirements necessary for implementation of this program plan are identified. Assuming that additional funding may not be forthcoming, the implementation plan was reduced in scope and/or delayed to develop a spending plan which matches the baseline budget. The impact of delaying activities in the program to match the baseline budget is discussed briefly.

All costs identified in Sect. 5 are compiled in Tables 6.1, 6.2, and 6.3. Table 6.1 summarizes expense funding requirements, and Table 6.2 presents the associated capital equipment requirements. Additional expense funding required to define and manage capital projects is summarized in Table 6.3. Also presented in Table 6.3 are rough estimates of capital projects that are needed to modify the LW system. Costs in Table 6.3 are presented separately because these capital projects will be coordinated through the Capital Projects Program (DPGF107 and/or ERKG002), while activities listed in Tables 6.1 and 6.2 will be coordinated by the ORNL LLLW Solidification Task (DPGF106).

The expense funding requirements for the LLLW Solidification Task are summarized in Table 6.4. In developing the budget presented in Table 6.4, every effort was made to defer significant cost items that would not delay the progression of the program. For example, significant new R&D initiatives are deferred to FY 1989, with only experimental plans and apparatus assembly being effected in FY 1988.

In spite of these efforts to defer major expenditures, additional funding is needed as is indicated by the unidentified funding line in Table 6.4. Associated additional capital equipment needs are summarized in Table 6.2. All LW system modifications listed in Table 6.3 are newly identified activities and are consequently unfunded. All additional funding needs are summarized in Table 6.5.

To actively progress with the program, the previously identified funds are required, but assuming no additional funding, a spending plan was developed to match the budget baseline. This spending plan is presented in Tables 6.6 and 6.7 and essentially delays long-term R&D activities for approximately 1 year. Under this plan, the only R&D activities conducted in FY 1988 are filtration testing and in-tank evaporation experiments. The detailed planning of long-term R&D experiments and the assembling of experimental apparatus would be delayed until FY 1989. The effect of no additional funding on the implementation of the LW system modifications is unclear because these projects would be prioritized and would compete with existing projects for funding. It is likely that a 1- to 2-year delay would result in the project funding and thereby delay the associated LW volume

Table 6.1. Expense funding requirements for program implementation

	Funding requirements ($1000)			
	FY 1988	FY 1989	FY 1990	FY 1991
Program planning (All)				
Program coordination and strategy development	85	110	120	120
Characterization (Sect. 5.1)				
Prepare sampling plan	30			
Sample acquisition and analysis		450	200	100
In-tank evaporation (Sect. 5.2.1)				
Obtain approval and coordinate effort	60	40	30	
Purchase equipment and install (Phases 1-3)	90	20		
Experimental testing	150	60		
Implement enhanced evaporation (Phases 4-5)	50	80	20	
Emergency Avoidance Solidification Campaign (Sect. 5.2.2)				
Implementation of EASC and contingency planning	1705	500		

Table 6.2. Capital equipment funding requirements for program implementation

Capital equipment item	Cost estimates ($1000) FY 1988	FY 1989	FY 1990
Diesel generator (Sect. 5.2.2)	150		
Stack monitor (Sect. 5.2.2)	60		
Noninterruptible power supply (Sect. 5.2.2)	49		
Liner handling equipment (Sect. 5.2.2)	40		
Radiation instruments (Sect. 5.2.2)	30		
Microwave system (Sect. 5.3)	198		
Tanker (radioactive liquid) (Sect. 5.2.1)		100	
Sludge removal equipment (Sect. 5.3)		380	
Wet-chemistry equipment with glove box (Sect. 5.1)			90
Anion chromatograph (Sect. 5.1)			40
Decontamination system (Sect. 5.4.2)			300
Filtration system (Sect. 5.2)			300
Unobligated funds			280
Total	527	480	1010
Budget baseline	259	268	1010
Unidentified funding	268	212	0

Table 6.3. **Capital projects and capital projects management for newly identified liquid waste system modifications**

Capital project management	Expense funding requirements ($1000) FY 1988	FY 1989	FY 1990	FY 1991
LW System Modification (Sect. 5.4.1)				
Building 3517, Fission Products Laboratory				
Sample and develop pretreatment scheme	25	50		
Prepare preliminary proposal	30			
Capital projects management		25	30	25
High Flux Isotope Reactor				
Characterization		25		
Vendor evaluation		50		
Waste-form testing		150		
Prepare preliminary proposal		30		
Capital projects management			50	50
Total	55	330	60	75

Project Title	**Funding year**	**Estimated cost ($1000)**
Enhanced Evaporation MVST	1989	300-500
FPDL Pretreatment System (Building 3517)	1989	500-750
HFIR Regenerate System Modification	1990	500-750

Table 6.4. LLLW Solidification Task expense funding summary and budget baseline

Activity	Expense funding requirements ($1000)			
	FY 1988	FY 1989	FY 1990	FY 1991
Program planning	85	110	120	120
Characterization	30	450	200	100
In-tank evaporation	280	200	50	
EASC	1705	500		
WHPP process support	120	675	1205	405
R&D support process selection	250	1040	3385	4045
Total	2470	2975	4960	4670
Budget baseline	2200	2500	4500	
Unidentified funding	270	475	460	

Table 6.5. Summary of additional funding needs

Program	Additional funding required ($1000)		
	FY 1988	FY 1989	FY 1990
LW Solidification			
Expense	270	275	460
Capital equipment	268	212	
Capital Projects			
Expense	55	330	60
Capital projects		800-1250	500-750

Table 6.6. Expense funding summary adjusted to meet funding baseline

Activity	Expense funding requirements ($1000)			
	FY 1988	FY 1989	FY 1990	FY 1991
Program planning	85	110	120	120
Characterization		350	340	100
In-tank evaporation	250	200	50	
EASC	1705	500		
WHPP process support	40	530	1005	229
R&D support process selection	120	810	2985	4045
Total	2200	2500	4500	4490

Table 6.7. Capital equipment funding adjusted to meet funding baseline

Item	Cost estimates ($1000)		
	FY 1988	FY 1989	FY 1990
Diesel generator	150		
Stack monitor	60		
Noninterruptible power supply	49		
Liner handling equipment		40	
Radiation instruments		30	
Microwave system		198	
Tanker (radioactive liquid)			100
Sludge removal equipment			380
Wet-chemistry equipment with glove box			90
Anion chromatograph			40
Decontamination system			200
Filtration system			200
Total	259	268	1010

reduction for that same period. More details of the activities to be conducted for the indicated funding and program milestones will be presented in Sect. 9.

It is essential that funding be provided to develop long-term solutions to our LW problems and to allow us to progress from our present reactive mode to methodical implementation of a well-structured, long-term solution.

7. REQUIRED PERMITS AND REGULATORY CONCERNS

Required permits and regulatory concerns that may impact the implementation of activities outlined in Sects. 4 and 5 of this plan will be discussed briefly in the following sections. The discussion provided here is not intended to constitute a comprehensive review of all regulatory requirements at ORNL; rather, it is simply meant to identify those requirements which have the greatest potential for impacting completion of the planned activities. A more complete discussion of required permits and regulatory concerns at ORNL is presented in the *ORNL Environmental and Waste Management Long-Range Plan*.[8]

7.1 CHARACTERIZATION OF ACTIVE AND INACTIVE TANKS

As outlined in Sects. 4.1.1 and 4.1.2 of this plan, additional characterization of the contents of the active and inactive tanks is required to allow appropriate processing steps to be provided to convert wastes to a form acceptable for final disposal. The sampling efforts for these tanks will involve handling radioactive liquids; therefore, systems for containment and shielding will be provided in accordance with standard ORNL health physics practices. Because significant radiation fields are associated with many of the samples, the sampling procedure will be prepared to improve the logistics of activities to minimize personnel exposure per as low as reasonably achievable (ALARA) requirements.

Environmental assessments, such as an Action Description Memorandum (ADM) and/or an Activities Description Memorandum, will be prepared and approved prior to conducting sampling activities. These documents will review the environmental impact of planned activities and will identify actions required for reducing the potential for releases to the environment. Sampling protocol and analytical procedures must be carefully scrutinized to ensure that data will be acceptable to the Environmental Protection Agency (EPA) and the Tennessee Department of Health and Environment (TDHE). Standard EPA procedures will be used where possible, but deviation from standard procedures will be necessary due to the radiation fields associated with the samples and the nonstandard characteristics of these concentrated salt solutions. Significant deviation from EPA procedures will be discussed with EPA and TDHE to ensure that data will be useful in future negotiations concerning the regulatory status of the tanks and permitting requirements for treatment facilities.

7.2 NEAR-TERM OPTIONS FOR INCREASING AVAILABLE TANK STORAGE VOLUME

7.2.1 In-Tank Evaporation

A phased implementation of in-tank evaporation is proposed in Sects. 4.2.1 and 5.2.1.

An ADM will be prepared for Phases 3, 4, and 5 of the implementation. Phases 1 and 2 will be conducted concurrently with the ADM preparation, but Phases 3, 4, and 5 will not become operational until the ADM has been approved.

Phases 1, 2, and 3 of the in-tank evaporation effort only provide equipment to allow several tanks to be sparged at their original design conditions; therefore, operation under these phases is consistent with existing safety documentation [*Operational Safety Report* (OSR) and the *Final Safety Analysis Report* (FSAR)]. Implementation of Phases 4 and 5, however, introduces significant operational changes that will require review by the ORNL Office of Operational Safety. If necessary, an additional safety assessment will be prepared to evaluate the potential for elevated safety risks associated with operations during Phases 4 and 5.

7.2.2 Emergency Avoidance Solidification Campaign

The EASC is now in the construction phase, and remaining regulatory uncertainties are being addressed. There are several challenges to resolving these uncertainties and completing the operational stage of the project. Only a summary of the current status of regulatory concerns will be presented in this section.

An ADM has been prepared and approved for the project. It was stated in the ADM that the facility would require permitting under RCRA, either via permit-by-rule (PBR) or Part B permitting. PBR is currently being pursued, and a PBR application has been submitted to the TDHE.

If a PBR for the EASC is allowed, it will constitute an addendum to the existing PBR for the ORNL LLLW collection and treatment system. The ORNL LW system is considered a wastewater treatment unit, and because the effluent from that system's LW evaporator is treated by another permitted treatment unit (the evaporator effluent is treated at the NPDES-permitted ORNL PWTP), the solidification of the LW in the MVST tanks, which is another product of the LW evaporator, may also be eligible for PBR.

If the EPA will not allow the PBR, then a Part A permit revision will be submitted to place the MVST and solidification facilities under interim status. This would allow for startup (or continuation) of operations while Part B is being prepared. The Part B permit application would have to be submitted within 6 months of the Part A revision.

Safety documentation for the project was planned well in advance, and the FSAR is now in a preliminary draft stage. The OSR, which defined limits of operations consistent with the FSAR, is being drafted. Both documents will require thorough review and approval by the ORNL Office of Operational Safety.

Final disposal of the waste forms produced by the EASC operation is currently the subject of intense negotiations with the TDHE. Regulatory concerns have been expressed, with the initial plan to dispose of the waste forms in greater confinement disposal units at the ORNL Solid Waste Storage Area 6 (SWSA-6). In response to these concerns, an alternative evaluation for disposal of the waste forms is being drafted. The alternative evaluation, entitled "Emergency Avoidance Solidification Campaign Waste Management Alternatives Evaluation," will be issued prior to the final issuance of this report. The evaluation considers the following seven waste management alternatives:

1. temporary storage of the waste on the SWSA-6 tumulus;
2. storage in new or existing facilities at ORNL;
3. storage at Oak Ridge Gaseous Diffusion Plant (ORGDP) facilities;
4. use of SWSA-6, type 1 silos for disposal/long-term storage;
5. shipment off-site;
6. disposal in SWSA-6 in conformance with LLWDDD Class II limits; and
7. delay of EASC.

The discussion of the details of these alternatives is outside the scope of this report.

7.3 TREATMENT AND DISPOSAL OF RH-TRU WASTES

As discussed in Sect. 4.3, the bulk of the existing LW inventory will be processed by the WHPP and shipped to the WIPP for final disposal.

The WHPP will require an EA, which is being planned early in the project. The EA will address the environmental issues in enough detail so that expansion into an EIS, if required, could be accomplished without delaying the project.

It has been assumed that the WHPP will be permitted under RCRA. A Part B permit is planned early in the project to allow time for the RCRA permitting procedure to be completed prior to the startup of the facility.

A facility as extensive as the WHPP will require the preparation of a Preliminary Safety Assessment Report, an FSAR, and an OSR to ensure that all potential safety risks have been evaluated and found acceptable. These documents are planned for preparation at the appropriate time in the project development.

The environmental concerns associated with transporting waste from the WHPP to the WIPP have been addressed by the EIS for the WIPP facility. The shipment of waste to WIPP is an essential link in the final disposal plan and will be monitored carefully by ORNL TRU-Waste Program personnel.

There is some uncertainty about the RCRA permitting status of the WIPP facility. Obviously, WIPP permitting is not the responsibility of ORNL, but the permitting process will be followed to ensure that it will not impact WIPP's availability to accept waste from ORNL for final disposal on the schedule that is needed.

7.4 LONG-TERM MANAGEMENT OF ORNL LW

The activities outlined in Sect. 4.4.1 are generally modifications to existing facilities. It is likely that each would require the preparation of an ADM, but more extensive environmental assessment documents would not be required.

Several of the modifications affect facilities having approved FSARs and OSRs. The details of the proposed modification will be reviewed with respect to the existing safety documentation, and revision of these documents may be required. Modifications to nuclear reactors (HFIR, ORR, and BSR) will be reviewed with extreme care to ensure that existing systems are not being impacted by the waste system modification. In all cases, the modification will be reviewed by the ORNL Office of Operational Safety.

Activities proposed in other parts of Sect. 4.4 are in a very preliminary stage of planning, and current information is not adequate to allow discussion of regulatory concerns. As the implementation schedule for these activities is defined, proposals for addressing regulatory concerns will be developed.

8. RECOMMENDATIONS

The recommendations resulting from this planning effort are listed in this section. Each recommendation is associated with one of the three established goals of the overall strategy for management of the radioactively contaminated LW and TRU sludges at ORNL. The recommendations are discussed in the paragraphs that follow.

Goal 1: Improve the near-term and intermediate-term operational flexibility of the current LW system prior to removal of the bulk of the RH-TRU wastes and associated LLLW from the active LW system.

1. Implement in-tank evaporation as soon as possible, including an aggressive R&D program for providing information necessary for implementation of this approach.

2. Proceed with the first EASC to regain a significant initial increment of LW system operational flexibility.

3. Identify LLLW solidification demonstrations that can be implemented, as necessary, prior to removal of RH-TRU wastes from the active LW system, including the R&D necessary for implementation of these demonstrations.

4. Complete work in progress for demonstration of the separation of LLLW from RH-TRU solids via filtration using actual wastes from the MVSTs.

Goal 2: Remove the bulk of the current legacy of RH-TRU wastes and associated LLLW from the active and inactive tanks to allow practical long-term management of LW.

1. Adopt as the primary waste management approach for the current inventories of the active and inactive LW tanks the disposal of RH-TRU sludges and associated LW at WIPP.

2. Implement a contingency waste management approach that is not susceptible to potential problems associated with the preferred approach for freeing significant active LW tank volume, and pursue necessary R&D to provide a fall-back basis in case difficulties are encountered with the primary approach.

3. Anticipate and include removal of the bulk of the RH-TRU wastes and associated LLLW from the active LW system in near- and intermediate-term strategic planning for LW management in order to maximize the benefits realized.

4. Expand the scope of WHPP to include facilities for removal of the RH-TRU sludges.

Goal 3: Develop an ORNL waste management system for the future collection and treatment of LW and disposal of the bulk of this waste as LLWDDD Class II solid LLW, while minimizing the quantities of RH-TRU waste or LLWDDD Class IV solid LLW that are also produced.

1. Conduct a continuing systems analysis to guide strategic planning and operational execution of all aspects of LW management and disposal.

2. Pursue an aggressive R&D program for development of processes for treating future newly generated LW to produce a waste form that will allow disposal of the bulk of the waste as LLWDDD Class II waste. Address in the program other waste types that may be produced in smaller quantities by the processing of newly generated LW (TRU waste and LLWDDD Class IV waste).

9. PROGRAM PLAN FOR MANAGEMENT OF RADIOACTIVELY CONTAMINATED LW AND SLUDGES AT ORNL

The purpose of this section is to describe the plan for implementing the strategy outlined in the earlier sections of this report. This section provides a brief review of the objectives and background presented earlier in Sects. 2, 3, and 4. To facilitate implementation, the work to be accomplished is subdivided into six subtasks, each of which is described in the following subsections. Five of these subtasks, (1) Program Planning, Strategy Development, and Waste Characterization, (2) Emergency Avoidance Solidification Campaign and Contingency Planning, (3) In-Tank Evaporation, (4) Waste Handling Pilot Plant Support, and (5) Research and Development Support for Long-Term Process Selection, will be funded and managed under the Liquid Low-Level Solidification Task (DPGF106) at ORNL. The sixth and final subtask, Capital Project Management for LW System Modifications, will be funded and managed under the Capital Projects Program. Also included in this section is the milestone schedule for the activities to be implemented.

9.1 OBJECTIVES AND BACKGROUND

The overall objective of this program plan is management of the ORNL LW Solidification Program, including near-term initiatives for immobilization, storage, and disposal of waste, as well as the development of a long-term strategy for processing and disposal of the existing waste inventory and the newly generated LW. To accomplish this objective, two major areas are emphasized: (1) near-term planning and R&D support for reducing the volume of stored waste; and (2) long-term planning, project management, and technical support for eliminating the inventory of waste and providing facilities for processing newly generated waste for on-site disposal. This task will be completed when facilities are in operation for processing the stored inventory waste and the newly generated waste, allowing the bulk of the waste to be disposed of on-site and the remainder to be packaged for shipment to an off-site disposal unit.

LW is generated by a number of activities at ORNL. The primary generators are R&D laboratories, radiochemical pilot plants, nuclear reactors, and isotope-production facilities. The LW is collected, transferred, and concentrated by the ORNL LW collection and transfer system, which also contains an evaporator facility. Treatment of process wastewater at the PWTP also produces an LW concentrate. Both the PWTP concentrate and the concentrate produced by the evaporator were disposed of prior to 1984 by the hydrofracture process; and since that time, they have been stored in the eleven 50,000-gal storage tanks located at ORNL. Because the LW concentrate can no longer be disposed of via the hydrofracture process, it is steadily filling the working volume of the active storage tanks. The stored inventory of concentrate has now reached a level that has reduced the operational flexibility of the ORNL LW system. Projection of the current generation rate into the future indicates total depletion of the active storage capacity in the fourth quarter of FY 1989.

If timely actions are not taken to increase the available storage volume in the LW tanks, the following consequences will either occur or are highly likely to occur:

- Shutdown of critical and unique Laboratory R&D facilities and isotope-production capabilities that generate LLLW.
- Loss of ORNL dominance in affected R&D areas.
- In the event of an unplanned incident which might produce large quantities of LLLW, use of LW storage tanks of lesser integrity than those currently used or increased discharge of radioactivity to surface streams (both of these actions are highly unacceptable).
- Violation of environmental regulations.

A major initiative to implement LW disposal techniques to replace disposal by hydrofracture was begun in FY 1986. In October 1986, ORNL and the DOE/ORO management selected both a "reference" and a "backup" flow sheet for processing the accumulating LW in the nearly full storage tanks. The reference flow sheet is a three-step process consisting of filtration and decontamination followed by a suitable immobilization process. Filtration would provide a positive means of ensuring that if any TRU sludges were present, they would be removed, while decontamination would remove most of the soluble cesium and strontium. The resulting CH waste would have been immobilized by a commercial firm using mobile systems.

When the reference flow sheet was selected, it was recognized that system constraints, namely funding and technology applications work, could yield a situation whereby the reference flow sheet could not be deployed soon enough. Accordingly, it was necessary to define a backup flow sheet which is based on decanting liquid from the tanks and immobilizing the high-activity liquid in cement without the benefit of filtration or supernate decontamination to reduce the activity of the waste being solidified.

The EASC is a project that will utilize the backup flow sheet for the immobilization of 50,000 gal of waste from the MVST. The project elements for the EASC include (1) the services of a commercial subcontractor to immobilize the decanted liquid in a cement-based matrix; (2) facilities for decanting and transferring the liquid to the vendor's system, a structure for containment of the vendor's system during liquid processing, and disposal units for the forms; and (3) supporting documentation for regulatory, environmental, quality, safety, and operational aspects.

Construction of the needed capital facilities via two GPPs was initiated at the MVST facility to support the EASC-LLLW Solidification Facilities (FY 1986 Waste Management GPP) and the MVST Decant System (FY 1987 Waste Management GPP). Construction and checkout of the capital facilities were completed in April 1988.

To complement the EASC activities and provide focus for long-term LLLW management, an overall strategy and program planning effort was initiated in November 1987. Documentation of the efforts was presented in the earlier sections of this program plan. The plan also provides the foundation for continued implementation of this planning effort. The key elements of the long-term strategy are as follows: (1) reduce the present waste inventory to regain operational flexibility by implementing EASC and in-tank evaporation, (2) coprocess the bulk of the LW inventory with the RH-TRU sludges in the proposed WHPP and dispose of the final RH-TRU waste form at the WIPP, and (3) develop a process for long-term LW treatment that will produce a waste form acceptable for on-site disposal. To implement this program strategy, several new initiatives should have begun in FY 1988 and FY 1989 but, due to the present inadequate FY 1988 and FY 1989 funding, have been delayed at the expense of the long-term goals of the program.

Although the summary program plan is being included in this strategic planning document, in the future a more-detailed program plan will be developed and updated, as necessary, to reflect results from ongoing work and newly recognized needs.

9.2 DESCRIPTION OF WORK

To ensure achievement of the objectives defined in Sect. 9.1 for both the near term and the long term, this task has been divided into six subtasks: (1) Program Planning, Strategy Development, and Waste Characterization; (2) EASC and Contingency Planning; (3) In-Tank Evaporation; (4) Waste Handling and Packaging Plant Support; (5) R&D Support for Long-Term Process Selection; and (6) Capital Projects Management for LW System Modifications. Each of these subtasks will be described in the remainder of this section.

9.2.1 Subtask 1. Program Planning, Strategy Development, and Waste Characterization

This subtask will provide overall coordination of the other subtasks, continue to develop the program strategy, and characterize both the dilute LW feed streams and the LW concentrate (existing and newly generated). The task coordination effort will include the overview of all program activities, budget control, schedule tracking, and reporting. The strategy development effort will continue to build on the overall program plan that is now being finalized. The established strategy has three key elements: (1) reduction of waste inventory to regain operational flexibility by implementation of EASC and in-tank evaporation, (2) processing of the bulk of the present inventory at the proposed WHPP and disposal at the WIPP, and (3) development of a process for long-term LW treatment which will allow the final waste form to be disposed of on the ORR.

Subtasks 2 and 3 support the first key element of the strategy to reduce the present inventory of waste. The EASC, which is to be conducted under Subtask 2, will provide all facilities and documentation to allow operations to proceed to immobilize 50,000 gal of LLLW. The solidification of 50,000 gal of waste will provide a short-term improvement in the inventory storage shortage, but continued volume reduction is needed. A significant potential for continued concentration of the stored LW concentrate has recently been identified. In-tank evaporation (Subtask 3) will capitalize on that potential and remove water from the waste storage tanks by sparging with dry air. The in-tank evaporation process has the potential to remove ~150,000 gal of water from the stored LW waste prior to 1996 and to provide needed storage for newly generated waste during that period.

Subtask 4 supports the second key element of the strategy to process the bulk of the present inventory at the WHPP and dispose of the final waste form at the WIPP. The sludges in the MVST have been classified as RH-TRU waste for some time, but it has been further determined by calculations that if the water was removed from all of the stored waste, the resulting solid form would be RH-TRU waste. The present strategy, therefore, is to slurry the RH-TRU sludge with the supernate in the tanks and dispose of the existing inventory of waste as RH-TRU waste at the WIPP following solidification at the WHPP. The solidification process and the sludge mobilization process to allow coprocessing of LW supernate and RH-TRU sludges at WHPP will be developed and demonstrated under Subtask 4.

Subtask 5 supports the third key element of the strategy to develop a process for long-term LW treatment that will allow the final waste form to be disposed of on-site. The use of off-site disposal units (WIPP) involves many uncertainties over which ORNL has no control. It is, therefore, ORNL's goal to segregate waste at the source and provide treatment, as needed, to produce waste forms that are acceptable for on-site disposal. In support of this goal, a system analysis will be continued to minimize waste constituents (TRU, nitrates, and others) that complicate production of acceptable waste forms. In addition, waste treatment processes (liquid/solid separation, concentration, and solidification) will be developed to allow waste to be treated and immobilized for disposal on the ORR.

All the previously discussed aspects of the program strategy will be coordinated under this subtask. Also included is the very important aspect of interfacing with other ORNL programs to ensure that the overall strategy is being applied to future activities.

Finally, this subtask will plan and conduct waste characterization. Complete understanding of the waste to be managed is essential to the success of this program. Sample planning will begin with a survey to determine existing data needs for the WHPP design and the process selection R&D. The sampling plan will be based on the lessons learned from sampling for the EASC and the inactive tanks. Portions of both the liquid phase (supernate) and the sludge phase will be withdrawn from each waste tank. The samples will be analyzed to determine the concentrations of radionuclides (alpha, beta, gamma, and neutron emitters) and chemical constituents (cation, anions, and organic screening).

Sampling and analysis of the MVSTs will begin in FY 1989 and continue into FY 1990 because the present funding level for FY 1989 is not adequate to complete the effort. The delay of the sampling effort until FY 1990 will allow uncertainties about waste characteristics to persist and may impact R&D and design activities. Sampling in FY 1991 and future fiscal years will be conducted to monitor the LW system for changes in the waste stream characteristics with time.

9.2.2. Subtask 2. Emergency Avoidance Solidification Campaign and Contingency Planning

This subtask is to provide management and engineering support for EASC and contingency planning. An extensive effort is needed in FY 1988 to complete the EASC; however, beginning in FY 1989, the major thrust of the subtask will be contingency planning.

The EASC will serve to immobilize 50,000 gal of LW, which involves five major groupings of tasks: (1) solidification contract with a qualified commercial firm; (2) regulatory interfaces with DOE, TDHE, and EPA for construction of support facilities and for operation of the process; (3) facility construction of a decanting system, solidification confinement structure to house the vendor-supplied system, and cask for emplacement of the liner in storage at ORNL; (4) operating equipment such as cameras for remote monitoring and radiation instrument, a diesel generator for backup power, and handling fixtures for the liner; and (5) operations planning, including preparation of safety and quality documentation and operating procedures for the solidification/storage/disposal operations.

The EASC effort under this subtask will be completed in FY 1988 by performing the following activities: (1) construction of the decanting system and the solidification confinement facilities, (2) establishment of a price agreement with a primary and alternate source for solidification services, (3) certification of the waste form of the primary and alternate sources as meeting the performance requirements, (4) mobilization of the vendor's solidification system and a cold checkout of a system at ORNL, and (5) commencement of solidification of actual hot waste.

It must be recognized that while an all-out effort is under way to prevent the tanks from filling up, some of the associated issues (e.g., questions related to interim storage of waste from the EASC) are such that institutional factors may preclude the development of a feasible consensus for proceeding with the EASC in the FY 1988 time frame as was originally planned. This task will focus on several contingency planning activities that will be undertaken for preparedness to deal with the situation should the LW tankage be exhausted. A number of activities will be pursued: (1) detailed planning for discontinuance of the centralized collection of LW from low-priority generators at increasing degrees of risk based on the remaining free board in the tanks, (2) risk assessments of the programmatic and environmental consequences of selected discontinuance of the collection activities, (3) use of storage tanks of lesser integrity than the present LW storage system (i.e., gunite tank), (4) options for treatment of waste at the source for disposal, and (5) development of second-generation plans for a follow-up solidification campaign.

The activities described for Subtask 2 are in support of operational activities for the EASC campaign that will be implemented using charge-back funds - about $2.77 million, which is in addition to the programmatic funding presented here for these subtasks.

9.2.3 Subtask 3. In-Tank Evaporation

This subtask includes all activities to fully implement in-tank evaporation. In-tank evaporation activities will include (1) monitoring of the off-gas ducting and sampling of the demister liquid (entrained/condensed liquids); (2) installation of a higher-capacity compressor to increase the number of spargers that can be operated; (3) installation of a system to remove and collect demister liquids for transport to Bethel Valley; (4) modifications to MVSTs to enhance evaporation rates (such as heaters and dehumidifiers); (5) preparation of operating procedures, safety assessments, and environmental assessments; and (6) experimental testing to determine the evaporation limits and the properties of the solids formed.

The in-tank evaporation will be implemented in a phased approach. Sparging will begin with the existing system after preparation of an ADM. A higher-capacity compressor will then be installed to increase the number of tanks that can be sparged at the design rate. After an increase in the sparge rates, the system will be installed to allow transport of the collected demister liquid to Bethel Valley for treatment. The final phase of the task is to add dehumidifiers to the tank air supplies and install heating units to increase the temperature of the waste to enhance evaporation rates.

An experimental testing effort will be conducted to collect the following data: (1) relative effects of temperature, salt concentration, and sparge rate on the rate of evaporation; (2) waste concentration at which solid forms and the characteristics of the solids; and (3) quantity of radioactive material in the off-gas. These experiments will be conducted with the actual waste in a hot-cell facility. Waste solutions from four of the waste tanks will be tested, and trends will be established to guide the in-tank evaporation operations.

9.2.4 Subtask 4. Waste-Handling and Packaging Plant Support

The work elements of this subtask are being performed in support of the WHPP. These activities will supplement the existing TRU program activities to allow coprocessing of LW supernate with the RH-TRU sludges. The elements of this task are as follows: (1) coordinate "cold" concentration and solidification tests at Rocky Flats (actual testing funded by TRU Program, $50 thousand); (2) conduct literature search and vendor survey of existing solidification and sludge mobilization techniques; (3) perform hot-cell tests and demonstration of concentration-solidification process for WHPP; (4) conduct waste-form testing and characterization; and (5) carry out mock-up demonstration of sludge mobilization equipment. This subtask will require significant interfacing with the WHPP conceptual design, design criteria, and the detailed design efforts by the TRU program.

The lack of FY 1988 funding severely limits the progress on this task. Under the present budget, only the coordination of the scouting work and the preparation of an experimental plan for hot testing will be completed in FY 1988. In FY 1989, experimental equipment will be procured and installed for hot testing. Testing with cold material to verify scouting studies will be conducted initially, with hot testing beginning late in the fiscal year.

The TRU program is providing $150 thousand of FY 1989 funding to support these efforts. Follow-on hot-cell testing will emphasize the addition of materials to produce leach-resistant waste forms. Waste-form testing will be conducted to characterize the products of the solidification process.

Sludge mobilization mock-up testing will also be performed. These tests will verify the operational acceptability of the approach and equipment to be installed by WHPP for sludge removal. Tests will be conducted in a mock-up of one of the MVST vessels.

9.2.5 Subtask 5. R&D Support for Long-Term Process Selection

The work elements of this subtask will support long-term solidification and will include (1) a system analysis and planning function, which provides the overall definition of the R&D program; (2) bench-scale screening of candidate processing steps; (3) development of potential flow sheets for evaluation; (4) experiments to allow selection of the best flow sheet; and (5) a pilot-scale demonstration of the selected flow sheet with actual waste.

The supernate decontamination is the process step for which the least is currently known. The decontamination R&D is crucial in determining whether the bulk of the waste liquid can be converted to LLWDDD Class II SLLW for on-site disposal. Thus, R&D on the supernate decontamination should be started to determine the extent of decontamination possible and the best method for accomplishment.

Several methods of decontamination should be examined. These include ion exchange, precipitation, solvent extraction, and biological sorption processes. In addition to determining the attainable decontamination, the available processes must be evaluated according to (1) the volume of waste material generated, (2) the complexity of the process and equipment, and (3) applicability to remote operation and maintenance.

The solidification step for the long-term flow sheet may be similar to the direct solidification process developed under Subtask 4 for WHPP. The long-term flow sheet will have the added requirement of leach resistance for on-site disposal, which is not required for WIPP disposal.

Proper staffing of this subtask is constrained by the FY 1988 budget; increased funding in FY 1988 and FY 1989 is needed to allow preparation of an R&D plan and to conduct initial screening studies.

9.2.6 Subtask 6. Capital Projects Management for LW System Modifications

This subtask defines and manages capital projects necessary for modification of the LW system. The key elements of this task are as follows: (1) sampling and R&D to define project needs, (2) development and documentation of functional criteria, (3) preparation of preliminary proposals, and (4) coordination of design and construction of the GPP. The following newly defined GPPs will be managed under this subtask:

Project Title	Funding year	Estimated cost ($1000)
FPDL Pretreatment System (Building 3517)	1989	500-750
HFIR Regenerate System Modification	1990	500-750

The above projects are "newly" defined, and the expense and capital funding needed for their implementation is not in the budget. Additional funding is needed to avoid delay of these projects.

9.3 SCHEDULE

The program schedule for this task is presented in Table 9.1 and is based on the funding level presented in Table 9.2.

9.4 BUDGET

The programmatic costs are presented according to the subtask activity in Table 9.1. The budget is not adequate in FY 1988 and FY 1989 to conduct Subtasks 1, 4, and 5 at an acceptable level. Additional funding of $270 thousand in FY 1988 and $475 thousand in FY 1989 is needed to allow experimental planning activities to be completed in FY 1988. The addition of $475 thousand in FY 1989 is needed to conduct an experimental program to adequately support the design of the WHPP. Capital equipment needs are presented in Table 9.3. Additional capital equipment funding of $268 thousand in FY 1988 and $212 thousand in FY 1989 is needed to productively progress with the program.

Table 9.1. Program schedule

Subtask/Milestone

1. Program planning, strategy development, and waste characterization
   - A. Develop overall strategy and program plan
   - B. Sampling
     1. Prepare sampling plan
     2. Complete Phase 2 sampling MVST
     3. Complete implementation of sampling plan

2. EASC and contingency planning
   - A. Emergency Avoidance Solidification Campaign
     1. Complete integrated system testing of LW solidification facilities
     2. Support cold checkout EASC
     3. Complete "hot" cross-flow
     4. Begin solidification campaign
     5. Complete campaign
   - B. Contingency planning
     1. Develop plan and procedures for phased discontinuance of low-priority LW generators
     2. Develop assessment of safety and environmental impact of discontinuance of LW generators

3. In-tank evaporation
   - A. Begin in-tank evaporation (Phase 2)
   - B. Complete installation of necessary evaporation enhance features
   - C. Complete evaporation experiments

4. WHPP support
   - A. Draft development plan
   - B. Complete collection of solidification process design data

5. R&D support for long-term process selection
   - A. Draft experimental plan
   - B. Complete status report on decontaminated process screening
   - C. Complete report on alternative flow sheet

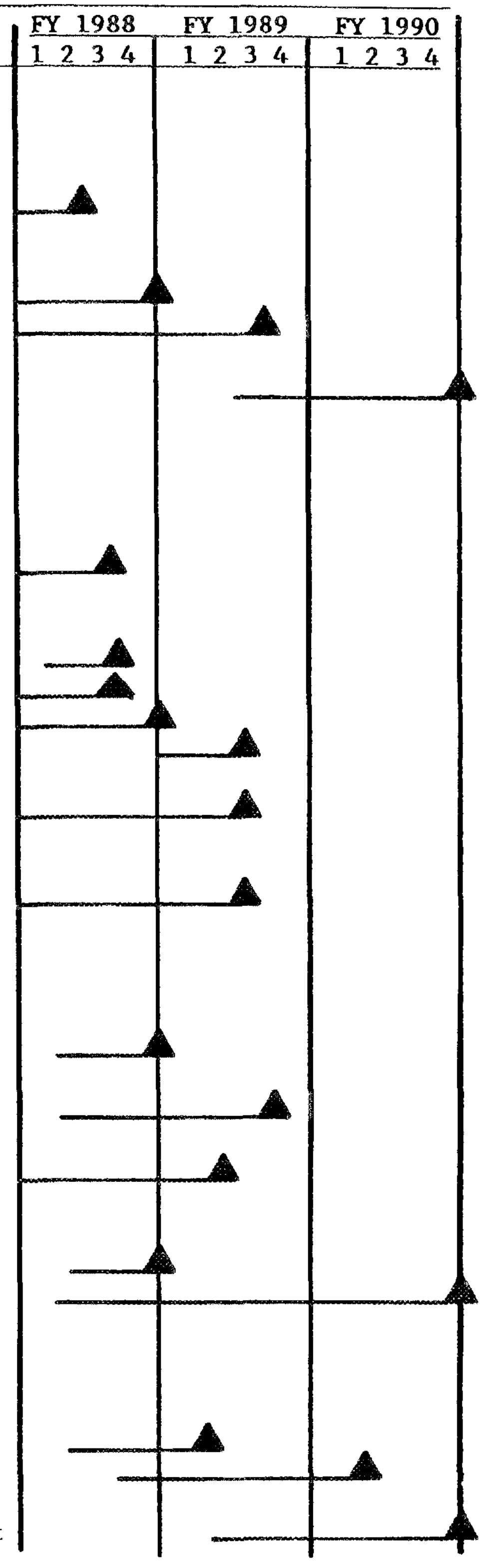

Table 9.2. Expense funding summary adjusted to meet funding baseline

Activity	Expense funding requirements FY 1988	FY 1989	FY 1990	FY 1991
Program planning	85	110	120	120
Characterization	--	350	340	100
In-tank evaporation	250	200	50	--
EASC	1705	500	--	--
WHPP process support	40	530	1005	229
R&D support process selection	120	810	2985	4045
Total	2200	2500	4500	4494

Table 9.3. Capital equipment funding adjusted to meet funding baseline

Capital equipment item	Cost estimates ($1000)		
	FY 1988	FY 1989	FY 1990
Diesel generator	150		
Stack monitor	60		
Noninterruptible power supply	49		
Liner handling equipment		40	
Radiation instruments		30	
Microwave system		198	
Tanker (radioactive liquid)			100
Sludge removal equipment			380
Wet-chemistry equipment with glove box			90
Anion chromatograph			40
Decontamination system			200
Filtration system			200
Total	259	268	1010

10. ACKNOWLEDGMENTS

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