WHC-EP-0600
Rev. 1

Status Report on Resolution of Waste Tank Safety Issues at the Hanford Site

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

Westinghouse
Hanford Company Richland, Washington

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

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Prepared for: Westinghouse Hanford Company

Prepared by: Los Alamos Technical Associates, Inc.

Date Published

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STATUS REPORT: RESOLVING WASTE TANK SAFETY ISSUES AT THE HANFORD SITE

ABSTRACT

As required by Public Law 101-510, Section 3137, "Safety Measures for Waste Tanks at Hanford Nuclear Reservation," *the Secretary of Energy reported to the U.S. Congress in 1991 on (1) actions being taken to promote waste tank safety; and (2) the timetable for resolving the safety issues for handling radioactive waste in Hanford Site waste tanks. Further review by the U.S. Department of Energy High-Level Waste Tank Force identified additional safety issues and a new category called system deficiencies.*

This report addresses actions, both completed and in progress, to promote tank safety and the timetable to mitigate or resolve safety issues and system deficiencies. The information contained in this report is based on a review of the status of each safety issue and system deficiency during the first quarter of calendar year 1995. This report updates two previous status reports, published in 1991[1] *and 1993*[2]*. Since the last report, specific key activities, called "Safety Initiatives", has been identified. These measures, are chosen to accelerate the resolution of selected tank farm safety and operational issues. No new safety issues have been identified since the last report.*

The status of the Waste Tank Safety Program, individual safety issues and system deficiencies are documented along with the technical basis for each. Action plans to

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[1] Wilson, G.R. and I.E. Reep, 1991, *A Plan to Implement Remediation of Waste Tank Safety Issues at the Hanford Site*, WHC-EP-0422, Revision 1, Westinghouse Hanford Company, Richland, Washington.

[2] Reep, I.E., 1993, *Status Report on Resolution of Waste Tank Safety Issues at the Hanford Site*, WHC-EP-0600, Westinghouse Hanford Company, Richland, Washington.

resolve the issues or to mitigate the hazards so that the waste can be safely stored in existing or new tanks until it is removed for final disposal are provided. In addition, planning schedules to close out all of the safety issues and system deficiencies are given.

This report is comprised of five sections. Section 1.0 provides background information on tank farm history, operations and tank contents, describes the history of waste tank safety issues and system deficiencies, and defines key terms. Section 2.0 describes the overall strategy for managing Hanford's tank waste. Section 3.0 describes the programs and organizations responsible for the management of issue resolution. Section 4.0 provides the status, estimated costs, and schedule for resolving safety issues and system deficiencies, and Section 5.0 summarizes cost and schedule data.

EXECUTIVE SUMMARY

BACKGROUND

On November 5, 1990, the U.S. Congress enacted Public Law 101-510, Section 3137, *Safety Measures for Waste Tanks at Hanford Nuclear Reservation,* which addressed safety issues concerning the handling of high-level nuclear waste in storage tanks at the Hanford Site. In response to this law, the Secretary of Energy reported to the U.S. Congress in June 1991 on (1) actions being taken to promote safety in the Watch List tanks identified (currently, there are 54 Watch List tanks); (2) the timetable for resolving waste tank safety issues; and (3) how to handle the radioactive waste in Hanford Site waste tanks.[3] Later in 1991, a second more detailed report was issued that provided safety issue descriptions, as well as technical bases, alternatives, and an action plan for each safety issue identified in the *Report to Congress*.[4]

Further review by the U.S. Department of Energy High-Level Waste Tanks Task Force, in 1992, identified additional safety issues and a new category called system deficiencies.[5] The High-Level Waste Tanks Task Force report identified a total of 30 safety issues and system deficiencies that needed to be addressed at the Hanford Site, Savannah River, Idaho Falls, and West Valley facilities. Of the 30 issues and deficiencies identified, 28 are applicable to the Hanford Site.

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[3]*U.S. Department of Energy Report to United States Congress on Waste Tank Safety Issues at the Hanford Site*, June 1991.

[4]WHC-EP-0422, *A Plan to Implement Remediation of Waste Tank Safety Issues at the Hanford Site*, December 1991, Westinghouse Hanford Company, Richland, Washington (see Wilson and Reep 1991).

[5]Department of Energy *High-Level Waste Storage Tank Safety Issues Report*, DOE High-Level Waste Tank Task Force Working Group, Revision 4, November 30, 1992.

PURPOSE

The purpose of this report is to provide an update of the status on the resolution of waste tank safety issues and system deficiencies at Hanford. Completed actions and actions being taken to promote tank safety are summarized and a timetable for resolving the safety issues and system deficiencies is provided. The information contained in this report is based upon a review of the status of each safety issue and system deficiency during the period from January through March 1995.

DISCUSSION

Hanford's 149 single-shell and 28 double-shell tanks contain high-level nuclear waste, a byproduct of the chemical processing of irradiated nuclear reactor fuel. The oldest single-shell tanks are over 50 years old. Many of the single-shell tanks are assumed to have leaked liquid radioactive waste to the ground, and the remaining tanks may be expected to leak in the near term. None of the double-shell tanks has leaked.

Over the last forty years management of the liquid radioactive waste has focused on reducing the volume waste in the tanks. The liquid waste reduction strategy was based on requirements to (1) provide much-needed space to support defense materials production by either evaporating the water or by chemical treatment and (2) pump as much drainable liquid as possible from the single-shell tanks to minimize the volume of liquid that could leak into the ground. The result is that today the 177 waste tanks at Hanford contain nearly 227 million liters (60 million gallons) of radioactive liquid, sludge and salt cake. The tank farm operations objective is to store this waste safely and without any further release to the environment until final disposal can take place.

Final disposal of double-shell tank waste was previously expected to occur beginning in the 1990's. In anticipation of final disposal, the waste management funding allocated to deal with waste aging problems and tank farm upgrades was reduced in the 1970's and 1980's. In recent years, more attention and greater funding have been given to these issues. The U.S. Department of Energy has taken the lead in reviewing the whole waste tank management approach and schedule in light of today's safety standards and the projected time (decades) that waste must continue to be stored in tanks prior to final disposal.

Safety issues have been prioritized into three categories, according to the potential for an accident to occur. System deficiencies are additional areas affecting tank farm operations that need improvement. Where practical, the Tank Waste Remediation System goals include resolving the safety issues in ways that leave the waste in the tank until it is removed for final disposal. This approach minimizes the cost as well as radiation exposure to plant personnel. If necessary, resolving safety issues by removing the waste from a tank for treatment or storage elsewhere will be recommended.

When complete, the Tank Waste Remediation System Program will have resolved the safety issues for all of Hanford's tanks. Table ES-1 summarizes the safety issues and system deficiencies and indicates changes in schedule over the two previous status reports.[6,7]. The total estimated cost for resolution of all safety issues and system

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[6]WHC-EP-0422, Revision 1, *A Plan to Implement Remediation of Waste Tank Safety Issues at the Hanford Site*, December 1991, Westinghouse Hanford Company, Richland, Washington (see Wilson and Reep 1991).

[7]WHC-EP-0600, *Status Report on Resolution of Waste Tank Safety Issues at the Hanford Site*, August 1993, Westinghouse Hanford Company, Richland, Washington (see Reep 1993).

deficiencies is $1.9 billion. The Waste Tank Safety Program has been chartered primarily to resolve the most severe (Priority 1) safety issues, plus a few additional key safety issues.

Table ES-1. Schedule Summary for Resolving Waste Tank Safety Issues and System Deficiencies (2 sheets).

Safety Issue Description	1991 Report Completion Date	1993 Report Completion Date	Current Completion Date	Change From 1993 Report
1-1. High Flammable Gas Concentrations	9/97	11/99	9/01	1 year 10 month delay[1]
1-2. Potentially Explosive Mixtures of Ferrocyanides	9/97	9/98	9/97	1 year earlier[2]
1-3. Potential for Runaway Organic-Nitrate Reactions	9/98	9/01	9/01	No change[3]
1-4. Water Additions Needed to Cool Single-Shell Tank	9/98	9/98	9/97	1 year earlier[4]
2-1. Inadequate Single-Shell Tank Leak Detection	9/99	9/98	9/98	No change
2-2. Storage of High-Level Waste in Tanks That Have Leaked	N/A	See Safety Issue 2-7 6/18	9/24	6 year 3 month delay[5]
2-3. Inability of Waste Tanks and Ancillary Equipment to Withstand a Design Basis Earthquake	N/A	See System Deficiency 4-5 9/98	9/98	No change
2-4. Single-Shell Tank Emergency Pumping Capability Inadequate	9/94	9/94	3/95	6 month delay
2-5. Tank Vapor Release	9/97	6/98	11/97	7 month earlier
2-6. Inadequate Response Time to a Leaking Double-Shell Tank	12/94	9/95	12/95	3 month delay
2-7. Storage of High-Level Waste in Tanks With No Secondary Containment	N/A	6/18	9/24	6 year 3 month delay[5]
2-8. Potential for Nuclear Criticality in High-Level Waste Tanks	N/A	9/99	9/99	No change
3-1. Insufficient Tank Storage Capacity to Handle Waste Resulting from Resolution of Existing Safety Issues	9/00	12/99	12/98	1 year earlier
3-2. Cracked Tank Farm Ventilation Header	9/97	1/96	12/96	11 month delay

[1] Based on treatment of 241-SY farms tank in the Initial Pretreatment Module by 212/01, if necessary.

[2] Based on resolution without the need for in-tank or out-of-tank treatment (if necessary).

[3] Based on resolution by mitigation without the need for remediation (i.e., out-of-tank treatment).

[4] Based on the retrieval of Tank 241-C-106 waste.

[5] Based on complete waste retrieval from all single-shell tanks.

Table ES-1. Schedule Summary for Resolving Waste Tank Safety Issues and System Deficiencies (2 sheets).

Safety Issue Description		1991 Report Completion Date	1993 Report Completion Date	Current Completion Date	Change From 1993 Report
3-3.	Insufficient Hydroxide Concentration in Tanks	9/96	9/06	9/97	9 years earlier
3-4.	Inadequate Sealing of Single-Shell Tanks to Prevent Intrusions that Could Leak Contamination Out of Tank	9/06	9/07	9/00	7 years earlier
3-5.	Inadequacies in Waste Transfer Line Leak Detection	N/A	See System Deficiency 4-8 10/97	2/98	4 month delay
3-6.	Excessive Unfiltered Airflow Passages into Tanks	9/96	9/99	6/05	5 years 9 month delay[6]
3-7.	Potential for Formation of Explosive Deposits	Not an Issue at Hanford			
3-8.	Uncharacterized Corrosion of High-Level Waste Tanks	N/A	New safety issue	12/97	N/A
3-9.	Questionable Integrity of High-Level Waste Tank Vaults	Not an Issue at Hanford			
System Deficiency Description		**1991 Report Completion Date**	**1993 Report Completion Date**	**Current Completion Date**	**Change From 1993 Report**
4-1.	Insufficient Tank Contents Characterization	9/98	9/98	9/99	1 year delay[7]
4-2.	Inadequate Safety Documentation	3/99	5/98	9/98	4 month delay
4-3.	Deficient Maintenance and Upgrade of Facilities	9/98	9/98	9/05	7 year delay[8]
4-4.	Deficient Instrument Upgrades in Single-Shell and Double-Shell Tanks	9/00	9/99	1/97	1 year 4 month earlier
4-5.	Extended Tank Safety Operating Life	9/96	9/98	9/98	No change
4-6.	Conduct of Operations Deficient	9/93	9/95	9/95	No change
4-7.	Lack of Plant-Essential Drawings	9/00	9/98	9/97	One year earlier
4-8.	Questionable Transfer Line Concrete Encasement Integrity	6/02	10/97	2/98	4 month delay
4-9.	Leak Detection in Double-Shell Tanks	9/99	9/94	Not Available	Undetermined delay

[6] Based on the completion of Project W-314 in June 2005.

[7] Based on issuing tank characterization reports for 177 Hanford high-level waste tanks.

[8] Based on the completion of Projects W-030, W-058, W-028, W-364, W-280, W-226, W-188 and W-236A.

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GLOSSARY

Activity data sheets. Activity data sheets are prepared as part of the *Tank Waste Remediation System Multi-Year Work Plan* (WHC 1994a). One sheet is prepared for each work breakdown structure program element. Activity data sheets were also used to assemble the Environmental Restoration and Waste Management *Five Year Plan* budget request.

Aging waste. The term usually reserved for high-activity and/or high-heat waste from fuel reprocessing that is stored until it decays sufficiently to simplify processing and/or disposal.

Annulus. The space between the inner and outer shells on double-shell tanks. Drain channels in the insulating and/or supporting concrete carry any leakage to the annulus space, where conductivity probes are installed. Alarms from the annunciators are received by the Computer Automated Surveillance System. Continuous Air Monitoring alarms are also located in the annulus. The annulus conductivity probes and radiation detectors are the primary means of leak detection for all double-shell tanks.

Boiling waste. Radioactive liquid waste containing radionuclides (principally strontium and cesium) in quantity to provide sufficient decay heat to be near the liquid's boiling point. This waste usually requires a supplemental means of cooling. The terms "boiling" and "aging" are synonymous.

Closure. The process by which a hazardous waste treatment, storage, or disposal facility that has discontinued active operation as a hazardous or mixed waste management unit removed (from the unit) all hazardous waste (or dispositions the unit with the waste in place) in accordance with a Washington state-approved closure plan.

Computer-aided design and drafting. A technique using mini- and microcomputers to aid in facility design and drawings.

Data quality objectives. Data quality objectives are quantitative and qualitative statements specified to ensure that data of known and appropriate quality are obtained during remedial investigation activities to support the selection of an appropriate remedial action alternative. The development of data quality objectives assures that:

- only the highest quality data are obtained during sampling and analysis activities;
- data collection is efficient, technically defensible, and cost-effective; and
- the decision process is auditable.

The data quality objective methodology directs program planners to define the precise problem, establish the desired action, identify the key variables that drive the action, and determine the cost of obtaining the minimum number of laboratory samples required.

Defense Nuclear Facilities Safety Board. The Defense Nuclear Facilities Safety Board is a federal panel independent of the U. S. Department of Energy. This board oversees work at federal nuclear facilities nationwide. The Defense Nuclear Facilities Safety Board has appraised Hanford tank farm activities, making several recommendations in areas relating to safety issues. Recommendations of this board are discussed in the individual safety issue and system deficiency sections.

Disposal. Emplacement of waste in a manner that ensures isolation from the biosphere for the foreseeable future, with no intent of retrieval, and which requires deliberate action to regain access to the waste.

Double-shell tank. A reinforced concrete underground vessel with two inner steel liners to provide containment and backup containment of liquid wastes. The annulus is instrumented to permit detection of leaks from the inner liner.

Drainable liquid. The interstitial liquid in single-shell waste tanks that is not held in place by capillary forces, and will therefore migrate or move by gravity or pumping.

Drywell. Vertical boreholes with 15.2-centimeter (6-inch) (internal diameter) carbon steel casings that are positioned radially around single-shell tanks. Periodic monitoring is done by gamma radiation or neutron sensors to obtain scan profiles of radiation or moisture in the soil as a function of well depth. These profiles could be indicative of tank leakage. These wells range between 15.2 and 76.2 meters (50 and 250 feet) in depth, and are monitored between the range of 15.2 to 45.7 meters (50 to 150 feet). The wells are sealed when not in use. There are called drywells because they do not penetrate to the water table and are therefore usually "dry."

Evaporator-crystallizer. The Hanford Site facilities used to (1) reduce the moisture content in tank waste; (2) reduce the volume of waste stored; and (3) minimize potential leaks from tank liner failures.

Exothermic reaction. A reaction between a group of chemicals that releases energy. The reaction of hydrogen with air is exothermic. Not all chemical reactions are exothermic; many require a significant input of energy to make the chemicals react.

Half-life. The time required for a radionuclide's activity to decay to half of its original value. Half-life is used as a measure of the persistence of radioactive materials; each radionuclide has a characteristic and constant half-life.

High-level nuclear (radioactive) waste. Highly radioactive waste resulting from fuel reprocessing or waste management activities that presents a potential threat to the safety of personnel, the public, or environment. This definition, which is taken from Section 3137 of Public Law 101-510, is a more general definition than that defined by the *Atomic Energy Act* or the U.S. Nuclear Regulatory Commission.

High-level waste. See high-level nuclear (radioactive) waste.

Interim-isolated. The administrative designation reflecting completion of the physical efforts required to minimize the addition of liquids into an inactive storage tank, process vault, sump, catch tank, or diversion box.

Interim-stabilized. A tank that contains less than 190,000 liters (50,000 gallons) of drainable interstitial liquid and less than 19,000 liters (5,000 gallons) of supernatant liquid.

Interstitial liquid. Liquid, usually nondrainable, that is trapped by capillary forces in the pores of solid waste in single-shell tanks.

Jet pumping. A technique for removing interstitial liquid from single-shell tanks.

Laterals. Horizontal drywells positioned under single-shell waste storage tanks to detect radionuclides in the soil that could be indicative of tank leakage. These drywells are monitored by radiation detection probes. Laterals are 10.2-centimeters (4-inch) inside diameter steel pipes located 2.4 to 3.0 meters (8 to 10 feet) below the tank's concrete base. There are three laterals per tank. Laterals are located only in A and SX tank farms.

Liquid observation well. In-tank liquid observation wells are used for monitoring the interstitial liquid level in single-shell waste storage tanks. The wells are constructed of fiberglass or TEFZEL-reinforced epoxy-polyester resin, and are sized to extend to within one inch of the bottom of the tank steel liner. They are sealed at their bottom ends and have a nominal outside diameter of 8.9 centimeters (3.5 inches). Two probes are used to monitor changes in the interstitial liquid level: gamma and neutron. These indicate intrusions or leakage by increases or decreases in the interstitial liquid level. There are 58 liquid observation wells (56 are in operation) installed in single-shell tanks that contain, or are capable of containing, greater than 190,000 liters (50,000 gallons) of drainable interstitial liquid, and in two double-shell tanks. The liquid observation wells installed in the double-shell tanks (241-SY-102 and 241-AW-103 tanks) are constructed of steel and re-used for special surveillance purposes only.

Lower flammability limit. The lowest composition of a flammable mixture (e.g., hydrogen and air) that will support combustion.

Mitigation. The action taken to reduce the severity of tank safety issues.

Neutralization. The reaction of acidic waste with an alkali (such as sodium hydroxide or potassium hydroxide). This reduces corrosion and increases the life of the waste tank liners.

Program Element. A major component (subsystem) of the Tank Waste Remediation System that requires a closely-interrelated set of processes for successful execution.

Psychrometric data. Temperature and humidity data collected for tank ventilation air. The data are used to estimate the heat content or thermal load of the waste.

Remediation. A method of permanent stabilization, cleanup, or disposal of waste in accordance with regulatory requirements. After waste has undergone final remediation, it will pose no significant threat to present and/or future generations or to the environment.

Resolution. The elimination of a tank safety issue by physical, chemical, or analytical methods.

Safety analysis report. A document containing a detailed safety analysis of a facility or operation. The safety analysis report contains a detailed description of the facility or operation. It identifies and quantifies risk from potential accidents, and defines the safety envelope for the facility or operation.

Safety initiative. A measure taken at the direction of the U.S. Secretary of Energy for the purpose of accelerating the resolution of a selected tank farm safety, management, or operational issue.

Safety issue. A potentially unsafe condition in the handling of waste material in underground storage tanks that requires corrective action to reduce or eliminate the unsafe condition.

Saltcake. Water-soluble solids from the evaporation of dilute neutralized nuclear reprocessing waste. The saltcake in the Hanford Site waste tanks consists largely of crystallized sodium nitrate, sodium nitrite, sodium carbonate, and other salts deposited in waste tanks. The saltcake usually forms after active measures have been taken to remove moisture.

Saltwell pumping. The act of removing drainable liquids from the bottom of a tank, generally using jet pumps capable of removing small volumes of liquid over extended periods of time.

Single-shell tank. An older style of Hanford Site underground radioactive waste storage tanks that is composed of a single carbon steel liner surrounded by reinforced concrete.

Sludge. A mixture of insoluble materials that usually settles to the bottom of waste tanks. Sludge primarily contains metal oxides and hydroxides mixed with other dense, settled tank solids. Sludges at the Hanford Site consist of aluminum, silicon, iron oxides, and the hydroxides of heavy metals (such as uranium).

Slurry growth. A change in volume of tank waste resulting from a chemical reaction of the organic component with some of the reaction products, thereby increasing the volume of the wastes.

Stoichiometric mixture. A mixture of chemicals whose concentrations (amounts present) allow the maximum extent of reaction. When chemicals react in a stoichiometric mixture, none of the starting materials are left over.

System deficiency. A tank farm operational concern that is related to or overlaps portions of safety issues.

Supernate. A free liquid layer above the settled solids in a waste tank.

Technical safety appraisals. A formal and detailed technical, safety, environmental, and management practices audit of a particular facility by the U.S. Department of Energy-Headquarters.

Technical safety requirement. A formal requirement (constraint) identified by safety analysis that limits the operation of a facility to enhance safety. Technical safety requirements are designed to limit the probability of occurrence or the consequences of an accident or malfunction of equipment important to safety. Technical safety requirements are formerly called operating safety requirements.

Transuranic waste. The term that identifies radioactive waste, without regard to source or form, that is contaminated with alpha-emitting radionuclides that have an atomic number greater than 92, a half-life period greater than 20 years, and concentrations greater than 100 nCi/g.

Treatment. Those processes that change and/or immobilize waste in preparation for disposal.

Tri-Party Agreement. This is formally known as the *Hanford Federal Facility Agreement and Consent Order*, which was originally signed in 1989. This is a consent agreement between the U.S. Environmental Protection Agency, the Washington State Department of Ecology, and the U.S. Department of Energy defining the responsibilities, management, regulatory focus, and schedule of the environmental cleanup of the Hanford Site for *Resource Conservation and Recovery Act (RCRA) of 1976* and *Comprehensive Environmental Response, Compensation and Liability Act (CERCLA) of 1980* compliance.

Unreviewed safety question. A determination made by examining the following circumstances: (1) temporary or permanent changes in the facility as described in existing safety analyses; (2) temporary or permanent changes in the procedures as derived from existing safety analyses; and (3) tests or experiments not described in existing safety analyses.

On identification of any of the above circumstances, an unreviewed safety question exists if one or more of the following conditions result: (1) the probability of occurrence, or the consequences of an accident or malfunction of equipment important to safety as previously evaluated in the facility safety analyses, could be increased; (2) the possibility for an accident or malfunction of a different type than any evaluated previously in the facility safety analysis could be created; and (3) any margin of safety as defined in the bases of the Technical Safety Requirements could be reduced.

Watch List Tanks. These are waste tanks that require special safety precautions because they have been identified, by law (Safety Measures Law), as tanks that may have a serious potential for release of high-level radioactive waste due to uncontrolled increases in temperature or pressure.

1.0 INTRODUCTION

1.1 PURPOSE

The purpose of this report is to provide and update the status of activities supporting the resolution of waste tank safety issues and system deficiencies at the Hanford Site. This report provides: (1) background information on safety issues and system deficiencies; (2) a description of the Tank Waste Remediation System and the process for managing safety issues and system deficiencies; (3) changes in safety issue description, prioritization, and schedules; and (4) a summary of the status, plans, order of magnitude, cost, and schedule for resolving safety issues and system deficiencies.

This report updates information found in two earlier reports: "*A Plan to Implement Remediation of Waste Tank Safety Issues at the Hanford Site*" (Wilson & Reep 1991) and "*Status Report on Resolution of Waste Tank Safety Issues at the Hanford Site*" (Reep 1993). The information contained in this report was gathered during the period from January through March of 1995.

1.2 SUMMARY OF HANFORD WASTE TANK HISTORY

Radioactive wastes from processing irradiated uranium fuels have been stored as alkaline slurries in underground tanks at Hanford since 1944. Tank capacities range from about 208,000 liters to approximately 3,800,000 million liters (55,000 gallons - 1,000,000 gallons). The tanks were constructed in groups called tank farms, which were generally located near the processing plant that generated the waste. Tanks in each farm shared supporting facilities such as an instrument building, air compressors, and tank ventilation system. Waste solutions were transferred among tanks via underground pipelines; overground pipelines were used only occasionally. The soil cover over the tanks and pipelines provided shielding from radiation in the waste solutions.

The oldest tank farms were constructed in 1943 coincident with the construction of the earliest fuel reprocessing plants (T Plant, B Plant, and U Plant). The first waste was routed to the storage tanks in December of 1944. Additional tank farms were constructed as space was filled in the existing tanks and as new processing plants started production.

Both the tank farms and the processes that generated the waste underwent significant changes over time. The earlier tank farms consisted of single-shell tanks constructed of a carbon steel liner with a concrete exterior and dome. Over time, the design of the single-shell tank farms was improved. For example, the later tanks had more access ports, known as risers; tanks in the last single-shell tank farm had bases with slots to channel liquids for leak detection; and tanks that received the hottest waste were improved to allow greater mixing capability. To date, sixty-seven single-shell tanks are assumed to have leaked waste to the surrounding soil (Hanlon 1995).

Later tank farms used a double-shell tank design. These tanks have a carbon steel inner tank, a carbon steel outer tank and dome, and a concrete shell and base. The newer double-shell tanks have been heat treated for stress relief in order to improve corrosion performance. The double-shell tank farms have improved leak detection capability; however, no double-shell tank has leaked. Figures 1-1 and 1-2 show typical single- and double-shell tanks, respectively.

Figure 1-1. Typical Single-Shell Tank.

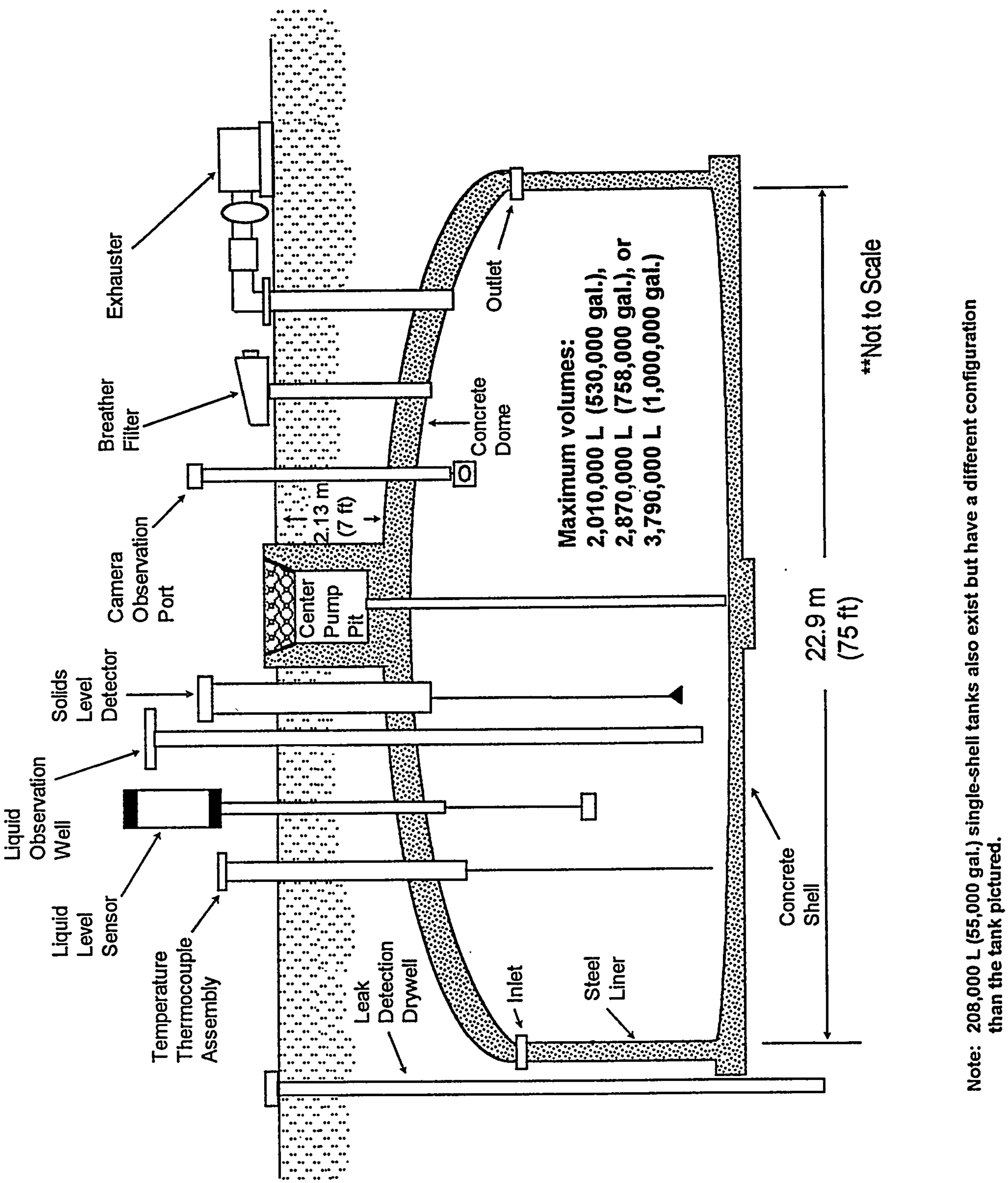
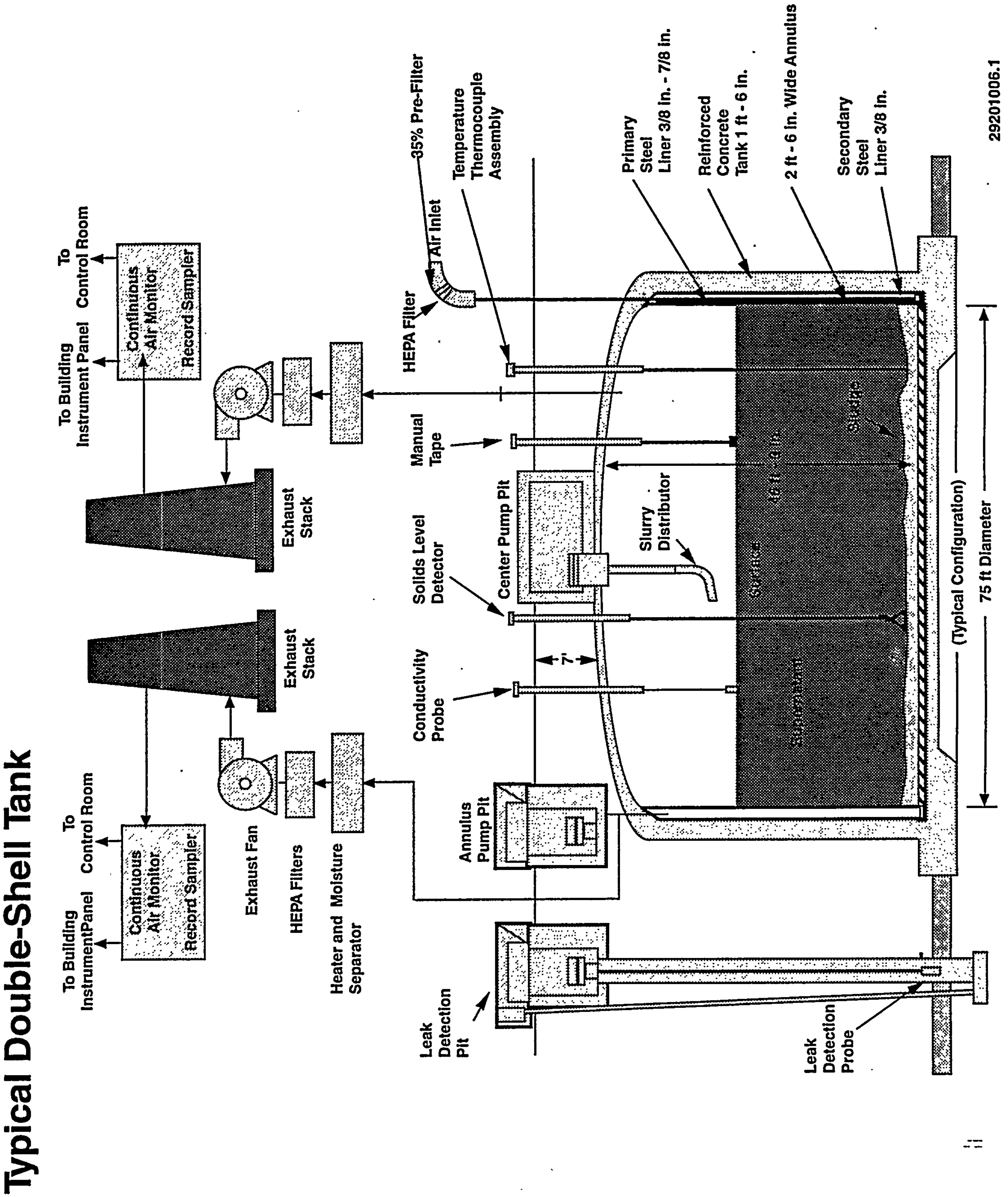


Figure 1-2. Typical Double-Shell Tank.



Fuel reprocessing plants produced several types of wastes. The greatest amount of radioactivity was located in the waste from the first separation step, during which uranium and plutonium were separated from most of the fission products found in the fuel. Other waste streams, arising from fuel cladding removal and later separations and washes, were less radioactive. Radioactive decay in the waste generates heat, with the most radioactive streams having the highest heat generation rate. (Over time, decay reduces both the level of radioactivity and the heat generation rate.)

As chemical reprocessing became more efficient, the wastes became more concentrated, thus conserving tank space. The more concentrated wastes generated more heat; therefore, they required additional operating equipment. The highest heat tanks were equipped with condensers and air lift circulators and were allowed to boil. (The circulators were used to prevent solids from settling to the bottom of the tank and forming hot spots and subsequent "bumps," which resulted in increases in pressure caused by steam bubbles). The waste in these tanks was allowed to self concentrate until pre-set limits were reached. Upon reaching these limits the condensate was recycled to the tank to prevent further concentration. Eventually, the waste had decayed long enough and boiling stopped.

The tank farms supported many activities in addition to the initial fuel reprocessing. At various times, some of the waste was removed from the tanks, processed to retrieve isotopes, and then returned to the tanks. Waste was evaporated, both in the tanks and in external evaporators, in order to create more tank space. Chemicals were added to some tanks to precipitate isotopes in order to reduce the radioactivity of the liquid phase (supernatant). The result of all of this activity, plus the changes in chemical processes, was that the tanks do not contain well-mixed waste of a single composition. Waste composition varies among tanks and within individual tanks, which often contain layers. All of the waste, however, is alkaline. Wastes here also had sodium nitrite added to aid in the reduction of corrosion in carbon steel. Detailed tank farm activities during early operations are described in *A History of the 200 Area Tank Farms* (Anderson 1990).

1.3 DESCRIPTION OF TANK WASTE INVENTORY

The single-shell tank farms, with a total of 149 tanks, have received no new waste since the end of 1980. Rather, a sustained effort has been made to remove liquids from these tanks and transfer them to double-shell tanks. Most of these tanks have had supernatant liquid pumped out, leaving several types of solid phases. Further efforts have been made to remove drainable liquid located within the solid phase and to prevent any new liquid (rainwater, etc.) from entering. Many of the single-shell tanks are not filled to capacity, since waste has been removed and sixty-seven tanks are known or are assumed to have leaked waste (Hanlon 1995). The liquid has been removed to minimize the potential for further leaks. Single-shell tank farms are known as 241-A, 241-AX, 241-B, 241-BX, 241-BY, 241-C, 241-S, 241-SX, 241-T, 241-TX, 241-TY, and 241-U.

The double-shell tank farms have a total of 28 tanks. These tanks contain wastes transferred from fuel and waste processing plants, from single-shell tanks, and from waste evaporation. Double-shell tanks contain liquids and solids. Unnecessary free liquid in double-shell tank waste is currently being evaporated to generate more tank space. Additional space is needed to receive more single-shell tank waste and to support future waste disposal operations. Information about the contents and status of individual single- and double-shell tanks is located in the waste tank summary reports, which are updated monthly (e.g., Hanlon 1995). Double-shell tank farms are known as 241-AP, 241-AY, 241-AZ, 241-AN, 241-AW, and 241-SY.

Both the single- and double-shell tank farms contain a wide variety of radioactive isotopes. The distribution of these isotopes changes with time, since species with short half lives decay more rapidly than those with long half lives. In addition, the tanks contain many chemicals, including compounds of aluminum (including aluminates), bismuth, calcium, cerium, iron, manganese, nickel, zirconium, and much smaller amounts of cadmium and mercury. Other species present are sodium and other salts, generally of carbonate, chloride, fluoride, ferrocyanide, nitrate, nitrite, hydroxide, phosphate and sulfate. Water and some organic carbon (including diluents and tributyl phosphate and their degradation products, and chelating agents and their fragments) are also present (DOE 1987).

1.4 BASIC TANK OPERATING PARAMETERS

Several operating parameters are important in the tank farms. Temperature is monitored/controlled to make sure that the tank structural design specifications are not exceeded. The level of the waste in most of the tank is also monitored in order to detect leaks and to ensure that waste transferred from one place to another arrives and is accounted for in the correct tank. Pressure in tank vapor spaces is monitored in some tanks because an increase in pressure could result in a release of contaminated vapor from some tanks that have vent systems with unfiltered pathways.

All double-shell tank farms and some single-shell tanks are equipped with ventilation equipment that pulls vapor from the tanks and exhausts it through high efficiency particulate air filters. This equipment creates a slight vacuum in the tanks, pulling clean air in. Single-shell tanks not equipped with ventilation systems are fitted with passive high efficiency particulate air filters so that as the tank "breathes" with changes in ambient pressure the tank vapor is filtered.

Leak detection in single-shell tank farms includes using dry wells and, for some tanks, lateral wells drilled around and beneath the tanks. These wells are monitored for increases in radioactivity that would indicate a leak. In addition, some of the tanks are equipped with liquid observation wells, which are dry wells inserted into the tank waste. These wells are used to monitor the level of interstitial liquid located within the solid waste.

Leak detection in double-shell tank farms includes ventilation systems that filter and exhaust air from the annular space between the inner and outer tanks. The air is monitored for elevations in radioactivity, which would occur if the primary containment wall leaked. The bottoms of tank annular spaces also have devices that directly detect liquids. Double-shell tanks sit on individual concrete grids. These grids have channels in them that would direct leakage from the outer tank to a leak detection pit, in the event both the inner and outer tanks leaked.

The systems described above are only part of the instrumentation associated with the tank farms, however, they represent basic parameters of concern. They are also topics of importance in describing safety issues.

1.5 SAFETY ISSUE BACKGROUND AND DEVELOPMENT

Use of the term "safety issue" to identify potential problems in the tank farms began in 1989 with the identification of tanks that contained potentially high amounts of ferrocyanide. Later that year, additional tanks with the potential to accumulate and, periodically, to vent concentrations of flammable gases were identified. Tank farm facilities and operations were reviewed to look for additional safety issues. Nine other issues were identified and added to the list by May of 1990. To date, twenty-three safety issues involving storage of radioactive high level waste and operating safety in the tank farms have been identified for resolution.

On November 5, 1990, the U.S. Congress passed Public Law 101-510, Section 3137, *Safety Measures for Waste Tanks at Hanford Nuclear Reservation* (Safety Measures Law), which addresses safety issues concerning the handling of high-level nuclear waste in Hanford Site storage tanks.

Section 3137 specifically addresses issues concerning Hanford Site waste tanks by directing that the Secretary of Energy take the following actions.

- Identify those tanks that *"...may have a serious potential for release of high-level waste due to uncontrolled increases in temperature of pressure..."*
- Ensure that *"...continuous monitoring to detect a release or excessive temperature or pressure..."* is being carried out.
- Develop *"...action plans to respond to excessive temperature or pressure or a release from any tank identified..."*
- Restrict additions of high-level nuclear wastes to the identified tanks unless no safer alternative exists or the serious potential for a release of high-level nuclear waste is no longer a threat.

The directives above were in response to four safety issues originally involving 53 Watch List tanks at the Hanford Site (there are currently 54 Watch List tanks). These safety issues are identified in Table 1-1, with the following titles: high flammable gas concentrations; potentially explosive mixtures of ferrocyanide; potential for runaway organic nitrate reactions; and water additions needed to cool single-shell tank.

Since the 1993 report (Reep 1993) was published the number of tanks on the Watch List has increased from 50 to 54. Tank 241-U-111 was added to the Organic Salts Watch List in August 1993, and Tank 241-T-111 was added to the same list in February 1994. In May 1994, another ten tanks (241-A-101, 241-AX-102, 241-C-102, 241-S-111, 241-SX-103, 241-TY-104, 241-U-103, 241-U-105, 241-U-203, and 241-U-204) were also added to the Organic Salts Watch List. As six of these tanks were already on the Watch List for other reasons, the total number of tanks on the Watch List by mid-1994 was 56.

In November 1994, two tanks (241-BX-102 and 241-BX-106) were removed from the Ferrocyanide Watch List, bringing the number of Watch List tanks to 54. Ten tanks are currently on more than one Watch List.

Additionally, the Safety Measures Law directs the Secretary of Energy to report to Congress *"...on actions taken to promote tank safety, including actions specifically taken pursuant to this section of the law, and the Secretary's timetable for resolving the outstanding issues on how to handle the waste in such tanks."* A total of 23 "outstanding issues" were identified in response to the Safety Measures Law. A description, technical basis, alternatives, and action plan for each safety issue were provided in *A Plan to Implement Remediation of Waste Tank Safety Issues at the Hanford Site* (Wilson and Reep 1991).

In 1992, the U.S. Department of Energy High-Level Waste Tank Safety Task Force Working Group completed a study of issues related to waste storage tanks at sites under Department of Energy jurisdiction. The Tank Task Force study identified a total of 30 safety issues and system deficiencies that must be addressed at the Hanford Site, Savannah River, Idaho Falls, and West Valley facilities (DOE 1992). Twenty-eight of the 30 issues and deficiencies are applicable to Hanford Site tanks.

1.6 SAFETY CATEGORIES

1.6.1 Safety Issues

Safety issues are divided into the following three categories:

- *Priority 1* - Issues that contain most of the necessary conditions that could lead to worker (onsite) radiation exposure through an uncontrolled release of radioactive waste. There are four priority 1 safety issues, which are described in Section 4.1.

- *Priority 2* - Issues that contain some of the necessary conditions that could lead to an uncontrolled release of radioactive waste under extreme assumptions. There are eight priority 2 safety issues. Priority 2 safety issues are described in Section 4.2.

- *Priority 3* - Issues that could lead to the future release of radioactive waste during 5 to 30 years of intermediate storage of high level waste (prior to waste removal, treatment, and vitrification.) Examples are corrosion, leakage, operating practices, and buried single-wall waste transfer pipelines. The eight priority 3 safety issues are described in Section 4.3.

The Waste Tank Safety Program within the Tank Waste Remediation System has the charter to ensure that all Hanford tank priority 1 safety issues are investigated and analyzed and that appropriate corrective action plans are prepared and implemented. When the program is completed, Hanford tank waste will be maintained in safe storage designed to last until final disposal takes place.

1.6.2 System Deficiencies

System deficiencies are additional concerns that relate to tank farm operations. These deficiencies were identified by the U. S. Department of Energy High Level Waste Tank Task Force. (The Department of Energy established the High Level Radioactive Waste Tanks Task Force and the Technical Advisory Panel in August 1990 to address high level waste safety on a national basis.) System deficiencies are described in Section 4.4 of this report. System deficiencies are resolved with the concurrence of the U. S. Department of Energy. A summary table of the safety issues and system deficiencies along with the affected waste tanks is given in Table 1-1.

1.6.3 Safety Initiatives

Safety initiatives are measures taken at the direction of the Secretary of Energy to accelerate the resolution of selected tank farm safety, management, and operational issues. Secretary O'Leary outlined this new approach in September of 1993. It includes near-term actions and strategies to address tank safety issues, environmental protection, operating and tank equipment problems, tank farm management improvements, and tank waste characterization.

The U.S. Secretary of Energy has directed that six safety initiatives be implemented in the Tank Waste Remediation System Program to accelerate the mitigation/resolution of high priority waste tank safety issues at the Hanford Site. Forty-two milestones were established for accomplishing the initiatives (Hanlon 1995). The designation of the safety initiatives has allowed significant improvements in the schedule for resolution/mitigation specific safety issues and system deficiencies. Safety initiatives are identified and discussed in this document within the sections that address individual safety issues or system deficiencies.

The overall progress towards completing the forty-two milestones associated with the safety initiatives has been significant. To date 67% of the milestones have been completed. Of the remaining 14 milestones, 7 milestones are projected to be met early or on time, 6 milestones are currently behind schedule, and one milestone will probably be cancelled.

Table 1-1. Safety Issues and System Deficiencies and Waste Tanks Affected.

Safety Issue Title	Number of Tanks by Area and Tank Farm																		Total Tanks
	200 East Area Tank Farms												200 West Area Tank Farms						
	Single-Shell Tank						Double-Shell Tanks						Single-Shell Tank						
	A	AX	B	BX	BY	C	AN	AP	AW	AY	AZ	SY	S	SX	T	TX	TY	U	
1-1. High Flammable Gas Concentrations	*101*	*101* *103*					*103* *104* *105*		*101*			*101* *103*	*102* *111* *112*	*101* *102* *103* *104* *105* *106* *109*	*110*			*103* *105* *107* *108* *109*	25
1-2. Potentially Explosive Mixtures of Ferrocyanides					*103* *104* *105* *106* *107* *108* *110* *111* *112*	*108* *109* *111* *112*									*107*	*118*	*101* *103* *104*		18
1-3. Potential for Runaway Organic-Nitrate Reactions	*101*	*102*	*103*			*102* *103*							*102* *111*	*103* *106*	*111*	*105* *118*	*104*	*103* *105* *106* *107* *111* *203* *204*	20
1-4. Water Additions Needed to Cool Single-Shell Tank						*106*													1
2-1. Inadequate Single-Shell Tank Leak Detection	Safety Tank Issue Resolved																		0
2-2. Storage of High Level Waste in Tanks That Have Leaked [1]	103 104 105	*102* 104	101 *103* 105 107 110 111 112 201 203 204	101 *102* 109 110 111	*103* *105* *106* *107* *108*	101 110 *111* 201 202 203 204							104	*104* 107 108 *109* 110 111 112 113 114 115	101 103 106 *107* 108 109 *111*	*105* 107 110 113 114 115 116 117	*101* *103* *104* 105 106	101 104 110 112	67
2-3. Inability of Waste Tanks and Ancillary Equipment to Withstand a Design Basis Earthquake	All Tanks																		177

Note: Watch List Tanks are in *Italic* type

Table 1-1. Safety Issues and System Deficiencies and Waste Tanks Affected.

Safety Issue Title	Number of Tanks by Area and Tank Farm																		Total Tanks
	200 East Area Tank Farms												200 West Area Tank Farms						
	Single-Shell Tank						Double-Shell Tanks						Single-Shell Tank						
	A	AX	B	BX	BY	C	AN	AP	AW	AY	AZ	SY	S	SX	T	TX	TY	U	
2-4. Single-Shell Tank Emergency Pumping Capability Inadequate				*106*									101 *102* 103 106		102 112			102 *103* *105* *106* *107* *108* *109* *111*	15
2-5. Tank Vapor Release	101	*102*	*103*	*102* *104* *106*	*103* *104* *105* *106* *107* *108* 109 *110* *111* *112*	101 *102* *103* 104 105 *106* *108* *109* 110 *111* *112*							*102* *111*	*103* *106*	*107* *111*	*105* *118*	*101* *103* *104*	*103* *105* *106* *107* *111* *203* *204*	45
2-6. Inadequate Response Time to a Leaking Double-Shell Tank							All Double-Shell Tanks												28
2-7. Storage of High-Level Waste in Tanks With No Secondary Containment [1]	All Single-Shell Tanks												All Single-Shell Tanks						149
2-8. Potential for Nuclear Criticality in High Level Waste Tanks [1]	All Tanks																		177
3-1. Insufficient Tank Storage Capacity to Handle Waste Resulting from Resolution of Existing Safety Issues							All Double-Shell Tanks												28
3-2. Cracked Tank Farm Ventilation Header											101 102								2
3-3. Insufficient Hydroxide Concentration in Tanks							107												1
3-4. Inadequate Sealing of Single-Shell Tanks to Prevent Intrusions that Could Leak Contamination Out of Tank	All Single-Shell Tanks												All Single-Shell Tanks						149
3-5. Inadequacies in Waste Transfer Line Leak Detection	All Tanks																		177

Note: Watch List Tanks are in *Italic* type

Table 1-1. Safety Issues and System Deficiencies and Waste Tanks Affected.

Safety Issue Title	Number of Tanks by Area and Tank Farm																		Total Tanks
	200 East Area Tank Farms												200 West Area Tank Farms						
	Single-Shell Tank						Double-Shell Tanks						Single-Shell Tank						
	A	AX	B	BX	BY	C	AN	AP	AW	AY	AZ	SY	S	SX	T	TX	TY	U	
3-6. Excessive Unfiltered Airflow Passages into Tanks	104 105 106					104 105 *106*	101 102 *103* *104* *105* 106 107	101 102 103 104 105 106 107 108	*101* 102 103 104 105 106	101 102	101 102	*101* 102 *103*		*101* *102* *103* *104* *105* *106* 107 108 *109* 110 111 112 114					47
3-7. Potential for Formation of Explosive Deposits	Not an issue at Hanford																		N/A
3-8. Uncharacterized Corrosion of High Level Waste Tanks	Potentially all Tanks																		177
3-9. Questionable Integrity of High Level Waste Tank Vaults	Not an issue at Hanford																		N/A
4-1. Insufficient Tank Contents Characterization	*101* 102 103 104 105 106	*101* *102* *103* 104	101 102 *103* 104 105 106 107 108 109 112 203 204	101 102 104 105 106 108 109 110 111 112	101 102 *103* *104* *105* *106* *107* *108* 109 *110* *111* *112*	101 *102* *103* 104 105 *106* 107 *108* *111* 201 202 203 204	*103* *104* *105* 107		*101*			*103*	101 *102* 103 105 106 107 108 109 110 *111* *112*	*101* *102* *103* *105* *106* 107 108 *109* 110 111 112 113 114 115	101 103 106 108 109 110 112 201 202 203 204	101 102 103 104 *105* 106 107 108 109 110 111 112 113 114 115 116 117 *118*	*101* 102 *103* *104* 105 106	101 102 *103* 104 *105* *106* *107* *108* *109* 110 *111* 112 201 202 *203* *204*	6 Double-Shell Tanks 133 Single-Shell Tanks
4-2. Inadequate Safety Documentation	All Tanks																		177
4-3. Deficient Maintenance and Upgrade of Facilities	All Tanks																		177

Note: Watch List Tanks are in *Italic* type

Table 1-1. Safety Issues and System Deficiencies and Waste Tanks Affected.

Safety Issue Title	Number of Tanks by Area and Tank Farm																		Total Tanks
	200 East Area Tank Farms												200 West Area Tank Farms						
	Single-Shell Tank						Double-Shell Tanks						Single-Shell Tank						
	A	AX	B	BX	BY	C	AN	AP	AW	AY	AZ	SY	S	SX	T	TX	TY	U	
4-4. Deficient Instrument Upgrades in Single and Double-Shell Tanks	All Tanks																		177
4-5. Extended Tank Operating Life	All Tanks																		177
4-6. Conduct of Operations Deficient	All Tanks																		177
4-7. Lack of Plant-Essential Drawings	All Tanks																		177
4-8. Questionable Transfer Line Concrete Encasement Integrity	All Tanks																		N/A
4-9. Leak Detection in Double-Shell Tanks.							System Deficiency Resolved												0

[1] The classification of the wastes in all of the underground storage tanks at the Hanford Site is not final, and some wastes may not be high-level radioactive wastes. However, until the characterization and classification is complete, all the tanks are treated as if they do contain high-level wastes. Thus, they are referred to as high-level wastes in this document.

Note: Watch List Tanks are in *Italic* type

2.0 STRATEGY FOR RESOLVING SAFETY ISSUES AND SYSTEM DEFICIENCIES

2.1 STRATEGY

The overall strategy for disposing of Hanford's tank waste is to separate (pretreat) the waste into high and low activity radioactive waste streams and to vitrify it. Vitrifying the waste will remediate the hazards associated with current tank storage.

2.2 OVERVIEW OF TANK SAFETY ISSUE RESOLUTION LOGIC

An overview of the waste tank safety issue resolution logic process is provided in Figure 2-1. A more detailed explanation of the safety issue resolution process and logic is provided in Appendix A. The logic and process were developed from a concept paper prepared by Science Applications International Corporation, Germantown, Maryland (SAIC 1991). The paper was prepared from the U.S. Department of Energy-Headquarters with input supplied by Westinghouse Hanford Company.

The process involves a problem definition phase followed by three optional paths leading to resolution of the safety issue. These are:

- 1.0 Evaluate and define the problem
- 2.0 Implement "Zero Option"
- 3.0 Implement mitigation
- 4.0 Implement remediation

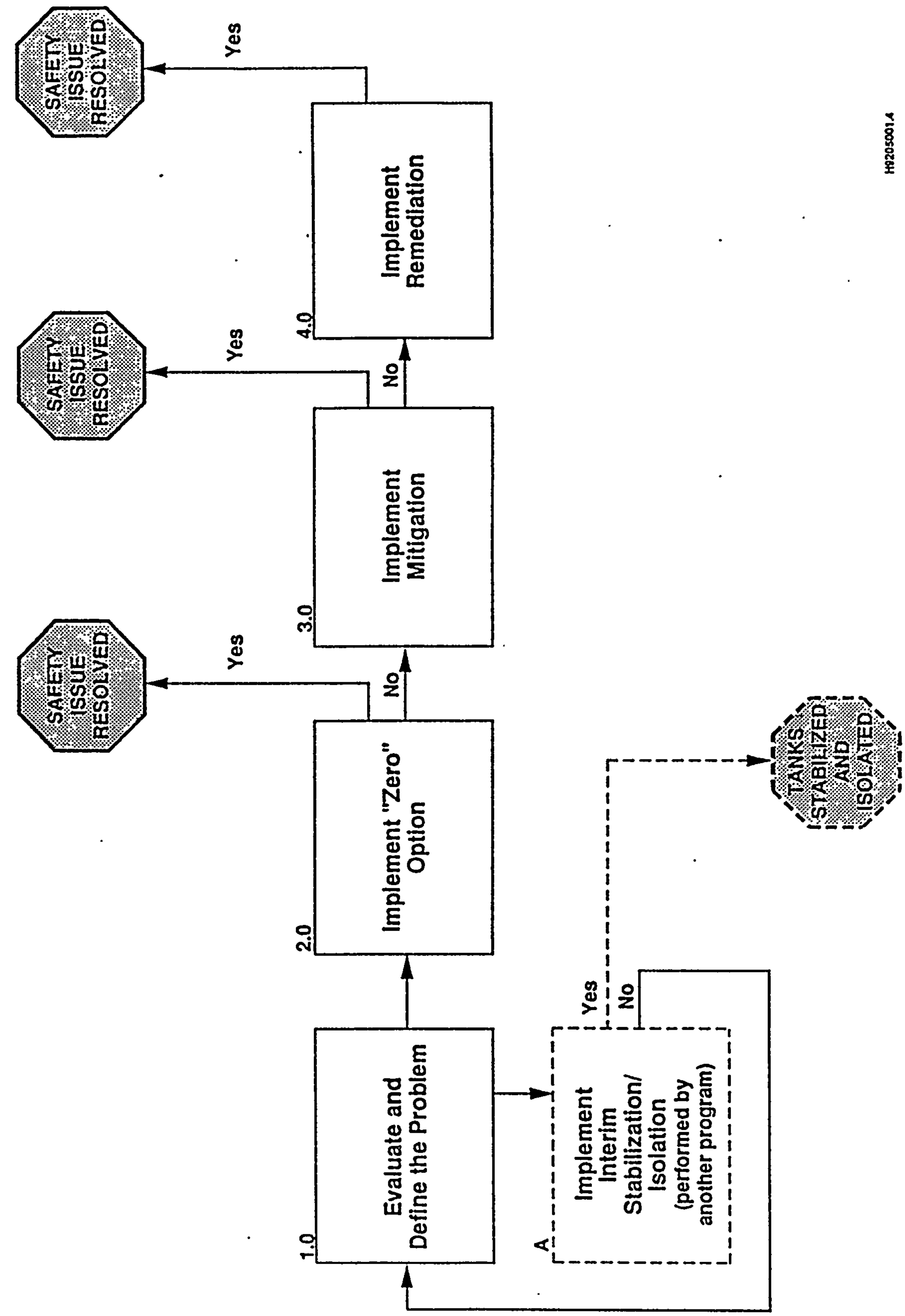
The three implementation paths lead to the final objective of removal of a tank (or group of tanks) from the Watch List (issue resolution) by either controlling the hazard or eliminating the hazard. The path selected to remove a tank (or group of tanks) from the Watch List depends on the safety issue, the tank (or group of tanks), and the magnitude of the hazard.

The optional path followed to resolve a safety issue related to a tank (or group of tanks) is ultimately a function of whether the waste requires treatment and where the waste treatment takes place, as shown in Table 2-1.

Table 2-1. Optional Paths for Resolving Safety Issues.

Implementation Path	Treatment Requirement
"Zero option"	None
Mitigation	In-tank
Remediation	Out-of-tank

Figure 2-1. Overview of Waste Tank Safety Issues Resolution Logic.



2.3 PRIORITIES

The three priority categories for safety issues (identified in Section 1.6.1) were developed by the High Level Waste Tank Safety Task Force of the U. S. Department of Energy. A risk-based approach was used to establish the priority assigned to each issue.

2.4 SAFETY DOCUMENTATION AND NATIONAL ENVIRONMENTAL POLICY ACT DOCUMENTATION

All actions taken by the Department of Energy to treat or dispose of the high-level radioactive waste at Hanford's tank farms is done in compliance with the *National Environmental Policy Act*. Disposal of the high-level radioactive waste in Hanford double-shell tanks is covered by the Hanford Defense Waste Environmental Impact Statement (DOE 1987). Currently, the Department of Energy is preparing a Tank Waste Remediation System environmental impact statement that will include the single-shell tank waste. Most of the safety issues addressed in this report are the subject of a separate environmental assessment published in 1994 (DOE 1994a). Major issues, including organic in Tank 241-C-103 and ferrocyanide and flammable gases in Tank 241-SY-101, are included in this assessment, for which there was a finding of no significant impact.

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3.0 SAFETY ISSUES RESOLUTION MANAGEMENT

This section contains an overview of the Tank Waste Remediation System Program, which has total responsibility for the mitigation and resolution of waste tank safety issues, as well as a description of the technical strategy. In addition, this section addresses the Site's and Program's Work Breakdown Structures and the management approach for the resolution of the Hanford Site's tank-related safety issues and system deficiencies.

3.1 TANK WASTE REMEDIATION SYSTEM OVERVIEW

3.1.1 Relation to Hanford Site Mission

The overall objective of the Tank Waste Remediation System Program is to support the goal of the Hanford Site cleanup mission by disposing of the waste contained in the underground storage tanks. As stated in the *Hanford Mission Plan*, the new Site mission identifies three focus areas: *"to clean up the site, provide scientific and technological excellence to meet global needs, and to partner in the economic diversification of the region* (DOE 1994b)." Cleanup of the Site is being performed in accordance with the Tri-Party Agreement, as amended and in other agreements, and in compliance with all applicable federal, state, and local laws, as well as in consideration of American Indian treaty rights (Ecology et al. 1994).

The negotiation of the 4th Amendment to the Tri-Party Agreement in January of 1994 resulted in significant changes that affect nearly every aspect of Site cleanup. Major changes that impact the direction of the Tank Waste Remediation Program include:

- Retrieving the single-shell tank wastes by 2024;
- Increasing the scope and delaying the start-date for the High-Level Waste Vitrification Facility;
- Eliminating the grout program and replacing it with a low-level vitrification process;
- Adding tank farm safety and tank farm upgrade milestones; and
- Closing single-shell tank farms by 2024 and closing all tank farms by 2028.

Hanford Site programs must also comply with the U.S. Department of Energy policies and directives. The cleanup work will be performed with the intent of transferring a positive legacy to the community through economic diversification activities.

3.1.2 Tank Waste Remediation System Program Objective

The Tank Waste Remediation System Program is an essential element in the cleanup of the Hanford Site nuclear production infrastructure and waste, which entails a legacy of nearly 50 years of nuclear materials production. The Program was established by the

U.S. Department of Energy in 1991 (DOE 1993) to "*store, treat, and immobilize the highly radioactive Hanford waste in an environmentally sound, safe and cost effective manner.*" Program objectives have been established to achieve the required levels of quality, safety, and environmental compliance with the technical, resource, and schedule objectives of the *Tank Waste Remediation System Program Plan*. One of the primary goals of the Tank Waste Remediation System Program is to minimize the safety and health risks associated with the cleanup of waste stored in double-shell and single-shell tanks. This specifically includes the mitigation and resolution of tank farm safety issues. Shown in Figure 3-1 is a summary flow diagram that depicts the Hanford Tank Waste Remediation System Strategy (Reep 1993).

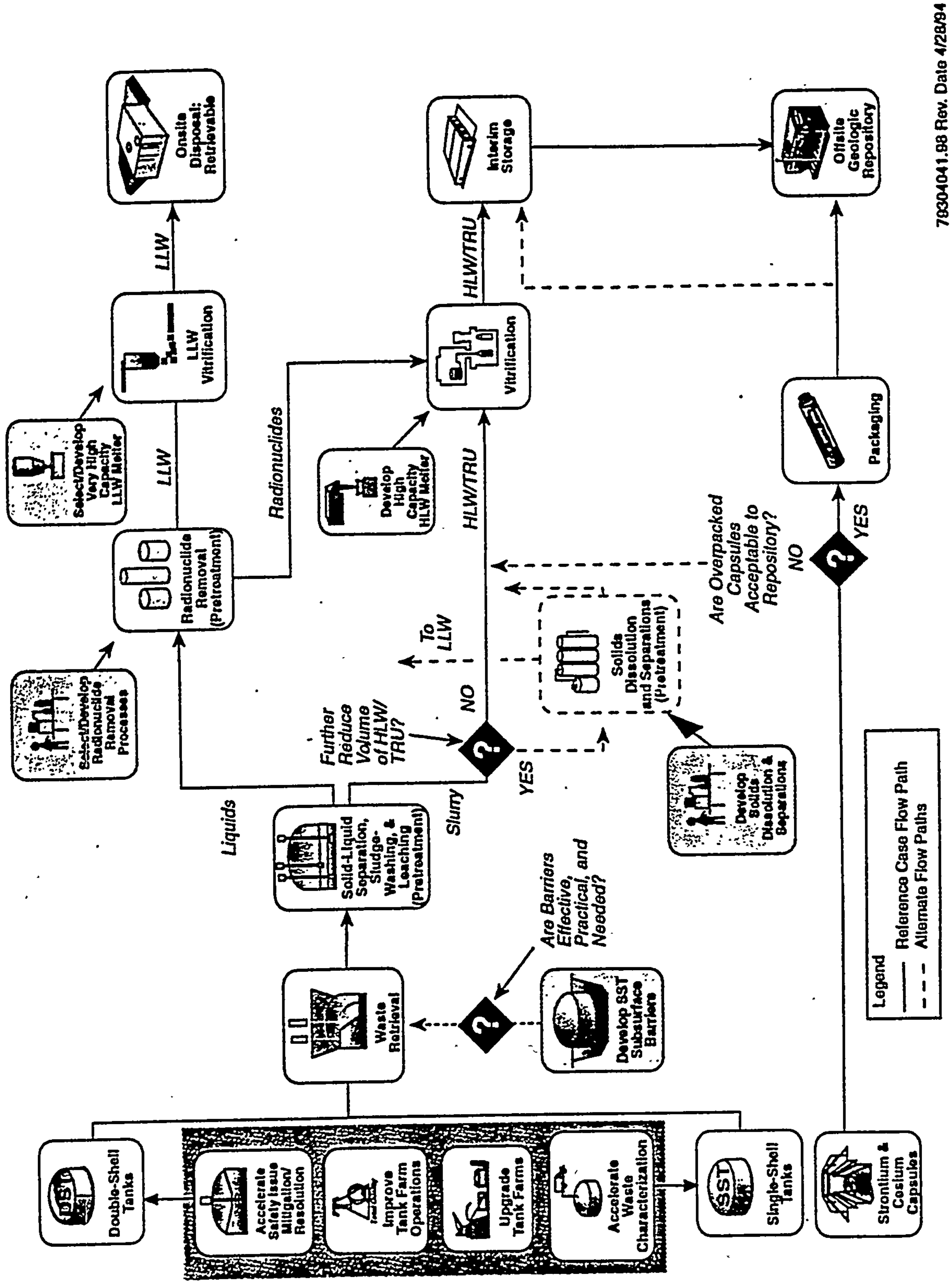
3.2 TECHNICAL STRATEGY

During the period following the issuance of the *Hanford Defense Waste Environmental Impact Statement Record of Decision* in 1988 and the approval of the Tri-Party Agreement in 1989, significant changes occurred that required a complete re-evaluation of the Tank Waste Remediation System. These changes included the following:

- Identification of safety issues in 44 (originally 48) of the 149 double-shell and single-shell tanks, which require active intervention to continue safe waste storage;
- The potential for significant environmental impact due to leaking and deteriorating single-shell tanks;
- Abandoning modification of existing facilities to pretreat tank waste, because full environmental compliance could not be achieved;
- A policy decision that all single-shell tank waste must be retrieved to meet current environmental laws, including the *Resource Conservation and Recovery Act of 1976,* which increased the volume of waste for treatment and immobilization by a factor of four; and
- Nuclear Regulatory Commission actions to require further treatment of low-level radioactive wastes prior to onsite disposal.

Because of the above-mentioned changes, it was necessary to evaluate the risk of proceeding with tank waste management and disposal with the strategy outlined in the *Hanford Defense Waste Environmental Impact Statement* (DOE 1987) and the Tri-Party Agreement. An evaluation of the Tank Waste Remediation System was performed using a combination of internal and independent reviewers. All reviewers concluded that there was significant uncertainty and risk in proceeding with the prior strategy, and these reviews identified the need for an integrated solution for tank waste management. As a result, the Secretary of Energy initiated a 15-month effort to develop a proposal for a new technical strategy for tank waste management at the Hanford Site.

Figure 3-1. Hanford Tank Waste Remediation System Strategy.



In November 1992, the Tank Waste Remediation System Program Leadership Council directed that systems engineering be adopted as the paradigm for development and management of the Tank Waste Remediation System Program. Currently, the systems engineering process is being applied to establish and maintain the integrated Hanford Site Technical Baseline, which is necessary to accomplish the Hanford Site Mission. The systems engineering approach, as adapted to Hanford Site cleanup, does the following:

- Identifies functions needed to complete the mission; requirements and constraints to performing those functions; performance criteria for accomplishing the functions; alternative physical solutions for accomplishing the functions give the requirements, constraints, and performance criteria; optimal physical solutions that consider risk factors and stakeholder values; and a technical baseline that is a sequence of activities necessary to implement the selected physical solutions;

- Delivers the integrated technical baseline of selected physical solutions to the Site Management System process for planning, organizing, scheduling, performing, and managing change; and

- As an iterative process, receives input from the Site Management System process or other processes regarding changes in risk factors or stakeholder values and redefines or identifies the impact on the Site technical baseline.

Planning of the Hanford site activities, based on the implementation of systems engineering is scheduled to begin in fiscal year 1995 for fiscal year 1996 and beyond (DOE 1994b). Work on the Tank Waste Remediation System's system engineering effort was begun in fiscal year 1992. The present foucs of this effort is the functional decomposition of program level functions and requirements to the project level.

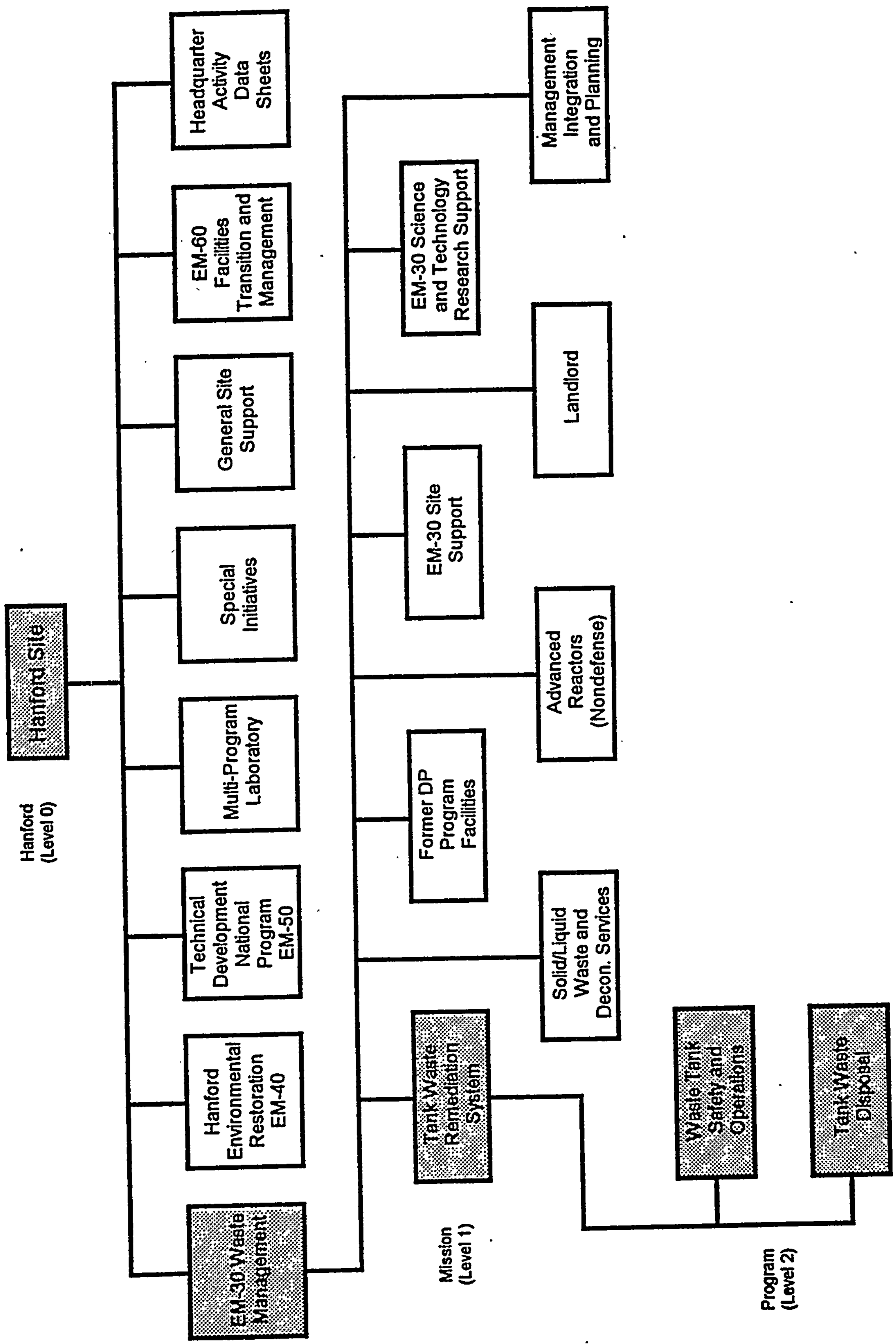
3.3 WORK BREAKDOWN STRUCTURE

The Tank Waste Remediation System Work Breakdown Structure is a product-oriented hierarchical structure that provides a consistent framework to facilitate uniform planning, identification of priorities, assignment of responsibilities, and reporting status within the Tank Waste Remediation System. The work breakdown structure is structured by levels. These levels and names are consistent with the *EM-30 Cost and Schedule Estimating Guidance for Waste Operations Baseline*, site management system guidance, and the Westinghouse Hanford Company Management Control System. The top four levels are listed below:

Level	Name
0	Hanford
1	Mission
2	Program
3	Program Element

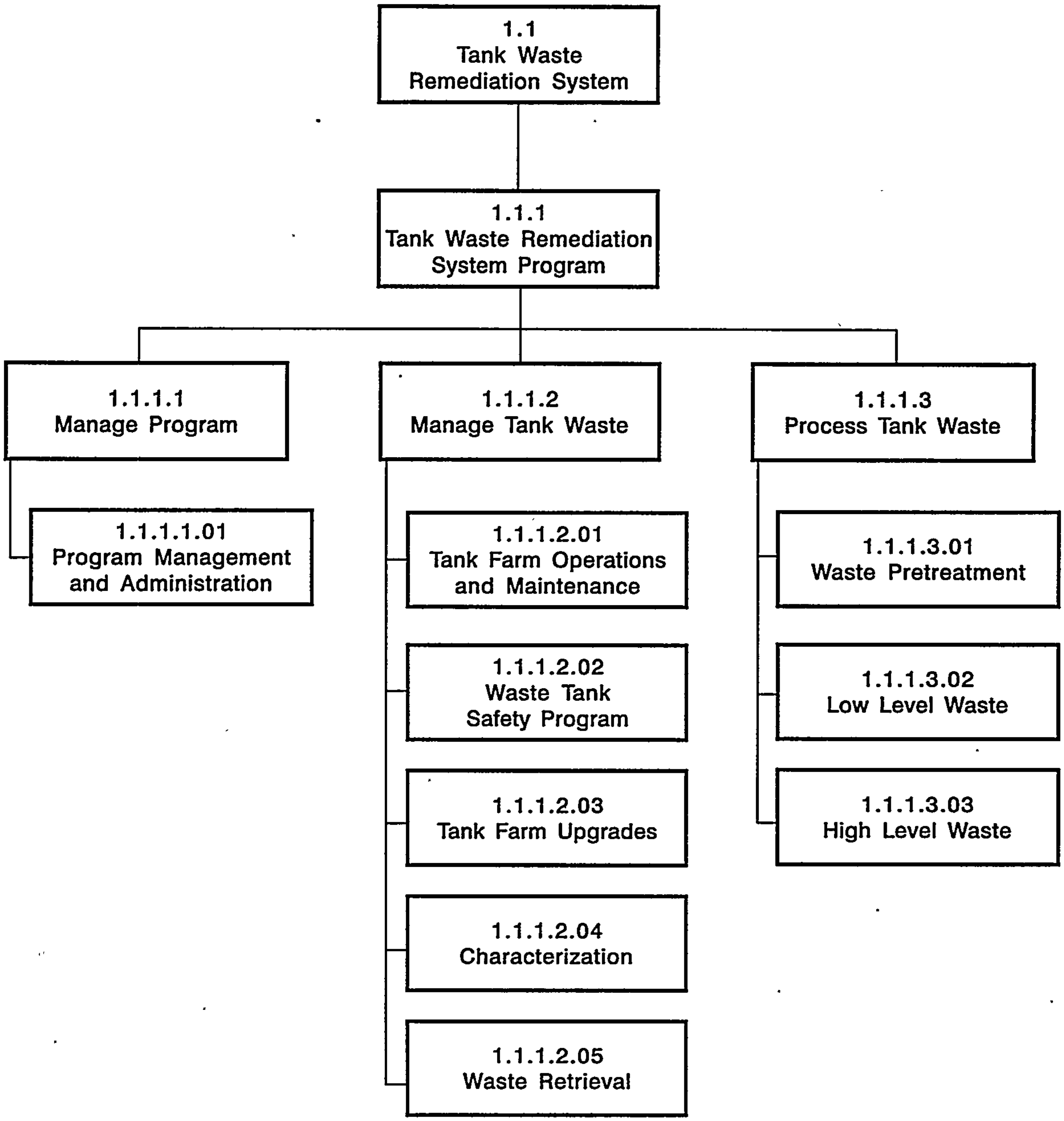
The Hanford Site Work Breakdown Structure is identified down to the program level in Figure 3-2. This figure shows the interrelationships of the Hanford Site missions, such as Solid/Liquid Waste, Site Support, and Science and Technology. These other programs maintain functions that interface with the Tank Waste Remediation System Mission.

Figure 3-2. Hanford Site Work Breakdown Structure.



The Tank Waste Remediation System Work Breakdown Structure is shown down to the Program Element Level in Figure 3-3. All work scope is managed through the Program Elements, which have the responsibility to plan, budget, control, and deliver final products in support of the Tank Waste Remediation System Mission. Work breakdown structure codes are also identified for the various Work Breakdown Structure elements (Reep 1993).

Figure 3-3. Tank Waste Remediation System Work Breakdown Structure.



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4.0 SAFETY ISSUES AND SYSTEM DEFICIENCIES

This section presents a discussion of all current safety issues and system deficiencies. Table 4-1 lists existing safety issues and system deficiencies and indicates changes that have occurred to the name or priority of each issue or deficiency since it was identified. The information presented in this section was reviewed during the first quarter of calendar year 1995 and was current at that time.

4.1 PRIORITY 1 SAFETY ISSUES

Priority 1 safety issues are those issues and/or situations that contain most of the necessary conditions that could lead to worker (onsite) or offsite radiation exposure through an uncontrolled release of radioactive waste. Priority 1 safety issues are:

- High Flammable Gas Concentrations (SI 1-1)
- Potentially Explosive Mixtures of Ferrocyanide (SI 1-2)
- Potential for Runaway Organic-Nitrate Reactions (SI 1-3)
- Water Additions Needed to Cool Single-Shell Tank (SI 1-4)

These are discussed in turn.

4.1.1 Safety Issue 1-1: High Flammable Gas Concentrations

4.1.1.1 Background and Description. Six double-shell and nineteen single-shell tanks at the Hanford Site have been identified as having the potential to accumulate flammable gas[1] in the waste, with periodic releases of the gas from the waste to the tank dome space (*gas release events*). These twenty-five high-level radioactive liquid-waste storage tanks are on the Flammable Gas Watch List, shown in Table 4-2. A flammable gas mixture in a tank, along with an ignition source,[2] could lead to deflagration (burning), increasing the risk of release of radioactive waste from these tanks to the environment. Radioactive waste might also be released through a ventilation system that fails as a result of excessive increases in pressure leading to a gas release event.

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[1]Examples of flammable gases are hydrogen, ammonia and methane. Radioactive liquid waste generates hydrogen gas through the radiolysis of water. Sometimes this waste generates the oxidizer nitrous oxide in addition to flammable gases.

[2]Operational restrictions have been put into effect at the Hanford Tank Farms to restrict ignition sources from coming into contact with these tanks (WHC 1990b).

Table 4-1. Changes in Safety Issue/System Deficiency Name, Priority, and Number from Previous Reports.

New Title	1993 Report	1991 Report	Comments
1-1. High Flammable Gas Concentrations	High Flammable Gas Concentrations	Flammable Gas Generation in Tank 241-SY-101 and Other Tanks	1995 - No change 1993 - Change in title only 1991 - Identified as priority 1 safety issue number 1
1-2. Potentially Explosive Mixtures of Ferrocyanide	Potentially Explosive Mixtures of Ferrocyanide	Potential Explosive Mixtures of Ferrocyanide in Tanks	1995 - No change 1993 - Change in title only 1991 - Identified as priority 1 safety issue number 2
1-3. Potential for Runaway Organic-Nitrate Reactions	Potential for Runaway Organic Nitrate Reactions	Potential Organic-Nitrate Reactions in Tanks	1995 - No change 1993 - Change in title only 1991 - Identified as priority 1 safety issue number 3
1-4. Water Additions Needed to Cool Single-Shell Tank	Water Additions Needed to Cool Single-Shell Tank	Continued Cooling Required for High-Heat Generation in Tank 241-C-106	1995 - No change 1993 - Change in title only 1991 - Identified as priority 1 safety issue number 4
2-1. Inadequate Single-Shell Tank Leak Detection	Inadequate Single-Shell Tank Leak Detection	Inadequate Single-Shell Tank Leak-Detection Systems	1995 - No change 1993 - Change in title and safety issue number 1995 - Identified as priority 2 safety issue number 8
2-2. Storage of High-Level Waste in Tanks That Have Leaked	Storage of High-Level Waste in Tanks That Have Leaked	Not Applicable	1995 - No Change 1993 - Identified as priority 2 safety issue number 2
2-3. Inability of Waste Tanks and Ancillary Equipment to Withstand a Design Basis Earthquake	Inability of Waste Tanks and Ancillary Equipment to Withstand a Design Basis Earthquake	Not Applicable	1995 - No Change 1993 - Identified as priority 2 safety issue number 3
2-4. Single-Shell Tank Emergency Pumping Inadequate	Single-Shell Tank Emergency Pumping Inadequate	Single-Shell Emergency Pumping	1995 - No Change 1993 - Change in safety issue name and number 1991 - Identified as priority 2 safety issue number 11
2-5. Tank Vapor Release	Tank Vapor Release	Tank Toxic Vapor Releases	1995 - No Change 1993 - Change in safety issue name and number 1991 - Identified as priority 2 safety issue number 13
2-6. Inadequate Response Time to A Leaking Double-Shell Tank	Inadequate Response Time to A Leaking Double-Shell Tank	Response to a Leaking Double-Shell Tank	1995 - No Change 1993 - Change in safety issue name and number 1991 - Identified as priority 2 safety issue number 17
2-7. Storage of High-Level Waste in Tanks With No Secondary Containment	Storage of High-Level Waste in Tanks With No Secondary Containment	Not Applicable	1995 - No Change 1993 - Identified as priority 2 safety issue number 7
2-8. Potential for Nuclear Criticality in High-Level Waste Tanks	Potential for Nuclear Criticality in High-Level Waste Tanks	Not Applicable	1995 - No Change 1993 - Identified priority 2 safety issue number 8

Table 4-1. Changes in Safety Issue/System Deficiency Name, Priority, and Number from Previous Reports.

New Title	1993 Report	1991 Report	Comments
1-1. High Flammable Gas Concentrations	High Flammable Gas Concentrations	Flammable Gas Generation in Tank 241-SY-101 and Other Tanks	1995 - No change 1993 - Change in title only 1991 - Identified as priority 1 safety issue number 1
3-1. Insufficient Tank Storage Capacity to Handle Waste Resulting from Resolution of Existing Safety Issues	Insufficient Tank Storage Capacity to Handle Waste Resulting from Resolution of Existing Safety Issues	Double-Shell Tank Space Requirements	1995 - Change in title only 1993 - Change in safety issue name, priority and number 1991 - Identified as priority 2 safety issue number 16
3-2. Cracked Tank Farm Ventilation Header	Cracked Tank Farm Ventilation Header	AZ Tank Farm Ventilation Line	1995 - No change 1993 - Change in safety issue name and number 1991 - Identified as priority 3 safety issue number 19
3-3. Insufficient Hydroxide Concentration in Tanks	Insufficient Hydroxide Concentration in Tanks	Excessive Hydroxide Consumption in Tank 241-AN-107	1995 - No change 1993 - Change in safety issue name and number 1991 - Identified as priority 3 safety issue number 20
3-4. Inadequate Sealing of Single-Shell Tanks to Prevent Intrusions that Could then Leak Contamination Out of Tank	Inadequate Sealing of Single-Shell Tanks to Prevent Intrusions that Could then Leak Contamination Out of Tank	Sealing of Single-Shell Tanks to Prevent Intrusions	1995 - No change 1993 - Change in safety issue name and number 1991 - Identified as priority 3 safety issue number 21
3-5. Inadequacies in Waste Transfer Line Leak Detection	Inadequacies in Waste Transfer Line Leak Detection	Not Applicable	1995 - No change 1993 - identified priority 3 safety issue number 5
3-6. Excessive Unfiltered Airflow Passages into Tanks	Excessive Unfiltered Airflow Passages into Tanks	Intertank Ventilation Connections	1995 - No change 1993 - change in safety issue name and number 1991 - Identified as priority 3 issue number 23
3-7. Potential for Formation of Explosive Deposits	Potential for Formation of Explosive Deposits	Not Applicable	Not an issue at Hanford
3-8. Uncharacterized Corrosion of High-Level Waste Tanks	Uncharacterized Corrosion of High-Level Waste Tanks	Not Applicable	1995 - No change 1993 - Identified as priority 3 safety issue number 8
3-9. Questionable Integrity of High-Level Waste Tank Vaults	Questionable Integrity of High-Level Waste Tank Vaults	Not Applicable	Not an issue at Hanford
4-1. Insufficient Tank Contents Characterization	Insufficient Tank Contents Characterization	Insufficient Tank Contents Characterization to Support Evaluations	1995 - No change 1993 - Change in safety issue name, priority, and number 1991 - Identified as priority 2 safety issue number 5

Table 4-1. Changes in Safety Issue/System Deficiency Name, Priority, and Number from Previous Reports.

New Title	1993 Report	1991 Report	Comments
1-1. High Flammable Gas Concentrations	High Flammable Gas Concentrations	Flammable Gas Generation in Tank 241-SY-101 and Other Tanks	1995 - No change 1993 - Change in title only 1991 - Identified as priority 1 safety issue number 1
4-2. Inadequate Safety Documentation	Inadequate Safety Documentation	Inadequate Safety Documentation	1995 - No change 1993 - Change in safety issue name, priority, and number 1991 - Identified as priority 2 safety issue number 6
4-3. Deficient Maintenance and Upgrade of Facilities	Deficient Maintenance and Upgrade of Facilities	Maintenance and Upgrades of Tank Farm Facilities and Equipment	1995 - No change 1993 - Change in safety issue name, priority, and number 1991 - Identified as priority 2 safety issue number 7
4-4. Deficient Instrument Upgrades in Single-Shell Tanks and Double-Shell Tanks	Deficient Instrument Upgrades in Single-Shell Tanks and Double-Shell Tanks	Instrument Upgrades in Single-Shell Tanks and Double-Shell Tanks	1995 - No change 1993 - Change in safety issue name, priority, and number 1991 - Identified as priority 2 safety issue number 9
4-5. Extended Tank Operating Life	Extended Tank Operating Life	Tank Safe Operating Life	1995 - No change 1993 - Change in safety issue name, priority, and number 1991 - Identified as priority 2 safety issue number 10
4-6. Conduct of Operations Deficient	Conduct of Operations Deficient	Improvement in Conduct of Operations	1995 - No change 1993 - Change in safety issue name, priority, and number 1991 - Identified as priority 2 safety issue number 14
4-7. Lack of Plant-Essential Drawings	Lack of Plant-Essential Drawings	Lack of Plant-Essential Drawings	1995 - No change 1993 - Change in safety issue name, priority, and number 1991 - Identified as priority 2 safety issue number 15
4-8. Questionable Transfer Line Concrete Encasement Integrity	Questionable Transfer Line Concrete Encasement Integrity	Transfer Line Concrete Encasement Integrity and Secondary Containment Compliance	1995 - No change 1993 - Change in safety issue name, priority, and number 1991 - Identified as priority 3 safety issue number 18
4-9. Leak Detection in Double-Shell Tanks	Leak Detection in Double-Shell Tanks	Improved Leak Detection in Double-Shell Tanks	1995 - No change 1993 - Change in safety issue name, priority, and number 1991 - Identified as priority 3 safety issue number 22

Table 4-2. Flammable Gas Watch List Tanks.

Single-Shell Tanks		Double-Shell Tanks
241-A-101[1]	241-SX-105[1,2]	241-AN-103[2]
241-AX-101[1]	241-SX-106[1,2]	241-AN-104[2]
241-AX-103[1]	241-SX-109[1,2]	241-AN-105[2]
241-S-102[1]	241-T-110[1]	241-SY-101[2]
241-S-111[1]	241-U-103[1]	241-SY-103[2]
241-S-112[1]	241-U-105[1]	241-AW-101[2]
241-SX-101[1,2]	241-U-107	
241-SX-102[1,2]	241-U-108	
241-SX-103[1,2]	241-U-109[1]	
241-SX-104[1,2]		

1. Ventilation to be upgraded via Project W-230
2. Ventilation to be upgraded via Project W-314

Tank 241-SY-101 is the best known and most active Flammable Gas Watch List tank. During a few gas release events hydrogen levels in this tank exceeded, for short periods, the concentration necessary to support combustion. The lower flammability limit is four volume-percent hydrogen in air. Gas release events in this tank almost always produce hydrogen levels exceeding twenty-five percent of the lower flammability limit[3]. While pressure increases were also measured, the tank ventilation system was never damaged, and contamination spread was not detected.

Gas venting in tanks like 241-SY-101 will recur periodically unless mitigating steps are taken. In Tank 241-SY-101, a recently installed mixer pump has effectively mitigated the hazard by allowing the gas to be released on a slower, continuous basis. Resolving the safety issue for other tanks may require removing waste from the tanks (remediation). Operations at the twenty-five Flammable Gas Watch List tanks have been restricted to eliminate potential ignition sources. Potential radiological consequences from a waste release following ignition of an accumulated mixture of nitrous oxide and hydrogen has been postulated, but this event has not been analyzed in any tank farm safety analysis. As a result, this issue was declared an unreviewed safety question.

Although the tendency of Hanford high-level radioactive waste to generate and retain flammable gas was recognized as a serious problem by 1979, this problem did not at first receive adequate attention. A 1990 investigation was initiated as a result of an unusual occurrence report for Tank 241-SY-101. The focus of the investigation was to identify those tanks that had the potential to generate and release flammable gases.

[3]Standard industrial practice is to maintain processes involving flammable gases to concentrations less than 25% of the lower flammability limit.

Initially, this investigation reviewed corporate reports and letters to find tanks that exhibited slurry growth, a possible symptom of gas retention in liquid. Slurry growth was the term used for increases in waste level in tanks that were not accounted for by additions of new waste. The initial review placed five double-shell tanks and fifteen single-shell tanks on the Flammable Gas Watch List. Changes to the criteria used to identify flammable gas tanks resulted in the addition of two more single-shell tanks for a total of twenty-two. Because the vapor spaces of five flammable gas tanks are vented through Tank 241-SX-109, it was also added to the Watch List. The waste surface level in Tank 241-AW-101 increased and later decreased, with pressure spikes accompanying both these changes. As a result, Tank 241-AW-101 was added to the Watch List. Finally, Tank 241-U-107 (an Organic Watch List tank) was recently added to the Flammable Gas Watch List because it exhibited slurry growth. This accounts for the basis for placing each of the twenty-five tanks on the Flammable Gas Watch List. In August 1994, *"Criteria for Flammable Gas Watch List Tanks"* was issued (Hopkins 1994). This document presents methodology for deciding which tanks should be placed on the Watch List for flammable gas concerns.

Several safety initiatives were developed to accelerate and track progress in completing major elements of the flammable gas safety issue. These include the following:

- **Safety Initiative 2e:** Design and install a permanent mixer pump for Tank 241-SY-101 (canceled).
- **Safety Initiative 2f:** Expedite design and construction of a backup portable exhauster for Tank 241-SY-101.
- **Safety Initiative 2g:** Evaluate contingency mitigation options.
- **Safety Initiative 2h:** Install gas monitoring equipment in the remaining potentially flammable gas tanks.
- **Safety Initiative 2k:** Replace ventilation fan in 241-SY Tank Farm to further reduce spark potential.
- **Safety Initiative 2l:** Close 241-SY Tank Farm flammable gas unreviewed safety question.

Scope and Schedule Changes from 1991 report to 1993 report. A review was conducted of waste tanks with chemistry similar to Tank 241-SY-101 (i.e., tanks containing complexed concentrate waste, double-shell slurry or double-shell slurry feed) and with similarly large waste volumes. This review identified five additional tanks having characteristics similar enough to those of Tank 241-SY-101 to warrant further investigation. The characteristics of these five tanks (241-AW-101, 241-AN-102, 241-AN-107, 241-AP-105, and 241-U-111) were compared to those of Tank 241-SY-101. Tank 241-AW-101 exhibits surface level fluctuations and pressure increases characteristic of Tank 241-SY-101 and was added to the Flammable Gas Watch List in November 1992.

In 1993, the schedule for mitigating this safety issue was extended by twenty-two months (from 09/97 to 11/99). The reason for the schedule extension was that one additional tank (241-AW-101) required mitigation. Also, installing mitigation test equipment (i.e., mixer pump) in Tank 241-SY-101 took longer than planned due to unforeseen problems. Additional time was required to approve safety analyses needed to install and operate equipment in the tank. Another change from the 1991 report was that the waste in the most hazardous flammable gas tanks (six double-shell tanks) could require out-of-tank treatment in the new double-shell tank farm and Initial Pretreatment Module (which are not yet constructed) to resolve the safety issue. The schedule for resolving this safety issue would be extended to December 2010, if the waste in all six flammable gas Double-shell tanks required out-of-tank treatment. The 1991 report was based on resolving the Watch List tank safety issues without removing waste from the tanks, since no provision for out-of-tank treatment had been identified. This strategy uses the full scope of the safety issue resolution logic, resolving the safety issue by remediation.

Planning for ventilation upgrades was accelerated one year, with completion by 9/99 instead of 9/00. Revised planning is based on using Capital Equipment Not Related to Construction funded modular exhausters instead of capital construction Line Items for providing near-term tank ventilation needs.

The schedule for completing instrumentation and monitoring upgrades for flammable gas double-shell tanks remains unchanged from the 1991 report but has slipped four years from September 1995 to September 1999 for single-shell tanks. The schedule for single-shell tank flammable gas tank instrumentation upgrades was delayed due to its relatively lower priority and the limited availability of tank farm resources due to higher priority activities (flammable gas mitigation, other Watch List tank instrumentation upgrades, resolving the tank vapor release safety issue, and resolving the high-heat tank safety issue).

Scope and Schedule Changes from 1993 Report to the Present.

- Double-shell tanks will no longer be used as feed for the Grout System because the Grout Project was canceled.

- Safety Initiative 2e, install a permanent mixer pump[4] 241-SY-101, was canceled.

- The schedule for completing ventilation upgrades in the 241-SY Tank Farm was changed from the 1993 report. This schedule milestone was changed from November 1993 to December 1994. Upgrades to the 241-SY Tank Farm include: 1) installation of inlet filters, 2) installation of the exhauster, and 3) replacement of the fan in the old K1 system. The first item has been completed, the second item is projected to be completed by March 1995, and the last item is scheduled for completion in August 1995. Upgrades via Project W-314 are discussed in Section 4.3.6.

[4]The mixer pump presently installed in the tank was originally referred to as a test pump, and it was to be replaced by a permanent pump, but the test pump works so well that the permanent pump will be retained as a spare.

4.1.1.2 Priority and Strategy. The strategy for resolving the Issue is to divide the tanks into groups for safety issue resolution and closure of the unreviewed safety question. The first group, consisting of six double-shell tanks, have somewhat similar chemistry; all of these tanks, except 241-AN-103, exhibit surface-level fluctuations and pressure increases characteristic of Tank 241-SY-101. These tanks may require mitigation.

The second group of tanks consists of nineteen single-shell tanks. There is relatively little information available on the behavior of waste stored in these tanks. Therefore, available data will be gathered, and new data obtained by installing monitoring equipment. All data will be evaluated to determine a course of action. It is highly unlikely that any single-shell tank will require mitigation. Waste behavior evaluations will likely only be used to develop methods to retrieve the waste for permanent disposal.

4.1.1.3 Work Completed to Date. Work completed prior to 1993 focused on understanding the cyclic venting of flammable gases phenomenon in Tank 241-SY-101. This included analyses of core samples of tank waste, laboratory studies, modeling studies, tank upgrades, developing mitigation alternatives, and preparing for a mitigation test in Tank 241-SY-101 using a mixer pump.

- A second core sample was obtained from Tank 241-SY-101. The core sample analysis results were documented in reports on waste chemistry and physical properties (Reynolds 1992). A data analysis report on Tank 241-SY-101 was also issued (Anantatmula 1992).

- A technical report was issued that closed out the issue of a potential for a crust burn in Tank 241-SY-101 (Fox et al. 1992).

- The Bureau of Mines study on the flammability of gas mixtures was issued (Cashdollar et al. 1992).

- Accident consequence criteria and requirements for resolving the flammable gas issue were documented (Christensen 1992).

- Excellent progress was made on modeling the behavior of Tank 241-SY-101 waste.

- Methods were developed to analyze Tank 241-SY-101 waste for chelating agents and to qualitatively identify low molecular weight degradation products.

- A high sensitivity mass spectrometer was installed and placed in routine operation in a Pacific Northwest Laboratory facility. Highly accurate analyses of gas samples from the vapor space of Tank 241-SY-101 are being obtained.

- A data interpretation report for Tank 241-SY-101 Window E core sample analysis was issued (Reynolds 1993), and Window criteria for operations in Tank 241-SY-101 were revised. ("Windows" were time periods following gas release events during which work could be safely performed in the tank.)

Work Completed Since the 1993 Report:

Major accomplishments for the Flammable Gas Safety Issue that have been completed recently are listed below.

- A mixer pump was modified, tested, and installed in Tank 241-SY-101 (Alleman et al. 1994 and Stewart et al. 1994a). Equipment necessary to support the mitigation test was also installed: a data acquisition and control system, two multi-functional instrument trees, and several gas monitoring systems. Four air lances and a bent thermocouple tree were also removed from the tank. Tank 241-SY-101 has been effectively mitigated by operation of the mixer pump since its installation in July, 1993.

- Safety Initiative 2g, evaluate contingency mitigation options, was completed.

- TPA Milestone M-40-15, install gas monitoring equipment in the remaining potentially Flammable Gas Watch List double-shell tanks, was completed for the six double-shell tanks in fiscal year 1994.

- Monitoring upgrades for the 241-SY Tank Farm were completed.

- Core sampling activities were completed for the first core for Tank 241-SY-103.

4.1.1.4 Work Required to Resolve the Issue. The flammable gas safety issue will be resolved when the hazards in the double-shell tanks are mitigated or the waste is removed and when analyses are complete for single-shell tanks, assuming the results show that single-shell tank mitigation is not required.

All twenty-five Flammable Gas Watch List tanks will be sampled and monitored, and the data will be analyzed and interpreted; ventilation systems and tank instrumentation will be repaired and upgraded to modern industrial standards. Current thinking is that while some of the double-shell tanks may require mitigation, none of the single-shell tanks will.

The following major equipment activities will be completed in fiscal year 1995:

- Ventilation system upgrades to tank the 241-SY tank farm will be completed in June, 1995.

- Gas monitoring cabinets will be installed on the nineteen single-shell tanks by April, 1995.

- Modern waste surface level gauges will be installed in the Flammable Gas Watch List tanks by September, 1995.

- TV cameras will be installed in all Flammable Gas Watch List double-shell tanks by September, 1995.

- Multifunctional instrument trees will be installed in all Flammable Gas Watch List double-shell tanks by September, 1995.

Other near-term plans include the following (Johnson and Sherwood 1994):

1. Continue mixer pump tests in Tank 241-SY-101.

2. Develop heating, dilution, and sonic mitigation methods.

3. Core sample double-shell Tanks 241-SY-103 and 241-AW-101. Core sampling Tank 241-SY-103 was performed in fiscal year 1994 and an interpretive report will be issued in fiscal year 1995.

Long-term plans focus on further evaluating and defining the flammable gas safety issue by obtaining further data on the waste tanks and their contents, developing tank safety criteria, and applying these criteria on a tank-by-tank basis. Current planning assumes that all six double-shell flammable gas tanks will require mitigation testing and mitigation, and that the nineteen single-shell tanks will not require mitigation.

Longer-term plans call for remediating the flammable gas hazards. In order to resolve the safety issue for the twenty-five flammable gas tanks, waste in all six double-shell tanks will be retrieved. Retrieval and treatment costs are funded by others. None of the nineteen single-shell tanks will be retrieved to resolve the safety issue, but some need to be pumped (funded by others) for the purpose of interim stabilization (removing drainable liquid).

4.1.1.5 Cost and Schedule. Resolution of the flammable gas safety issue is on the order of $280 million. This figure includes the costs of both hydrogen mitigation and the Waste Tank Flammable Fas Safety Program. Hydrogen mitigation is projected to be completed during fiscal year 2000 and the flammable gas safety issue resolved in fiscal year 2001. The resolution of this issue is not dependent on the availability of new double-shell tanks.

If remediation (out-of-tank resolution) is required to resolve the safety issue for some tanks, then additional costs would be incurred for retrieval, new double-shell tanks, and treatment in the Initial Pretreatment Module. The cost for retrieval, new double-shell tanks, and treatment are included in ADS TDDs 1210-3, W-211, Initial Tank Retrieval System; 1280-AA, W-236A, Multi-Function Waste Tank Facility; and 1280-AB, W-236B, Initial Pretreatment Facility, respectively. The capital construction cost for these new facilities is on the order of $700 million. Operating costs are estimated to be on the order of $300 million, for a total cost of about $1 billion to remediate the six Flammable Gas and seven Organic Watch List tanks (see Section 4.1.3, Potential for Runaway Organic Nitrate Reactions). These facilities would also be used to retrieve, store, and treat waste from single-shell tanks in support of the Tri-Party Agreement after Watch List tank waste is processed. Retrieval and treatment costs are included in the cost for resolving Safety Issue 2-7, Storage of High Level Waste in Tanks with No Secondary Containment. The cost of new double-shell tanks is included in Safety Issue 3-1, Insufficient Tank Storage Capacity to Handle Waste Resulting from Resolution of Existing Safety Issues.

The major milestones, excluding those completed, from the 1993 report and the *Tank Waste Remediation System Multi-Year Work Plan* (WHC 1994a) are shown in Table 4-3.

Table 4-3. Milestones Associated with Safety Issue 1-1.

Milestone	Description	Completion Date
T2B-95-141	Issue status report on gas monitoring data for double-shelled tanks (Tri-Party Agreement Milestone M-40-15)	01/95
T2B-95-107	Install gas monitoring equipment in the remaining potentially Flammable Gas Watch List tanks (Safety Initiative - 2h)	04/95
T2B-95-108	Expedite design and construction of a backup portable exhauster for Tank 241-SY-101 (Safety Initiative - 2f)	06/95
T2B-95-105	Close 241-SY tank farm flammable gas unreviewed safety question (Safety Initiative - 2l)	06/95
T2B-95-142	Issue interpretive report on Tank 241-SY-103 core sample data	06/95
T2B-95-156	Complete Tank 241-SY-103 initial void fraction and viscometer testing	06/95
T2B-95-138	Issue waste physical properties and behavior modeling report	07/95
T2B-95-143	Issue status report on gas monitoring data for single-shell tanks (Safety Initiative - 2h)	08/95
T2B-95-145	Recommend closure of 241-AW tank farm flammable gas unreviewed safety question	08/95
T2B-95-106	Replace ventilation fan in 241-SY farm to further reduce spark potential (Safety Initiative - 2k)	08/95
T2B-95-139	Issue report on gas generation studies	09/95
T2B-95-140	Issue report on gas retention and its affect on waste properties and relationship to gas release	09/95
T2B-95-144	Issue report on retained gas sampling of Tank 241-SY-101	09/95
T2B-95-157	Issue letter report on void/viscometer characterization of Tank 241-SY-101 and 241-SY-102 (Pacific Northwest Laboratory)	09/95
T2B-95-161	Complete Initial Tank 241-AW-101 void fraction and viscometer testing	09/95
T2B-96-369	Recommend 241-AN tank farm flammable gas unreviewed safety question for closure	02/96
T2B-96-301	Install permanent mitigation pump in Tank 241-SY-103	07/96
T2B-97-100	Complete vapor space monitoring for all Flammable Gas Watch List tanks (Tri-Party Agreement Milestone M-40-10)	01/97
--	Complete in-tank testing in Tank 241-AN-105	08/97
--	Install permanent mitigation pump in Tank 241-AW-101	05/98
--	Install permanent mitigation pump in Tank 241-AN-104	09/98
--	Recommend 19 single-shell tanks flammable gas unreviewed safety question for resolution (Close all unreviewed safety questions for double-shell tanks and single-shell tanks per Tri-Party Agreement M-40-09.)	09/98
--	Install Permanent Mitigation Pump in Tank 241-AN-105	05/99
--	Complete evaluation and definition of flammable gas tanks	09/00

Table 4-3. Milestones Associated with Safety Issue 1-1.

Milestone	Description	Completion Date
--	Recommend 19 single-shell tanks flammable gas safety issue for resolution	09/00
--	Install permanent mitigation pump in Tank 241-AN-103	11/00
--	Complete treatment of 241-SY farm tanks in Initial Pretreatment Module (mitigate/resolve tank waste safety issue for High Priority Watch List tanks, Tri-Party Agreement Milestone M-40-00)	09/01
--	Resolve safety issue	09/01

4.1.1.6 Alternate Strategies or Treatments. A large number of options were considered for mitigating (i.e., reducing the severity or intensity of the hazard) episodic release of flammable gas in waste tanks. A ranking of all concepts was conducted based on the following factors.

- Confidence in effectiveness of technology
- Potential risk reduction
- Risk of Implementation
- Complexity of data/prototype modeling requirements
- Implementation time required
- Operating time to achieve mitigation
- Maintenance, operational, and surveillance requirements
- Risk affecting waste disposal options.

The top four concepts selected for further evaluation were heating, dilution, sonic/ultrasonic agitation, and mixing with a horizontal jet pump. Report PNL-10105, *Assessment of Alternative Mitigation Concepts for Hanford Flammable Gas Tanks*, evaluates these four concepts in detail (Stewart et al. 1994b); only heating is considered not to be a viable technique. The sonic agitation concept would take substantially more development work to demonstrate its viability. Both mixer pumps and dilution are assured mechanisms for mitigation.

The mitigation option that is selected is expected to take one to two years to install and to complete safety and National Environmental Policy Act documentation on the proposed actions. Mixing pump systems will likely be used on other double-shell tanks if needed while ventilation systems would likely be used for the single-shell tanks. In the long term, the tanks could be passively mitigated by dilution, but new tank capacity would be required.

4.1.2 Safety Issue 1-2: Potentially Explosive Mixtures of Ferrocyanide

4.1.2.1 Background and Description. In the early 1950s, Hanford needed more tank space to support its ongoing defense mission. To rapidly obtain the additional storage volume while minimizing the need to build new tanks, Hanford scientists developed a process to reduce radionuclide concentrations in the free standing liquid tank wastes to levels low enough to permit disposal of the liquid to the soil. This process added a total of approximately 140 metric tons (154 tons) of ferrocyanide to the waste in some of the single-shell tanks. The ferrocyanide caused radionuclides (primarily cesium) dissolved in the liquid waste to precipitate (Sloat 1954 and Sloat 1955).

Ferrocyanide, in the presence of oxidizing material such as sodium nitrate and/or sodium nitrite, can be explosive under certain conditions, including dryness, proper chemical concentrations, and high temperatures. The explosive nature of ferrocyanide in the presence of an oxidizer has been known for decades, however the conditions and concentrations under which the compound can undergo endothermic and exothermic reactions had not been thoroughly studied.

Studies used in developing the ferrocyanide scavenging flowsheets did not include final disposal of ferrocyanide-containing solids. A report of a 1965 investigation on the stability of ferrocyanide waste material concluded that reactions between solid nitrate salts and ferrocyanides occur only at abnormally high concentrations of the constituents and at elevated temperatures, stating: "*There appears no possibility of a reaction with the 0.005 M concentrations specified in the flowsheet. An efficient method of destroying cyanide complexes even at low concentrations is being sought*" (GE 1965). The report of this study did not include the effects of subsequent evaporation and concentration. Furthermore, no rigorous inventory was kept for the ferrocyanide added to the tanks. Because the scavenging process precipitated ferrocyanide from solutions containing nitrate and nitrite ions, an intimate mixture of ferrocyanides and nitrates and/or nitrites is likely to exist in some regions of the ferrocyanide tanks.

Ferrocyanide as a safety issue first began when the Pacific Northwest Laboratory identified a possible safety problem involving potential explosive mixtures of ferrocyanide (Burger 1989; Burger and Scheele 1988). The potential consequences of a postulated ferrocyanide burn or explosion were not included in the single-shell tank farm safety analysis reports. Safety analysis reports historically considered an explosion from fuel/nitrate reactions as an incredible event and analyses of incredible events are not required to be addressed (WHC 1993a).

Other evaluations included those made by the U. S. Department of Energy (DOE 1987) and the General Accounting Office (Peach 1990). These evaluations had conflicting estimates as to the results of a worst-case accident.

In March 1989, Westinghouse Hanford Company identified 22 tanks as potentially containing 1000 g-mole (465 pounds) or more of ferrocyanide [as the $Fe(CN)_6^{-4}$ anion] (Nguyen 1989). These tanks were placed on the Ferrocyanide Watch List and were strictly controlled according to formal operating specifications for Watch List tanks (WHC 1994b). In September 1990, Westinghouse Hanford Company commissioned a special Hanford Site ferrocyanide task team to address all issues involving the ferrocyanide tanks. The Ferrocyanide Safety Issue was declared an unreviewed safety question in October 1990, because the potential consequences of a ferrocyanide reaction could be greater than those included in the single-shell tank safety analysis reports (Deaton 1990).

In March of 1990, the Defense Nuclear Facilities Safety Board issued Recommendation 90-3 to the U.S. Department of Energy, regarding storage of ferrocyanide bearing waste at the Hanford Site (DNFSB 1990b). The U.S. Department of Energy responded in August with an implementation plan. The Defense Nuclear Facilities Safety Board reviewed this implementation plan and concluded that it did not adequately respond to the recommendation. In October, the board strengthened its communication, issuing Recommendation 90-7 (DNFSB 1990a). In this recommendation the Defense Nuclear Facilities Safety Board recommended changes to the U.S. Department of Energy's Response Plan in six specific areas.

The U.S. Department of Energy responded in March 1991 with an implementation plan to Recommendation 90-7, which was accepted by the Defense Nuclear Facilities Safety Board that same month. The status of activities described in the implementation plan is included in Sections 4.1.2.3 and 4.1.2.4, below. These activities support an effort to resolve the Ferrocyanide Safety Issue, close Defense Nuclear Facilities Safety Board Recommendation 90-7, and comply with the Wyden amendment.

In order to accelerate the resolution of tank safety issues the Secretary of Energy issued 41 "Safety Initiatives" (O'Leary 1993). Three affect the Ferrocyanide Safety Issue. They are also described in the Section 4.1.2.3.

There are currently 18 single-shell tanks identified that potentially contain appreciable amounts of ferrocyanide precipitates (1,000 gram-moles [465 pounds] or greater). The criterion for being placed on the Watch List was changed in 1994 from the 1,000 g-mol (465 pounds) inventory to a fuel concentration of 115 cal/g of dry sample [this is an energy equivalent of 8 wt% $Na_2Fe(CN)_6$] (Postma et al. 1994a). The Watch List has not yet been revised to account for the new criterion. Tanks were placed on the Watch List because they could contain explosive mixtures of ferrocyanide (several of these tanks are also associated with other safety issues). There have been several changes in the number of ferrocyanide-containing tanks on the Watch List. Originally, in 1989, 22 tanks were listed for ferrocyanide content. In 1991, two more tanks were added to the list (Borsheim and Cash 1991). These 24 tanks were included in the report to the U.S. Congress mandated by the Wyden Amendment (DOE 1991a). Review of historical documents revealed that six of the 24 tanks did not contain the requisite 1,000 g-moles (465 pounds) of ferrocyanide (Borsheim and Simpson 1991). Subsequently, it was determined that these six tanks should not have been included on the Watch List nor been identified in the response to the Wyden Amendment. Four of the six tanks were removed from the Watch List in July 1993. The other two tanks were removed in December 1994.

Current Status: The following eighteen tanks are currently on the Ferrocyanide Watch List are listed in Table 4-4. They are suspected of originally receiving greater than 1,000 gram-moles of ferrocyanide.

Table 4-4. Ferrocyanide Watch list Tanks

241-BY-103	241-BY-108	241-C-109	241-TY-101
241-BY-104	241-BY-110	241-C-111	241-TY-103
241-BY-105	241-BY-111	241-C-112	241-TY-104
241-BY-106	241-BY-112	241-T-107	
241-BY-107	241-C-108	241-TX-118	

The estimated ferrocyanide content originally placed in these 18 tanks ranges from slightly greater than 1,000 gram-moles (465 pounds) to approximately 83,000 g-moles (38,600 pounds) in Tank 241-BY-104. The probability of an exothermic ferrocyanide nitrate/nitrate reaction jeopardizing tank integrity and putting the public at risk is extremely small for several reasons. First, the maximum temperature observed in any of the 18 ferrocyanide tanks is 53 °C (128 °F) (Hanlon 1995), which is well below the minimum temperature of 250 °C (482 °F) required for a propagating reaction. The moisture content of waste is likely to be great enough to prevent a propagating reaction from taking place, and extensive measures have been taken to greatly reduce the chance that a heat or ignition source could be introduced into the tanks. In addition, the tanks have followed a general cooling trend as the fission products in the waste continue to decay. In addition, experimental work conducted on ferrocyanide waste simulants has shown that hydrolysis and radiolysis will degrade the fuel value of the waste to insignificant levels (Lilga et al. 1993, 1994a, 1994b). This degradation has also shown for waste samples obtained from the highest concentration ferrocyanide tanks (Simpson et al. 1993a; 1993b).

4.1.2.2 Priority and Strategy. *Potentially Explosive Mixtures of Ferrocyanide* is a priority 1 safety issue because, if it could be initiated, a reaction in the waste could lead to onsite or offsite radiation exposure through an uncontrolled release of radioactive material. It is also one of the six most serious issues, according to the *Waste Tank Safety Program's Multi-Year Work Plan* (WHC 1994a).

A strategy for closing the ferrocyanide unreviewed safety question and resolving the safety issue was developed by the U.S. Department of Energy and Westinghouse Hanford Company and was presented to the Defense Nuclear Facilities Safety Board in August 1993 (Grumbly 1993). This strategy allowed the unreviewed safety question to be closed separately from the safety issue. The strategy contains two key steps:

1. Development of criteria to rank the hazard for each tank into one of three safety classes; *Safe, Conditionally Safe, and Unsafe*; and

2. Confirmation and final placement of each tank into one of the categories based on core sampling and analyses of the tank contents, thus resolving the safety issue.

The first step separates the unreviewed safety question from resolution of the safety issue. The criteria developed in step one identify safety classes, criteria for each class, and the technical basis for the criteria. Thus, when the hazard for each tank is assessed against the criteria and documented according to U.S. Department of Energy Order 5480.21, the unreviewed safety question was closed. Closing the unreviewed safety question is a milestone in resolving the ferrocyanide safety issue.

A safety classification of *Safe* implies that a significant reaction is not possible during interim storage. A safety classification of *Conditionally Safe* implies that the waste is safe on the condition that the moisture content be maintained at or above a minimum level. A safety classification of *Unsafe* implies that the possibility of significant reactions cannot be ruled out and a change in waste state is required to assure safe interim storage. The safety issue will be resolved by characterizing each tank and implementing any monitoring and controls needed to ensure operations are conducted within the *Safe* or *Conditionally Safe* levels. The safety criteria are presented in *Ferrocyanide Safety Program: Safety Criteria for Ferrocyanide Watch List Tanks* (Postma et al. 1994a).

4.1.2.3 Work Completed to Date. As mentioned earlier, there are three safety initiatives for accelerating ferrocyanide safety issue resolution. The status of each is summarized below.

- Define tank conditions required for safe storage of ferrocyanide wastes by December 1993.

This safety initiative was completed on December 1, 1993 per Westinghouse Hanford Company letter 9360203 (Harmon 1993). The conditions for safe storage are presented in *Ferrocyanide Safety Program: Safety Criteria for Ferrocyanide Watch List Tanks* (Postma et al. 1994a).

- Close the Ferrocyanide Unreviewed Safety Question by January 1994.

The unreviewed safety question was closed on March 1, 1994 per Department of Energy memorandum from T. P. Grumbly to the Manager of Richland Operations (Grumbly 1994).

- Complete installation of new thermocouples and continuous temperature monitoring systems in all ferrocyanide tanks by December 1994.

Progress has been made on the third safety initiative (see actions under temperature measurement and continuous temperature monitoring); however, the completion date has been delayed to September 30, 1995 as reflected in the Tri-Party Agreement milestones. This delay was requested to allow thermocouple tree installation in the remaining tanks to occur after the tanks are sampled, maximizing the number of risers available for taking core samples. This request was approved and a new milestone was issued for the installation of a total of seven instrument trees by September 30, 1995.

The Ferrocyanide Safety Program has issued a report on the potential consequences of a ferrocyanide - nitrate/nitrite explosion (Payne 1994a). This report addresses all the recommendations given in the General Accounting Office report. It summarizes the progress made to determine the potential for reactions in Hanford Site ferrocyanide tanks, and the conditions necessary to sustain an exothermic ferrocyanide reaction. Based on the results of the study, the Ferrocyanide Safety Program considers dose consequence calculations and aerosol experiments unwarranted. Westinghouse Hanford Company recommended that the General Accounting Office issue be closed, and this action is pending.

Activities of the Ferrocyanide Safety Program are aimed directly at closing the Defense Nuclear Facilities Safety Board Recommendation 90-7 and complying with the Wyden amendment. Work done in response to Recommendation 90-7 in the areas of Temperature Measurement and Continuous Temperature Monitoring also support requirements of the Wyden amendment. Recommendation 90-7 does not address pressure monitoring of the ferrocyanide tanks. The Wyden amendment indicates it may be necessary to continuously monitor the pressure in tanks that *"have serious potential for release of high-level waste."* Currently there are no plans to install continuous pressure monitors in the ferrocyanide tanks. Westinghouse Hanford Company submitted the rationale for not installing pressure monitors in ferrocyanide tanks to the U.S. Department of Energy in July 1994 (Payne 1994b). The Department of Energy concurred with this recommendation when it forwarded the revised program plan to the Defense Nuclear Facility Board in December 1994 (O'Leary 1994), which recommends that pressure monitoring of Ferrocyanide Watch List tanks not be required.

Work completed in the six areas identified in Defense Nuclear Facilities Safety Board Recommendation 90-7 (DNFSB 1990a) is described below:

1. Enhanced Temperature Measurement

In response to the Defense Nuclear Facilities Safety Board Recommendation 90-7.1, each ferrocyanide tank will be modified to have at least one instrument tree with replaceable thermocouples or resistance temperature detectors. The following activities have been completed:

- In fiscal years 1991 and 1992, 265 existing thermocouple elements were evaluated, of which 92 were repaired and returned to service.
- The first new instrument trees with replaceable temperature-sensing elements were installed in two ferrocyanide tanks in March 1993.
- Thermal modeling, completed in 1993 and 1994, has shown the formation of hot spots in ferrocyanide tanks is not credible (Dickinson et al. 1993; Epstein et al. 1994; McGrail 1994).
- Studies have shown infrared monitoring to be a useful technology for detecting temperature anomalies in a tank (Efferding et al. 1994), but infrared monitoring is not warranted because hot spots in the ferrocyanide tanks are incredible (Dickinson et al. 1993, Epstein et al. 1994).
- Installation of instrument trees in 10 non-leaking ferrocyanide tanks was completed in July 1993.
- A method was developed for installing instrument trees in assumed leaker tanks that minimizes water additions to the tank (Hertelendy 1993).
- Instrument trees were installed in two assumed leaker tanks in April and November 1994. Heated vapor sampling tubes have been included in the instrument trees for assumed leaker tanks.
- All additional instrument trees for assumed leaker tanks were fabricated.
- Thermal modeling was completed in 1994, demonstrating tank heat loads can be estimated from tank dome space temperatures (Crowe et al. 1993, McLaren 1994).
- A report analyzing possible waste dry-out mechanisms in passively-ventilated ferrocyanide tanks was completed in fiscal year 1994 (Epstein et al. 1994).
- Heat load analyses of all ferrocyanide tanks were completed in a final report which was issued in September 1994 (McLaren 1994).

- A report on the use of infrared scanning for temperature monitoring was issued in September 1994 (Efferding et al. 1994).

- A paper examining moisture monitoring technologies was completed in April 1993 (Meacham et al. 1993).

- Installation of two of seven instrument trees to be installed in fiscal year 1995 was completed in March 1995, completing Tri-Party Agreement Milestone M-40-02B.

2. Continuous Temperature Monitoring

In response to Defense Nuclear Facilities Safety Board Recommendation 90-7.2, temperature-sensing elements in each ferrocyanide tank will be connected to the Tank Monitoring and Control System. This system provides continuous monitoring of temperature-sensing elements. In addition, the system has the capacity to assign alarms for a change in the value of any temperature point. The alarms trigger an audible annunciator and are logged immediately to hard copy. Actions completed to close this recommendation will include:

- All Ferrocyanide Watch List tanks have been connected to the Tank Monitor and Control System. Each tank has at least one instrument tree connected to the system. Temperature readings from the working thermocouple elements in these tanks are recorded continuously.

- Recommendation 90-7.2 will be considered closed when all instrument trees, including the seven to be installed in fiscal year 1995, are connected to the Temperature Monitoring Control System (Tri-Party Agreement Milestone M-40-02).

3. Cover Gas Monitoring (Tank Vapor Space)

In response to Defense Nuclear Facilities Safety Board Recommendation 90-7.3, the dome spaces of each ferrocyanide tank will be sampled for flammable gases. Tasks completed towards closing this recommendation are:

- The dome spaces of all 18 ferrocyanide tanks have been sampled. All of the tanks had vapor composition less than 5% of the lower flammability limit. Furthermore, all but three tanks had vapor composition less than 1% of the lower flammability limit (Meacham et al. 1995).

- A July 1994 report concluded that continuous vapor space monitoring in ferrocyanide tanks is not warranted (Fowler and Graves 1994).

- Recommendation 90-7.3 will be considered closed when all 18 tanks have been vapor sampled using heated sampling tubes. This milestone is scheduled for September 30, 1995.

4. Ferrocyanide Waste Characterization

In response to Defense Nuclear Facilities Safety Board Recommendation 90-7.4, each ferrocyanide tank will be sampled and characterized. Although the recommendation indicates that two core samples are too few for characterization, the Waste Tank Ferrocyanide Safety Program has demonstrated the adequacy of two core samples through the Data Quality Objectives Process (Meacham et al. 1994a). Actions taken towards closing this recommendation include:

- Three ferrocyanide tanks have been sampled and characterized (DiCenso et al. 1995; Valenzuela and Jensen 1994; Sasaki and Valenzuela 1994, Simpson et al. 1993a, 1993b).
- The sampling schedule for the Hanford Site tanks has been revised to give priority to the Watch List tanks.
- A report documenting analyses of simulated U Plant and In Farm wastes was issued by Westinghouse Hanford Company in January 1993 (Jeppson and Wong 1993).
- A report on the chemical and physical properties of simulated T Plant waste was issued in July 1994 (Fauske and Jeppson 1994).
- Saltcake samples were obtained from Tank 241-BY-104 in 1993 (Neskas and Borsheim 1993).
- Pacific Northwest Laboratory has developed two methods based on infrared spectroscopy and ion chromatography to determine tank waste chemical composition (Bryan et al. 1993, 1994).

Key findings in characterizing two 241-C farm ferrocyanide tanks include the following (Simpson et al. 1993a; 1993b):

- The waste material contains appreciable moisture content [enough to suppress a propagating reaction based on the fuel (ferrocyanide) content of the tank].
- The fuel (ferrocyanide) is such that the waste will not support a propagating exothermic reaction, even when dry.
- The bulk of the precipitated ferrocyanide has degraded and the ^{137}Cs is still retained in the solids. Therefore, the ^{137}Cs may be present as sodium cesium nickel ferrocyanide [$NaCsNiFe(CN)_6$].

The significance of these findings is that the ferrocyanide is degrading to less energetic compounds, reducing the potential hazard associated with the tank. Further, the fuel content of these two tanks suggests that these two tanks are safe. The moisture content for these two tanks is also great enough to suppress any ferrocyanide - nitrate/nitrite exothermic reaction regardless of the fuel concentration. The findings from these two tanks cannot be generalized to all ferrocyanide tanks; however, they do suggest that the ferrocyanide wastes are becoming less hazardous as time progresses and that these wastes can be safely stored until final disposal.

Samples from Tank 241-T-107 also confirmed that no fuel is present in this Tank (Neskas and Borsheim 1993). This tank is also considered to be in the *safe* category.

Recommendation 90-7.4 will be considered close when a sufficient number of ferrocyanide tanks have been sampled and the waste analyzed to verify that ferrocyanide does degrade with time under tank storage conditions. The end milestone for completion of ferrocyanide tank waste characterization is June 27, 1997.

5. Ferrocyanide Chemical Reaction Studies

Chemical reaction studies of simulated ferrocyanide wastes are continuing in response to Defense Nuclear Facilities Safety Board Recommendation 90-7.5. Studies of simulated ferrocyanide wastes have been conducted by Westinghouse Hanford Company, Fauske and Associates Inc., Pacific Northwest Laboratory, Los Alamos National Laboratory, and Washington State University. Actions completed in support of closing this recommendation include:

- Los Alamos National Laboratory completed chemical reaction sensitivity tests on simulated ferrocyanide wastes to identify what events might cause a reaction to occur (Cady 1993).
- A report on the chemical and physical analyses on simulated T Plant waste was issued in 1994 (Fauske and Jeppson 1994).
- Westinghouse Hanford Company and Pacific Northwest Laboratory have produced flowsheet simulated wastes for testing (Jepson and Wong 1993, Scheele et al. 1994).
- Fauske and Associates, Inc. are conducting adiabatic calorimetry and propagation tests on the simulated flowsheet materials (Fauske 1992; 1993a, 1994).
- Fauske and Associates, Inc. have also studied aerosols, potential hot spots, and waste rheology (Fauske 1993b; Epstein and Fauske 1994; Epstein et al. 1993).
- Washington State University completed real time x-ray diffraction studies with stoichiometric mixtures of sodium nickel ferrocyanide with sodium nitrate/nitrite heated to reaction temperatures and above (Dodds and Thomson 1994).

Pacific Northwest Laboratory completed chemical reaction studies in the following areas:

- A report on the effects of catalysts, initiators, and other fuels was issued in 1993 (Scheele et al. 1993a).
- A report on the concept of ferrocyanide waste aging was issued in 1993 (Lilga et al. 1993). Additional aging of simulated ferrocyanide wastes was investigated in fiscal year 1994 (Lilga et al. 1994a; 1994b).

- Reports on cyanide speciation were issued in 1993 and 1994 (Bryan et al. 1993; 1994).

- Tests were performed on the solubility of sodium-cesium nickel ferrocyanide compounds in caustic waste solutions (Rai et al. 1994).

- Reports were issued that investigated the concept of mixing at the solid-liquid interface (microconvection) of non-agitated ferrocyanide tanks (McGrail et al. 1993; McGrail 1994).

Many of the tasks completed in 1993 and 1994 are parts of tasks that continue into 1995 and 1996.

6. Emergency Response Planning

In support of closing Defense Nuclear Facilities Safety Board Recommendation 90-7.6, Westinghouse Hanford Company prepared an *Action Plan for Response to Abnormal Conditions in Hanford Radioactive Waste Tanks Containing Ferrocyanide* (Cash and Thurman 1991a; 1991b; Fowler 1994). This document, along with the *Tank Farm Stabilization Plan for Emergency Response* (WHC 1991a) issued by Westinghouse Hanford Company in 1991, closes Recommendation 90-7.6 provided that abnormal conditions response plans and emergency plans are (1) reviewed on a periodic basis; (2) revised and updated as required to incorporate any additional controls determined appropriate by the ongoing Waste Tank Safety Program investigations; and (3) validation exercises for various waste tank accident scenarios are conducted.

4.1.2.4 Work Required to Resolve the Issue. This safety issue will be resolved when the unreviewed safety question is closed (already complete), the third safety initiative is closed [complete installation of new thermocouples and continuous temperature monitoring systems in all ferrocyanide tanks by December 1994 (delay approved to September 1995)], and the Defense Nuclear Facility Safety Board recommendations are closed. Actions planned to close the recommendations are listed below.

The following work is planned to close Recommendation 90-7.1:

- Install instrument trees in seven remaining assumed leaker ferrocyanide tanks by end of fiscal year 1995.

- Continue development, demonstration, and implementation of a tank moisture monitoring capability. Currently the Ferrocyanide Safety Program is pursuing neutron diffusion and electromagnetic induction for this purpose.

Activities planned to close Recommendation 90-7.2 are:

- Connect nine new instrument trees to the Tank Monitor and Control System.

Planned work to close Recommendation 90-7.3 includes:

- Sample for flammable and noxious gases, as required, to support planned core sampling and instrument tree installation.

- Continuous gas monitoring is not required (Meacham et al. 1995).

Actions planned to close Recommendation 90-7.4 are:

- Sample remaining ferrocyanide tanks by March 1997.

- Issue a report on water loss as a function of relative humidity.

- Continue development of Fourier transformed infrared spectroscopy for use in laboratory measurements.

The latest schedule for obtaining and analyzing samples from the ferrocyanide tanks and interpreting the data is given in Table 4-5.

Table 4-5. Sampling and Analysis Schedule for the Ferrocyanide Tanks.

Activity	Completion Date
Secure rotary-core samples from ferrocyanide Tank 241-BY-106	in progress
Obtain core and/or auger samples from three ferrocyanide tanks	06/95
Complete data interpretation reports, available for public release, for three ferrocyanide tanks	09/95
Obtain core samples for five ferrocyanide tanks	06/96
Complete data interpretation reports, available for public release, for five ferrocyanide tanks	09/96
Obtain core samples from the remaining ferrocyanide tanks	03/97
Complete data interpretation reports, available for public release, for the remaining ferrocyanide tanks	06/97

The schedule to sample all tanks by March 1997 is inconsistent with the schedule presented by the U.S. Department of Energy in its Recommendation 93-5 Implementation Plan, which responded to another recommendation by the Defense Nuclear Facilities Safety Board, (Recommendation 93-5). This recommendation called for accelerated sampling and characterization efforts of the Hanford Site tanks. However, the March 1997 completion is the best estimate of what can be achieved, and is consistent with the new integrated characterization schedule finalized in September 1994 (Stanton 1995).

The following work is planned to close Recommendation 90-7.5:

Work will be completed by Pacific Northwest Laboratory in the following areas:

- Cyanide speciation by July 1995,

- Ferrocyanide waste aging by September 1995, and

- Comparing selected chemical and physical parameters of simulated ferrocyanide waste with actual tank waste by September 1995.

In addition to the work by Pacific Northwest Laboratory, studies by Fauske and Associates, Inc. will continue in the areas of calorimetry and reaction propagation and water loss with time for various tank relative humidities. Fauske and Associates, Inc. work is scheduled for completion in fiscal year 1996.

4.1.2.5 Cost and Schedule. The estimated total cost to resolve the Ferrocyanide Safety Issue is 29.3 million dollars. The Ferrocyanide Safety Program is expected to end at the end of fiscal year 1998. Major milestones established by the Waste Tank Ferrocyanide Safety Program to remove ferrocyanide tanks from the Watch List are shown in Table 4-6.

Table 4-6. Milestones for Removal of Ferrocyanide Tanks from the Watch List.

Milestone	Description	Completion Date
TBD-96-118	Issue documentation supporting and recommending resolution of the ferrocyanide safety issue for the four 241-C Farm tanks	01/96
--	Obtain U.S Department of Energy approval to resolve the ferrocyanide safety issue for 241-C Farm tanks	07/96
TBD-97-116	Issue documentation supporting and recommending closure of the ferrocyanide safety issue for the remaining tanks	03/97
--	Obtain U.S. Department of Energy approval to resolve the ferrocyanide safety issue. End of Ferrocyanide Safety Program, unless in situ pressure monitoring and infrared monitoring are required.	09/97

Lower level milestones for fiscal years 1995 through 1997 and possibly 1998, are identified in the *Tank Waste Remediation System Multi-Year Work Plan* (WHC 1994a) and the *Program Plan for Resolution of the Ferrocyanide Waste Tank Safety Issue at the Hanford Site* (O'Leary 1994). They are shown in Table 4-7.

Table 4-7. Milestones Associated with Safety Issues 1-2.

Milestone	Description	Completion Date
T2B-94-490	Install two of seven thermocouples in ferrocyanide tanks (TPA M-40-02B)	04/95
T2B-95-133	Transmit quarterly progress reports	07/95
T2B-95-112	Transfer cyanoferrate speciation technology to analytical laboratories	07/95
T2B-95-118	Implement moisture monitoring for ferrocyanide tanks with existing liquid observal wells using dual neutron probe	09/95
T2B-95-114	Issue report on ferrocyanide aging studies	09/95
T2B-95-115	Issue report on moisture retention modeling of ferrocyanide waste	09/95
T2B-95-123	Transmit data interpretation reports for three ferrocyanide tanks	09/95
T2B-95-100	Upgrade temperature monitoring capabilities in ferrocyanide tanks (TPA M-40-02)	09/95

Table 4-7. Milestones Associated with Safety Issues 1-2.

Milestone	Description	Completion Date
T2B-95-113	Install new thermocouples trees and hookup to Tank Monitor and Control Systems in remaining ferrocyanide tanks (TPA M-40-02)	09/95
T2B-95-120	Complete engineering testing and in-tank application of electromagnetic induction moisture monitoring system and provide report	09/95
T2B-96-114	Transmit quarterly progress reports	07/96
T2B-95-104	Implement electromagnetic induction probe surveillance system	09/96
T2B-96-103	Provide interpretation reports for neutron probe moisture measurements	09/96
T2B-96-105	Transmit data interpretation report for five ferrocyanide tanks	09/96
T2B-96-111	Implement moisture monitoring for ferrocyanide tanks using dual neutron probe	09/96
T2B-97-106	Transmit data interpretation for remaining ferrocyanide tanks	06/97
T2B-97-111	Transmit quarterly progress reports	07/97
T2B-96-102	In-situ infra-red camera design upgrade surface measurements	09/97
T2B-97-103	Provide interpretation report for neutron probe measurement scans	09/97
T2B-97-104	Complete installation of liquid observation wells in ferrocyanide tanks	09/97
T2B-97-105	Provide routine interpretation of electromagnetic induction probe moisture measurements	09/97
T2B-97-330	Implement moisture monitoring capabilities for all ferrocyanide tanks	09/97
	Resolve safety issue	09/98

4.1.2.6 Alternate Strategies or Treatments. Alternatives considered for resolving the Ferrocyanide Safety Issue include leaving the tanks "as is," installing monitoring or moisture controls, or removing the waste for treatment. Actions taken depend on the results of studies that are verified and thoroughly peer reviewed.

4.1.3 Safety Issue 1-3: Potential for Runaway Organic Nitrate Reactions

4.1.3.1 Background and Description. Twenty of Hanford's single-shell tanks may contain significant concentrations of organic chemicals (e.g., total organic carbon content of more than 3 wt.% on a dry basis) mixed with nitrate/nitrite salts. Accurate concentrations and chemical compositions for the organic materials are not known at present. Concentrated mixtures of organics with nitrate/nitrite salts could support an exothermic reaction at temperatures above approximately 200 °C (392 °F) (Fauske 1993c). If the waste in the tanks was overheated, the tank integrity may be compromised and radioactive materials may be released to the environment.

Hanford single-shell tanks contain mainly inorganic salts. However, some organic chemicals used in the plutonium and uranium separation processes were disposed to the single-shell tanks. Organic complexants, normal paraffin hydrocarbon, and tributyl phosphate are the major organic species in the tank wastes. These organics are in intimate contact with excess quantities of inorganic salts, such as sodium nitrate and sodium nitrite. One tank, 241-C-103, contains a separate organic layer that floats on top of the remaining waste. The potential danger of mixing organic wastes with oxidizing salts was recognized as early as 1967 when Battelle Northwest Laboratories surveyed B Plant wastes for explosive hazards (Phillips 1967). The stability of organic materials in single-shell tank salt cake waste was investigated in 1976 by the Atlantic Richfield Hanford Company, which found the salt cake to be stable against exothermic reactions (Beitel 1976). Limited explosive studies, performed by Beitel in 1977 with the organic complexant N-hydroxyethyl-ethylenediaminetriacetic acid and sodium nitrate, indicated the mixture was not explosive at temperatures encountered in waste storage.

In 1989, information was released about an industrial accident at Kyshtym, U.S.S.R. in which a nuclear waste storage tank containing sodium nitrite and sodium acetate exploded, causing widespread contamination. This report prompted additional investigation at Hanford. In 1990, Westinghouse Hanford Company investigated both the possible existence of explosive mixtures of organics and oxidizing salts in waste storage tanks, and the reactivity of mixtures containing various proportions of sodium acetate, sodium nitrate/sodium nitrite, and diluents (Fisher 1990). This investigation defined an upper limit of 3 wt% total organic carbon constituents in the waste (Fisher 1990). In 1991, this limit was applied to available information on Hanford's 149 single-shell tanks. Based on this screening, seven tanks were identified as having total organic carbon greater than 3 wt% and were placed on the Organic Watch List.

The 3 wt% total organic carbon limit was not applied to double-shell tanks because the double-shell tank wastes are mostly liquid. There are no credible organic safety issues identified for tanks that contain mostly liquid or dilute aqueous solutions. The safety concern affects tanks that primarily contain solids because they could dry out, heat up, and reach a temperature sufficient to initiate a self propagating exothermic reaction.

Since 1991 the Organic Watch List has undergone several revisions. Tanks 241-T-111 and 241-U-111 were added to the Watch List on February 28, 1994 and August 31, 1993 respectively because historical documentation was found indicating total organic carbon greater than 3 wt%. Ten more tanks were added to the Organic Watch List during May 1994. The bases for the adding each of these tanks are given below (Turner 1994a):

- Tanks 241-AX-102, 241-U-203, and 241-U-204 may contain total organic carbon equal to or greater than the 3.0 wt% criterion used to develop the Organic Watch List. The estimated total organic carbon content for the waste in these single-shell tanks was derived from a Pacific Northwest Laboratory study, *Organic Carbon in Hanford Single-Shell Tank Waste* (Toth et al. 1994).

- Tank 241-C-102 has been treated as an Organic Watch List tank since December 1993. Westinghouse Hanford Company added this tank to the Organic Watch List due to suspicion that the tank may have formerly contained a floating organic liquid layer.

- The remaining six tanks, 241-A-101, 241-S-111, 241-SX-103, 241-TY-104, 241-U-103, and 241-U-105, appear to have been candidates for the Organic Watch List when the Watch List was originally developed during 1991. These tanks were inadvertently not included on the Watch List at that time.

On September 21, 1992, an unreviewed safety question was declared concerning the floating organic layer in Tank 241-C-103 (WHC 1992b). The existence of this separate organic phase was declared an unreviewed safety question because the consequences of this floating layer igniting and burning had not been fully analyzed and documented in a safety analysis report. The unreviewed safety question was closed on May 19, 1994 when the Department of Energy approved documentation of the technical bases for unreviewed safety question closure. The tank remains on the Organic Watch List because the organic safety issue has not yet been resolved.

Five safety initiatives were established by the Department of Energy to accelerate resolution of the Organic safety issue. They are:

- **Safety Initiative 2i**, resolve the flammability issues on Tank 241-C-103 by January 1994;

- **Safety Initiative 2j**, close Tank 241-C-103 unreviewed safety question by January 1994;

- **Safety Initiative 2q**, complete sampling and safety evaluation of liquid organic in Tank 241-C-103 by March 1994;

- **Safety Initiative 2t**, install new thermocouples and continuous temperature monitoring systems in all organic tanks by March 1995;

- **Safety Initiative 2u**, remove the organic layer from Tank 241-C-103 by March 1995.

The first three safety initiatives have been completed. A request to delay the completion date for the fourth safety initiative has been made. A decision on the request is pending. The delay will provide time to determine which tanks belong on the Organic Watch List. The majority of suspected organic tanks will be characterized by December 1996 and, if needed, the Organic Watch List will be revised by December 31, 1996. The request to delay Safety Initiative 2t reflects this schedule.

A change to Safety Initiative 2u has also been approved. This request reflects the results of recent studies showing the safety concerns driving removal of the organic layer are greatly reduced. Rather than removing the organic layer, the request is to make a decision by May 1995 (Postma et al. 1994b) on whether to remove the organic. The decision will address a new concern about interim stabilization of the tank with the organic layer left in place. (Interim stabilization involves pumping out the supernatant and interstitial liquids from single-shell tanks in order to reduce the consequences in case of a leak.)

The tanks shown in Table 4-8 are currently on the Organic Watch List. They are suspected of containing greater than 3 wt% total organic carbon, or are associated with a floating organic layer.

Table 4-8. Organic Salts Watch List Tanks.

241-A-101	241-S-102	241-TX-105	241-U-106
241-AX-102	241-S-111	241-TX-118	241-U-107
241-B-103	241-SX-103	241-TY-104	241-U-111
241-C-102	241-SX-106	241-U-103	241-U-203
241-C-103	241-T-111	241-U-105	241-U-204

The probability of a runaway exothermic organic-nitrate reaction is very small. The temperature necessary to initiate a reaction, 200 °C (392 °F), is well above the most recently recorded highest organic tank temperature, observed in Tank 241-A-101, of 68.3 °C (155 °F) (Hanlon 1995). In addition, it is suspected that the moisture content of the organic waste in the Hanford Site single-shell tanks is likely to be great enough to prevent a propagating organic nitrate/nitrite reaction (Babad and Turner 1993). Extensive measures have been taken to protect these tanks from external heat or ignition sources. The energy content of the tank waste continues to decrease with time because the organic species are degrading to less reactive species. The temperature in the tanks is also decreasing due to decay of fission products in the waste.

The total organic carbon content of the 20 single-shell tanks on the Organic Watch List ranges from 3.01 wt% for Tanks 241-U-203 and 241-U-204 to 14.1 wt% for Tank 241-U-111 (Toth et al. 1994).

The unfiltered airflow passages to Tanks 241-SX-103 and 241-SX-106 are being upgraded under the scope of Project W-314: Tank Farm Upgrade System. The cost and schedule for Project W-314 are discussed in Section 4.3.6.

4.1.3.2 Priority and Strategy. Potential for runaway organic-nitrate reactions is a Priority 1 safety issue because, if it could be initiated, a reaction in the waste could lead to onsite or offsite radiation exposure through an uncontrolled release of radioactive material. It is also the third of the six most serious issues, according to the *Tank Waste Remediation System Multi-Year Work Plan* (WHC 1994a).

The strategy for closing the Tank 241-C-103 organic unreviewed safety question and resolving the organic safety issue is based on the strategy developed by Waste Tank Ferrocyanide Safety Program (see Section 4.1.2.2). The strategy contains two key steps:

1. Develop criteria that rank the hazard for each tank into one of three safety classes: *safe, conditionally safe, and unsafe*; and

2. Evaluate and place each tank in one of the categories based on core sampling and analyses of tank contents.

The criteria developed in step one identify safety classes, criteria for each class, and the technical basis for the criteria. A safety classification of *safe* implies that significant reaction is not possible during interim storage. A safety classification of *conditionally safe* implies that the waste is safe on the condition that moisture content be maintained at or above a minimum level. A safety classification of *unsafe* implies that the possibility of significant reactions cannot be ruled out and a change in waste state is required to assure safe interim storage. The Organic Safety issue will be resolved when a tank can be characterized as *safe* or *conditionally safe*. Monitoring and controls will be implemented to ensure operations are conducted within the *safe* or *conditionally safe* levels.

The Waste Tank Organic Safety Program has developed a phased approach to defining and applying the criteria for safety classification. Presently the tanks on the Organic Watch List for high organic content have been screened against "interim" safety criteria. The interim safety criteria will be upgraded to "preliminary" safety criteria by January 31, 1995. The preliminary safety criteria will be applied to all 149 Hanford Site single-shell tanks and, if needed, the Organic Watch List will be revised. The preliminary safety criteria will be upgraded to "safety criteria" by December 2, 1996. Once again the safety criteria will be applied to all 149 single-shell tanks and the Watch List revised.

This phased approach allows use of results obtained from waste characterization and surrogate and simulated waste studies to develop safety criteria. Interim criteria are based primarily on results obtained from waste surrogate studies. Preliminary criteria will use the results from studies of surrogate wastes and available characterization results. The final safety criteria will incorporate data from simulated wastes and tank waste characterization. Thus the phased approach to safety criteria and Organic Watch List revisions allows the Watch List to accurately reflect tanks that "*have a serious potential for release of high-level waste due to uncontrolled increases in temperature or pressure.*" The interim safety criteria are documented in *Interim Criteria For Organic Watch List Tanks at the Hanford Site* (Babad and Turner 1993).

Strategy or resolution of Tank 241-C-103 floating organic layer safety issues. Tank Waste Remediation System Safety Analysis and Engineering will complete three safety analyses which will then be reviewed by the United States Environmental Protection Agency, the Washington State Department of Ecology, and the Department of Energy Richland Field Office. Based upon their review of these safety analyses, a decision will be made as to the preferred path forward for the resolution of 241-C-103 safety issue. The three safety analyses to be performed are:

- Disposal of the floating organic layer to the 242-A evaporator.
- Interim stabilization of Tank 241-C-103 with the organic layer in place.
- Removal of the floating organic layer from Tank 241-C-103 and the transfer of the organic to a dedicated aboveground storage tank.

The safety analysis relies heavily upon data from waste simulant analysis, actual tank waste sample analysis, and an unreviewed safety question evaluation on interim stabilization of non-stabilized Organic Watch List tanks. The unreviewed safety question evaluation will also be performed by Tank Waste Remediation System Safety Analysis and Engineering. Tank 241-C-103 was core sampled in 1994 and 1995, and Pacific Northwest Laboratory is currently analyzing the samples. Pacific Northwest Laboratory has also completed simulant waste studies investigating the likelihood of organics be adsorbed onto the surface sludge particles during stabilization and Fauske and Associates, Inc., have investigated the combustibility of the adsorbed organics. In addition, Science Applications International Corporation has completed an engineering study on the technical feasibility of disposing the organic liquid to the 242-A Evaporator system.

The preferred path forward is anticipated to be one of three alternatives; interim stabilization of the tank with the organic layer in place, removal of the organic layer to a double-shell tank prior to interim stabilization, or removal of the organic layer to a dedicated above ground storage tank prior to interim stabilization. If the decision is that the organic liquid does not need to be removed before stabilization, then interim stabilization of Tank 241-C-103 will proceed as planned. If the organic liquid must be removed before interim stabilization, and it is acceptable to pump to a double-shell tank, transfer of the floating organic layer to a double-shell tank will be completed by July 1996. If the organic liquid must be removed before interim stabilization, and it is not acceptable to pump to a double-shell tank, removal of the floating organic layer to a dedicated above ground storage tank will be completed by December 1996.

4.1.3.3 Work Completed to Date. The Waste Tank Organic Safety Program has aggressively pursued the resolution of the Organic Safety Issue. Major accomplishments in several key areas are listed below.

Activities completed to identify and document Organic Watch List tanks are:

- Interim criteria were defined for organic tanks to determine requirements for placing tanks on the Organic Watch List (Babad and Turner 1993).
- The 149 Hanford single-shell tanks were reassessed against the interim criteria to update the Organic Watch List (Turner 1994a).
- Data Quality Objectives for the Waste Tank Organic Safety Program were issued (Turner et al. 1994b).

Activities completed to close the Tank 241-C-103 Floating Organic Layer Unreviewed Safety Question are:

- A Justification for Continued Operation and an Environmental Assessment were completed to support Tank 241-C-103 vapor and supernatant sampling (Carothers 1993).
- An analytical plan for the Tank 241-C-103 supernatant sample was prepared using the data quality objective process (Wood et al. 1993).
- An analytical plan was prepared for vapor gas sampling using the data quality objective process (Osborne et al. 1994).
- Tank 241-C-103 has had vapor and liquids sampled and is in the process of having core samples taken. Analytical reports for liquid and vapor sampling activities were issued.
- Tank 241-C-103 Vapor Sample Analyses were completed for the January 1994 Sampling (Huckaby 1994a).
- Analyses of Liquid Samples from Hanford Waste Tank 241-C-103 were completed (Pool and Bean 1994).

- A report on the flammability of Tank 241-C-103 was issued (Huckaby 1994b). This report resolved the flammability issue safety initiative for Tank 241-C-103 (Fulton 1994).

- Tank 241-C-103 Safety Analysis was completed to support unreviewed safety question resolution.

- Safety Initiative 2g, complete sampling and safety evaluation was completed on March 31, 1994 (Grigsby 1994).

The unreviewed safety question for Tank 241-C-103 was closed on May 19, 1994 per a Department of Energy Headquarters memorandum from T.P. Grumbly to the Richland Manager for the Department of Energy. A Westinghouse Hanford Company document, *Safety Analysis of Exothermic Reaction Hazards Associated With Organic Liquid Layer in Tank 241-C-103* (Postma et al. 1994b) establishes the technical basis for closing the unreviewed safety question associated with the floating liquid organic layer in Tank 241-C-103.

Activities completed to upgrade instrumentation and monitoring capabilities in the organic tanks are:

- A new thermocouple tree was installed in one organic tank (241-TX-118) on July 30, 1993 as part of the Waste Tank Ferrocyanide Safety Program (Tank 241-TX-118 is also a ferrocyanide tank).

Chemical reactivity and waste energetics studies completed on surrogate and simulated wastes are:

- Tests of organic waste surrogate energetics were completed by the U.S. Bureau of Mines (Turner and Miron 1994) and Fauske and Associates, Inc. (Fauske 1993c).

- Studies of sodium acetate - sodium nitrate/nitrite waste surrogate equilibrium moisture content were completed by Fauske and Associates, Inc. (Babad and Turner 1993).

The following work has been completed by Pacific Northwest Laboratory in support of the Waste Tank Organic Safety Program:

- A high resolution mass spectrometer was installed and calibrated in Fiscal Year 1993.

- A report was issued (Campbell et al. 1994) documenting progress made in developing analytical methods to support organic waste characterization.

- A report was issued detailing a multi-year plan for simulated waste chemical reactivity studies (Scheele 1993b).

- A multi-year work plan for waste aging studies was issued (Camaioni and Samuels 1993).

- A report was issued on mechanisms that could concentrate waste constituents and increase the likelihood of a propagating reaction (Gerber et al. 1992).

- A multi-year work plan for investigating organic concentration mechanisms was developed (Gerber 1993).

- To prepare for waste aging studies, a literature search was completed on the effects of radiolysis and/or oxidation on waste organics and their analogs.

- Waste aging studies were begun.

- A report was prepared in which available data on tank organic content were used to predict the organic content of tanks for which no data were available (Toth et al. 1994).

4.1.3.4 Work Required to Resolve the Issue. This safety issue will be closed when all of the safety initiatives are closed (two are remaining), the tanks are screened against the final safety criteria, and any required monitors or controls are installed. Planned actions are listed below:

- Issue an update to the Waste Tank Organic Safety Program Plan.

- Complete Hazards Analysis for Organic Watch List tanks (except Tank 241-C-103).

- Use results from simulant waste studies and sampling activities to develop revised safety criteria.

- Issue preliminary safety criteria for Organic Watch List tanks by January 31, 1995

- Revise Organic Watch List - Based on preliminary safety criteria by February 28, 1995.

- Issue updated organic data quality objectives by March 1995.

- Complete organic data quality objectives analysis for all Organic Watch List tanks by December 1995.

- Perform safety screening data quality objectives analysis on all Organic Watch List tanks by September 1995.

- Issue final safety criteria for Organic Watch List tanks by December 2, 1996.

- Revise Organic Watch List based on final safety criteria by December 31, 1996.

- Characterize (i.e., issue data reports for core samples) all Organic Watch List tanks by June 1997.

- Issue engineering study on retrieval and disposal of Tank 241-C-103 organic layer.

- Issue an engineering study of technology available for moisture monitoring and control by March 1995.

- Select a concept for moisture monitoring and control from engineering study and perform a two year moisture monitoring and control demonstration to be completed by December 1998.

- Perform unreviewed safety question screening for tanks suspected of formerly holding floating organic layers (currently 4 tanks).

- Complete instrumentation upgrades in organic tanks by September 1997 (pending approval of change to safety initiative completion date).

- Pacific Northwest Laboratory will support the Waste Tank Organic Safety Program by continuing research efforts in the following areas:
  - waste aging studies
  - organic concentration mechanism studies
  - development of organic analytical methods
  - organic simulated-waste energetics studies.

4.1.3.5 Cost and Schedule. The cost for the Waste Tank Organic Safety Program through fiscal year 1999 is estimated at 90 million dollars. The organic safety is scheduled to be resolved by September 30, 2001. However, budgets have not been projected beyond fiscal year 1999. Milestones established by the Waste Tank Organic Safety Program to resolve the Organic Safety issue are given below in Table 4-9 (WHC 1994a).

Table 4-9. Milestones Associated with Safety Issue 1-3.

Milestone	Description	Completion Date
T2B-95-132	Issue preliminary safety criteria for Organic Watch List tanks	01/95
T2B-95-127	Revise Organic Watch List based on preliminary safety criteria	02/95
T2B-95-110	Safety initiative 2u, complete removal of organic layer from Tank 241-C-103	03/95
T2B-95-129	Complete engineering study -- moisture monitoring/control demonstration	03/95
TW2-94-455	Issue data interpretation report on Tank 241-C-103 core sample	03/95
T2B-95-117	Reach decision to interim stabilize Tank 241-C-103 with floating organic layer in place or proceed with removal of floating organic layer	05/95
T2B-95-101	Complete removal of floating organic layer from Tank 241-C-103 (TPA M-40-04) (* Complete 3/95 per Safety Initiative 2u)	06/95*

Table 4-9. Milestones Associated with Safety Issue 1-3.

Milestone	Description	Completion Date
T2B-95-130	Select waste moisture monitoring/control concepts for Organic Watch List tanks	06/95
T2B-95-124	Complete unresolved safety question, safety screening/evaluation for Tank 241-C-102	06/95
T2B-95-126	Update program plan strategy document -- waste tank organic safety program	06/95
T2B-96-117	Complete installation of organic separations equipment for Tank 241-C-103	03/96
T2B-96-108	Update program plan strategy document -- waste tank organic safety program	07/96
T2B-96-112	Install moisture monitoring and control system in an organic tank	09/96
T2B-96-110	Complete installation of pressure monitoring system and monitor 5 organic tanks	09/96
T2B-96-113	Complete readiness review moisture monitoring and control demonstration	09/96
T2B-96-116	Complete unresolved safety question, safety screening evaluation for Tanks 241-C-102 and 241-BY-112	09/96
T2B-96-107	Issue status report on organic solubility study	09/96
TW2-94-456	Complete installation of new thermocouples and continuous temperature monitoring systems in 50% of organic tanks	09/96
T2B-96-109	Begin installation of thermocouple trees in organic tanks	10/96
T2B-97-109	Revise Organic Watch List based on safety criteria	12/96
T2B-97-107	Issue safety criteria for Organic Watch List tanks	12/96
T2B-97-108	Update program plan strategy document --waste tank organic safety program	06/97
T2B-97-114	Complete operation of treatment system for Tank 241-C-103	06/97
T2B-97-110	Complete core data interpretation of Organic Watch List tanks core samples	06/97
T2B-97-117	Install new thermocouple trees and connect to Tank Monitor and Control System - all organic tanks	09/97
T2B-97-112	Complete installation of pressure monitoring system and monitor remaining organic tanks	09/97
	Resolve safety issue	09/98

4.1.3.6 Alternate Strategies or Treatments. The investigation of this safety issue has focused on whether the waste can be safely stored in the tanks. The alternative is to remove and treat the waste to eliminate the hazard. Areas of concern in the investigation include:

- The potential for igniting flammable gases such as airborne organic vapor mixtures.
- The potential for igniting organic-nitrate and/or organic-nitrite mixtures.
- Verifying that existing concentrations in the tanks are safe to store until disposal vs. removal, treatment and storage elsewhere.

4.1.4 Safety Issue 1-4: Continued Cooling Required for High Heat Generation in Tank 241-C-106

4.1.4.1 Background and Description. Between 1969 and 1971, high heat sludge was water-sluiced from waste stored in single-shell tanks in the 241-A and 241-AX boiling waste Tank Farms to recover ^{137}Cs and ^{90}Sr. The sludge washing/decanting step of the process did not function as planned, and strontium-rich solids were transferred to Tank 241-C-106. In mid-1971, the waste temperature of Tank 241-C-106 exceeded 100 °C (212 °F). Because the tanks in the 241-C farm were not equipped for storing self-boiling waste, the tank was immediately placed on an active ventilation system. This tank now contains as much as 182,000 liters (48,000 gallons) of drainable liquids and 746,000 liters (197,000 gallons) of sludge (Wang 1993; Hanlon 1995). In 1993, the heat generation rate was estimated to be 110,000 ± 20,000 British Thermal Units per hour (Btu/h) (32,000 ± 5,900 Watts) (Bander 1993b). Since mid-1971, in addition to active ventilation, water has been periodically added to the tank to maintain a safe operating temperature by promoting heat transfer and evaporative cooling. The "safe" concrete temperature limit has been determined conservatively as 177 °C (350 °F) in the Safety Analysis Report/Operating Safety Requirements (WHC 1990). The operating safety document sets the waste temperature operating limit at 149 °C (300 °F) (WHC 1994b).

A stabilization evaluation of Tank 241-C-106 (Pauley and Torgerson 1987) concluded, based upon an assumed heat transfer coefficient, that Tank 241-C-106 could not be cooled solely by forced-air circulation until approximately 2045 (when the radioactive strontium would be sufficiently decayed). Cooling water (averaging 23,000 liters (6,000 gallons) per month over the last 5 years) is added to the tank, and the tank is ventilated at 71 cubic meters per minute (2,500 cubic feet per minute). At this rate of ventilation, the maximum temperature is approximately 102 °C (216 °F) (Hanlon 1994). Water will be used to cool the tank until it is no longer required and/or alternate cooling methods are implemented or until sufficient sludge material is removed to negate the need for water cooling (Welty 1988).

In January 1991, in accordance with Public Law 101-510, Section 3137 (the Wyden Amendment), Tank 241-C-106 was identified as a high-level Watch List tank that "*may have a serious potential for release of high-level waste due to uncontrolled increases of temperature or pressure.*" If sufficient liquid is not maintained in Tank 241-C-106, an uncontrolled increase in temperature could result in structural damage to the tank's concrete dome, with a potential subsequent release of high-level waste (Wang 1993). Tank 241-C-106 was put on the Watch List due to the need to maintain a drainable amount of water to cool its high heat load. A "high heat" waste tank at the Hanford Site is defined as a single-shell tank with total heat generated at a rate of 40,000 British Thermal Units per hour (Btu/h) (12,000 Watts) or more (Wang 1993). Tank 241-C-106 is on the Watch List because it is the only Hanford Site single-shell tank identified as a safety issue High Heat Watch List tank. The tank is the only single-shell tank that requires water for cooling.

Tank 241-C-106 is presently a non-leaking tank (Bailey 1993). If Tank 241-C-106 were to leak, maintaining cooling water levels would result in continual water loss to the ground. If cooling water additions to the tank are stopped in the event of a leak, the sludge could heat to temperatures greater than established safety limits and could cause tank structural damage, possibly leading to dome failure and an unacceptable radioactive release to the environment. A Tri-Party Agreement milestone and a Department of Energy safety initiative milestone have been established to start of waste retrieval from Tank 241-C-106 in October of 1996.

Up to two years will be needed to complete retrieval Project W-320 construction, develop and install additional instruments and equipment, obtain and characterize in-tank core samples, and complete safety and National Environmental Policy Act documents to retrieve the waste. In the interim, a contingency action plan will be followed if the tank leaks (DeFigh-Price and Wang 1993). Plans call for the Tank 241-C-106 high-heat safety issue to be resolved by September 1997 by sluicing all the waste from the tank. The Waste Tank Safety Program is coordinating its efforts with the efforts of the Waste Retrieval Program to retrieve the waste in Tank 241-C-106.

4.1.4.2 Priority and Strategy. The high rate of heat generation in Tank 241-C-106 is a Priority 1 safety issue because, if the tank leaked and water cooling was stopped, an uncontrolled release of radioactive material could occur due to dome failure, leading to onsite or offsite radiation exposure.

Two options are being considered to resolve the safety issue in Tank 241-C-106. The first option is to partially remove enough of the tank contents to double-shell tanks to reduce heat generation in Tank 241-C-106 to an acceptable level. The second is to provide a mechanical means of cooling the radioactive waste without the need for liquid that could drain from the tank. The first option is the preferred alternative. Westinghouse Hanford Company Project W-320 is designed to retrieve most of the waste in Tank 241-C-106 to resolve the high heat safety issue.

Removing waste from the tank in 1997 will resolve the safety issue. In addition, major emphasis has been placed on developing plans for reducing the amount of water needed for cooling Tank 241-C-106. (A certain volume of interstitial liquid in the tank would not drain if the tank leaked, since it is held up by capillary forces. Water above this amount is "drainable." The goal is to reduce the quantity of water in the tank that is drainable.) The overall strategy is to continue with current cooling method with a "stand-by" contingency plan until waste retrieval is complete (Wang 1993). The contingency plan is to complete conceptual designs for alternative cooling methods as soon as possible; then the field implementation, if called for, could be implemented within three months after a tank leak is confirmed. In addition, the minimum amount of water inventory necessary to achieve acceptable cooling will be assessed. The plan is to conduct a safety alternative process on Tank 241-C-106 by stopping water additions. If the Tank 241-C-106 safety alternative process is successful, the amount of liquid inventory needed for cooling the tank will be reduced with the goal of eliminating a drainable volume in the tank. Possible elimination of water cooling requirements for Tank 241-C-106 using an air chiller will be coordinated with retrieval efforts.

4.1.4.3 Work Completed to Date. A list of major fiscal year 1992-1994 accomplishments follows.

- Completed a detailed plan for accelerated retrieval of Tank 241-C-106 using conventional sluicing techniques.
- Updated thermal (Bander 1993a) and structural models (Julyk 1994) of Tank 241-C-106 to support alternative cooling studies and waste retrieval.
- Completed a report predicting the unmitigated consequences of a leak from Tank 241-C-106 (Bander 1993b).
- Completed an unreviewed safety question screening process; no unreviewed safety questions exist for Tank 241-C-106.
- Issued a revised program plan for high-heat safety program (Wang 1993).
- Completed testing of the existing thermocouple tree in Tank 241-C-106.
- Prepared a hazard assessment report.
- Updated the contingency plan to cover the possibility of leaks from Tank 241-C-106 (DeFigh-Price and Wang 1993).
- Completed a liquid inventory reduction process test in Tank 241-C-106.
- Completed a sprinkler system design for 241-C-106 (Rensink 1994).
- Completed an air-chiller design for Tank 241-C-106 (Kriskovich 1994).
- Replacement/repair of the liquid level indicator in Tank 241-C-106 during fiscal year 1994 (October).
- Issued a technical report in 1993 documenting the results of thermal analysis to simulate refrigerated ventilation cooling (Bander 1993c).
- Connected thermocouple trees and liquid level indicator to Tank Monitor and Control System in Tank 241-C-106 during fiscal year 1994.
- Conducted in-tank video surveillance during the second quarter of fiscal year 1994.

- Completed the *"Assessment of Tank 241-C-106 Temperature Response Indications"* (Milestone T2B-95-381) in November, 1994 (Eyler 1994).
- Updated the *High Heat Tank Safety Resolution Plan* (Milestone 95-146) in December, 1994 (Wang, 1994).

4.1.4.4 Work Required to Resolve the Issue. This safety issue will be resolved when the presence of drainable liquid is no longer required for cooling Tank 241-C-106.

The effort to retrieve waste from Tank 241-C-106 (Project W-320) is covered in Section 5.2.7, Storage of High-Level Waste in Tanks with No Secondary Containment (Safety Issue 2-7). Retrieving waste from Tank 241-C-106 is a high priority in the tank waste retrieval sequence.

4.1.4.5 Cost and Schedule. Cost and schedule information are given in the *Tank Waste Remediation System Multi-Year Work Plan* (WHC 1994a). The estimated cost for resolving this safety issue includes the cost of the Waste Tank High-Heat Safety Program and the cost of waste retrieval. The cost for waste retrieval is not included in the High-Heat Safety Program, rather it is included in the funding for Project W-320. The cost of Waste Tank High-Heat Safety Program through fiscal year 1997 (which is the expected end of the program) is on the order of $2.5 million. Project W-320, the Tank 241-C-106 sluicing activity, which provides the required capital facilities, will cost about $60 million. Operating costs will be on the order of $15 million for a total cost of $75 million to retrieve Tank 241-C-106 waste. Important milestones are listed in Table 4-10.

Table 4-10. Milestones Associated with Safety Issue 1-4.

Milestone	Description	Completion Date
T2B-95-147	Update action plan for high heat Tank 241-C-106	01/95
T2B-95-148	Complete alternative contingency system design study for high-heat Tank 241-C-106	05/95
T2B-95-104	Complete contingency cooling tests in high-heat tank 241-C-106	06/95
T2B-95-102	Complete safety alternative test and document results in a report for public release (TPA Milestone M-40-05)	09/95
--	Issue data interpretation report on Tank 241-C-106 core samples	11/95
--	Complete installation of instrument upgrades in Tank 241-C-106	09/96
T2B-96-366	Review status of high-heat safety resolution progress and provide a list of closure activities	09/96
T2B-96-365	Review progress of Project W-320 and recommend contingency action for Tank 241-C-106	09/96
--	Complete resolution of the high-heat tank safety issue (Retrieval of Tank 241-C-106 per TPA Milestone M-07 funded by Activity Data Sheet 1210, Waste Retrieval	09/97

Table 4-10. Milestones Associated with Safety Issue 1-4.

Milestone	Description	Completion Date
T2B-96-368	Evaluate high heat program after retrieval of Tank 241-C-106 and close the waste tank high heat safety program	09/97
T2B-96-367	Reassess thermal loads of Tanks 241-C-106, 241-A-104, 241-SX-110, and 241-SX-114	09/97

4.1.4.6 Alternate Strategies or Treatments. Alternate technologies for cooling the contents of Tank 241-C-106 have been studied. Alternate methods for waste removal have also been examined, including sluicing and mechanical retrieval using robotics.

4.2 PRIORITY 2 SAFETY ISSUES

Priority 2 safety issues are those issues and/or situations that contain some of the necessary conditions that could lead to worker (onsite) or offsite radiation exposure through an uncontrolled release of radioactive waste. Priority 2 safety issues are:

- Inadequate Single-Shell Tank Leak Detection (SI 2-1),
- Storage of High Level Waste in Tanks that have Leaked (SI 2-2),
- Inability of Waste Tanks and Ancillary Equipment to Withstand a Design Basis Earthquake (SI 2-3),
- Single-Shell Tank Emergency Pumping Capability Inadequate (SI 2-4),
- Tank Vapor Release (SI 2-5),
- Inadequate Response Time for a Leaking Double-Shell Tank (SI 2-6),
- Storage of High Level Waste in Tanks with No Secondary Containment (SI 2-7), and
- Potential for Nuclear Criticality in High Level Waste Tanks (SI 2-8).

4.2.1 Safety Issue 2-1: Inadequate Single-Shell Leak Detection

4.2.1.1 Background and Description. For single-shell tanks that do not have free-standing liquid above the solids, the current type of liquid-level conductivity probe is ineffective, making it nearly impossible to determine if a tank has begun to leak. Some tanks have had liquid observation wells installed through the tank solids to find the interstitial liquid level within the tank solids. The liquid observation wells typically can detect a minimum liquid loss of 7,600 liters (2,000 gallons). Leak detection systems, consisting of dry wells external to the tanks, are also used, but they are only able to detect leaks typically in excess of 26,500 to 38,000 liters (7,000 to 10,000 gallons).

4.2.1.2 Priority and Strategy. A technical basis was completed for leak detection surveillance requirements for waste storage tank areas at Hanford. The leak detection strategy for single-shell tanks that have not been interim stabilized and do not have free-standing liquid above the solids was determined. The strategy called for liquid observation wells to be designated as the primary leak detection device with backup from liquid level indicators. If the liquid observation wells are inoperable for some reason, level readings or radiation measurements from drywells will be provided.

Single-shell tanks that have been interim stabilized and that really do not have liquid level observation wells will have liquid observation wells installed as funding permits. Drywell readings will not be taken for interim stabilized tanks with dry surfaces the liquid observation wells are out-of-service.

4.2.1.3 Work Completed to Date. Eighteen liquid observation wells were procured and received during fiscal year 1992. The plan to install four liquid observation wells in fiscal year 1992 was postponed due to budget constraints. Therefore, the plan was reevaluated and the installation of three liquid observation wells was completed in fiscal year 1994. Also, in fiscal year 1994, a technical basis for the leak detection surveillance of single-shell tanks was completed. The basis determined that only two single-shell tanks, not interim stabilized, lack liquid observation wells. These tanks are currently being interim stabilized and have very little (less than 78,000 liters [20,000 gallons]) pumpable liquid remaining.

4.2.1.4 Work Required to Resolve the Safety Issue. The installation of additional liquid observation wells in single-shell tanks that are interim stabilized will continue as funding is available.

4.2.1.5 Cost and Schedule. Twenty-seven single-shell tanks are scheduled to have liquid observation wells installed in fiscal year 1996, and an additional 15 tanks are scheduled for fiscal year 1997. All single-shell tanks are scheduled to have liquid observation wells installed by September 1998. The cost to complete the liquid observation well installation is estimated to be $2.7 million.

4.2.1.6 Alternative Methods. No alternative methods have been identified.

4.2.2 Safety Issue 2-2: Storage of High-Level Waste In Tanks That Have Leaked

4.2.2.1 Background and Description. Sixty-seven of the 149 single-shell tanks at the Hanford Site are suspected or known to have leaked liquid radioactive waste to the ground (Hanlon 1995). Sixty of the 67 single-shell tanks (i.e., the assumed leakers) have been interim-stabilized and contain only minimum quantities, if any, of drainable liquids. The remaining solids in the tanks (saltcake and sludge) are relatively immobile, Radioactive waste leaks are not expected if, after interim stabilization, the tank is protected from liquid intrusions into the tank (intrusion prevention) that would leach out the contamination from the solids.

The term "interim stabilized" is an administrative designation that indicates a tank contains less than 190,000 liters (50,000 gallons) of drainable interstitial liquid and less than 19,000 liters (5,000 gallons) of supernatant liquid. If the tank was jet pumped to achieve interim stabilization, then the jet pump flow must also have been at or below 0.19 liters (0.05 gallons) per minute before the interim stabilization criteria could be met.

Over the last two years, two of the 8 assumed leaker single-shell tanks that have not been interim-stabilized have been declared assumed re-leaker tanks. Tank 241-T-111, which was declared as having questionable integrity in 1974, was declared an assumed re-leaker on February 24, 1994 and Tank 241-BX-111 was declared an assumed re-leaker on April 30, 1993. The surface level of Tank 241-T-111 showed decrease in surface level after the automatic liquid level indicator was repaired in August 1993. The surface level measurement after the indicator repair was 410.7 centimeters (161.7) inches and continued to decrease to 409.2 centimeters (161.1) inches by January 31, 1994. This was a 2.5 centimeters (1.0 inch) decrease from the baseline of 411.7 centimeters (162.1 inches). An Off-Normal Occurrence Report (WHC 1994c) was issued on February 24, 1994.

The remaining seven assumed leakers that have not been interim stabilized are scheduled to have interim stabilization completed by November 1999 (see cost and schedule section below). Interim stabilization of all single-shell tanks is scheduled to be completed by the end of fiscal year 2000 (Tri-Party Agreement Milestone M-41-00). The solid waste in the assumed leaker tanks is likely to remain in place until a final disposal method for the single-shell tank waste is implemented.

4.2.2.2 Priority and Strategy. Storage of high-level waste in tanks that have leaked is a priority 2 safety issue. Assumed leaker tanks represent a condition that could potentially lead to an uncontrolled release of radioactive waste. Assumed leakers that have not been interim stabilized or contain liquid volume could begin to leak again. Efforts to upgrade single-shell tank leak detection systems have been completed and upgrades to single-shell tank emergency pumping capabilities are underway. Failure of both of these safety measures is highly unlikely and therefore this situation meets the criteria for a priority two safety issue.

The strategy for safety issue resolution is to minimize the possibility for further leaks through interim stabilization and then intrusion prevention of the single-shell tanks until waste retrieval can be accomplished. Intrusion prevention is an administrative designation reflecting the completion of the physical effort required to minimize the addition of liquids into an inactive storage tank (Hanlon 1995). Six of the seven assumed leakers which have not been interim stabilized are Watch List tanks. These tanks are 241-BY-103, 241-BY-105, 241-BY-106, and 241-T-107, which are on the Watch List because of ferrocyanide content and 241-SX-104, which is a Flammable Gas Watch List tank.

Safety issue 2-2 overlaps with several other safety issues. Activities affecting tanks on the Watch List must be coordinated with safety programs related to that tank. In addition, *Safety Issues 2-1, Inadequate Single-Shell Tank Leak Detection; 2-4, Single-Shell Tank Emergency Pumping Capability Inadequate; 2-7, Storage of High Level Waste in Tanks with No Secondary Containment;* and 3-4, *Inadequate Sealing of Single-shell Tanks to Prevent Intrusions That Could Then Lead to Contamination* all address safety concerns related to single-shell tank leak detection and/or prevention.

- Interim stabilization (Safety Issue 2-7) and intrusion prevention (Safety Issue 3-4) of the remaining single-shell tanks will reduce the liquid inventory of radioactive waste available for leaking into the ground should these tanks develop leaks. These activities are funded as sub-elements of the Tank Farms Operations and Maintenance Program Element.

- Resolution of *Safety Issue 2-1, Inadequate Single-Shell Tank Leak Detection,* has confirmed the ability to identify the existence of a leak in a stabilized single-shell tank. This safety issue is covered in Section 4.2.1.

- Resolving *Safety Issue 2-4, Single-Shell Tank Emergency Pumping Capability Inadequate,* will improve the ability to respond to single-shell tank leaks and reduce the amount of liquid radioactive waste released to the soil. Resolution of this safety issue is covered in Section 4.2.4.

- Resolving *Safety Issue 3-4, Inadequate Sealing of Single-Shell Tanks...* will improve the ability to prevent intrusions into single-shell tanks that could then leak contamination out of the tank to the ground. Resolution of this safety issue is covered in Section 4.3.4.

While the foregoing activities will mitigate the subject safety issue, high-level waste will continue to be stored in single-shell tanks that have leaked or may leak until the tank wastes have been retrieved in accordance with the Tri-Party Agreement. Resolution of this safety issue will require retrieval of the waste from all single-shell tanks. The status, plans, cost, and schedule for this effort are covered in Section 4.2.7, *Storage of High Level Waste in Tank with No Secondary Containment.*

4.2.2.3 Work Completed to Date. Work that has been completed towards resolution of this safety issue includes the pumping of assumed leaker Tanks 241-T-111 and 241-BX-111. Emergency pumping of Tank 241-T-111 began on May 17, 1994. A total of 11,000 liters (9,600 gallons) was pumped. Interim stabilization of this tank was completed in February of 1995. Interim stabilization of Tank 241-T-111 completed Tri-Party Milestone M-41-16A-T01. Section 4.2.4, *Single-Shell Tank Emergency Pumping Capability Inadequate,* contains further information on emergency pumping. Pumping of Tank 241-BX-111 commenced on October 22, 1993, and was completed as of April 30, 1994. Pumping was restarted May 25, 1994 to remove additional pumpable liquid after review of in-tank photos taken May 19, 1994. Pumping resumed in December 1994. A total of 435,700 liters (116,900 gallons) was pumped from this tank.

Milestone T2A-95-104, which required that safety studies and analysis (M-41-07) on the interim stabilization of assumed leaker Watch List tanks be made and submitted to the Washington State Department of Ecology and the U.S. Environmental Protection Agency, was completed in December, 1994 (required by Tri-Party Agreement Milestone M-41-07).

All of the eight assumed leaker tanks that remain to be interim stabilized have been partially interim isolated. Partial interim isolation reflects the completion of the physical effort required for intrusion prevention except for isolation of risers and piping that is required for jet pumping or for other methods of stabilization.

4.2.2.4 Work Required to Resolve the Safety Issue. The schedule for interim stabilization of the remaining eight assumed leaker tanks is shown in Table 4-11.

Table 4-11. Milestones Associated with Safety Issue 2-2.

Milestone	Description	Completion Date
T2A-95-316	Complete removal of pumpable liquid from 6 of 43 single-shell tanks	11/95
--	Complete interim stabilization of 4 ferrocyanide tanks in the 241-BX and 241-BY tank farms (TPA M-41-12-T01)	12/97
--	Complete interim stabilization of ferrocyanide tank in the 241-T tank farm TPA (M-41-17-T01)	05/98
--	Complete interim stabilization of 7 Flammable Gas Watch List tanks in 241-S and 241-SX tank farms (TPA M-41-14-T01)	11/99
--	Resolve safety issue (Complete waste retrieval from all single-shell tanks. TPA M-45-00)	09/24

Emergency procedures, outlining the requirements for pumping of each of the tanks listed above, were submitted to the Washington State Department of Ecology and the U.S. Environmental Protection Agency in March 1995 (required by Tri-Party Agreement Milestone M-41-02-T03).

4.2.2.5 Cost and Schedule. The cost for mitigation of this safety issue by interim stabilization and intrusion prevention is included as part of the scope of Safety Issue 2-7, Storage of High-Level Waste in Single-Shell Tanks with No Secondary Containment (see Section 4.2.7.5 for cost and schedule). The schedule for interim isolation of assumed leakers is given in the previous section. Final resolution of the safety issue will be accomplished by single-shell waste retrieval. The Tri-Party Agreement Milestone M-45-05-5 calls for completion of single-shell waste retrieval by September 2024.

4.2.2.6 Alternatives Methods. No alternative methods have been identified.

4.2.3 Safety Issue 2-3: Inability of Waste Tanks and Ancillary Equipment to Withstand a Design Basis Earthquake

4.2.3.1 Background and Description. The Hanford Site single-shell tank structures were designed and constructed using available 1940 and 1950 era consensus building codes. These codes had minimal provisions for seismic and natural forces resistance. The intent and provisions of these codes did not specify or include requirements for structures that confine radioactive materials. In addition, these codes did not contain provisions for underground tank structures.

The Hanford Site double-shell tank structures were designed and constructed using available 1960 and 1970 era consensus building codes, including portions of the American Society of Mechanical Engineers pressure vessel code. Additional tank design requirements were developed and used, including design earthquake provisions, for ensuring the ability of the double-shell tank structures to store and confine radioactive waste.

For both the single-shell tank and double-shell tank tank farms, the ancillary equipment and systems have various required functions because the tanks confine radioactive waste (e.g., ventilation systems and monitoring instrumentation). There are potential seismic resistance deficiencies in these systems and equipment (WHC 1991b).

The structural ability of the single-shell tanks to continue to store solid radioactive waste, particularly their ability to withstand seismic forces, should be reevaluated. For the double-shell tanks, structural reviews should be conducted to determine their ability for an extended cleanup mission. These evaluations and reviews must consider the long term effects of soil backfill loads, elevated temperatures, other operating loads, and the potential design basis earthquake. Though structural and seismic design reports exist for double-shell tanks; it may be necessary to conduct additional or more comprehensive structural evaluations for double-shell tanks.

4.2.3.2 Priority and Strategy. Seismic resistance for the Hanford Site waste storage tanks and their ancillary equipment and systems reduces the potential for uncontrolled release of radioactive material. Therefore, the seismic resistance of the waste tank and ancillary equipment and systems is a priority two safety issue.

The strategy for resolution of this safety issue consists of completing planned projects to upgrade the tank farms ancillary equipment, systems and components. The projects will require seismic resistance design, fabrication, and installation for equipment and system replacements and upgrades commensurate with their functions for the confinement of radioactive waste. Thus, seismic qualification evaluations for the ancillary systems will be a requirement of the upgrades projects.

The Tank Waste Remediation System Life Management/Aging Management Program has proposed development of acceptance criteria, including seismic requirements for the waste tank structures. Then, as necessary, the existing seismic analyses will be reviewed and updated, and some additional seismic analyses will be conducted for waste tank structures.

4.2.3.3 Work Completed to Date. A summary status of the seismic evaluations conducted for Hanford Site waste tanks was completed in fiscal year 1991 (Becker et al. 1990). At that time, seismic analyses had been performed for one single-shell tank structure in the 241-AX Tank Farm and all of the double-shell tank structures. These analyses were performed during the 1970's and early 1980's. The double-shell tank seismic analyses were conducted during the design phase. Additional activities completed include a double-shell tank soil-structure interaction study (Giller and Weiner 1991) and a seismic evaluation for the 241-C-106 single-shell tank (Wallace 1994).

Some of the projects to upgrade tank farm ancillary equipment and systems are underway (see Section 4.4.3). The waste tank life management plan includes the development of waste tank structural acceptance criteria with seismic requirements (see Section 4.4.5).

4.2.3.4 Work Required to Resolve the Safety Issue. In summary, the upgrades projects for the tank farms ancillary systems should be completed. The Life Management/Aging Management Program should continue with development of seismic resistance acceptance criteria, and related requirements for the tank structures and ancillary systems should be initiated.

4.2.3.5 Cost and Schedule. The cost and schedule for the tank life management program which includes seismic criteria development and evaluations to resolve this issue are presented in Section 4.4.5.5, and the cost and schedule for tank farm upgrades is given in Section 4.4.3.5

4.2.3.6 Alternative Methods. No alternate strategies have been identified.

4.2.4 Safety Issue 2-4: Single-Shell Tank Emergency Pumping Capabilities Inadequate

4.2.4.1 Background and Description. Currently, seven single-shell tanks contain drainable liquid waste that can not be pumped out because there is not a viable transfer route. Eight single-shell tanks do not have an operable double-contained receiver tank. For those cases where no transfer routes exist, equipment and procedures will be developed and demonstrated for overground transfers and a safety assessment will be performed for use in an emergency situation. Double-contained receiver tanks will need to be refurbished or have equipment installed, followed by operability tests and readiness reviews.

The work to support resolution of this safety issue is part of a larger effort supporting fulfillment of Tri-Party Agreement Milestone M-41-00, Interim Stabilization of all Single-shell Tanks. Activities supporting resolution of this safety issue also support resolution of Safety Issues 2-1, 2-2, 2-7, and 3-4 which are all part of the single-shell tank Interim Stabilization Program. ICF Kaiser Hanford has been incorporated into this effort and is supplementing the Westinghouse Hanford Company engineering, scheduling, and project management resources. The additional resources and flexibility will also help to reduce the overall response time. These resources, as well as personnel from other interim stabilization activities (see Safety Issues 2-1, 2-2, 2-7, and 3-4) will be available to be utilized to respond to any tank that is identified as an assumed leaker in fiscal year 1995.

Two Secretary O'Leary safety initiatives are associated with the resolution of this safety issue. Both safety initiatives have been completed as indicated below:

- Restore the double contained receiver tank in a key tank farm (241-U Farm) to operating condition to support emergency pumping by June 1994. (Also a Tri-Party Agreement Milestone, M-41-02-T4 "Restore this 244-U Double Contained Receiver Tank to Compliant Operating Conditions" completion date March 1995). This safety initiative was completed on September 30, 1994 per Westinghouse Hanford Company letter number 9456878, and the Tri-Party Agreement Milestone was completed in March 1995.

- Complete fabrication of line for emergency pumping of leaking single-shell tanks by 9/94. This safety initiative was completed on September 19, 1994 per Westinghouse Hanford Company letter number 94563879. This also completed Tri-Party Agreement Milestone M-41-02-T2, complete and mount appropriate equipment in emergency pumping trailer by September 1994.

4.2.4.2 Priority and Strategy. Inadequate Single-shell Tank Emergency Pumping Capability is a priority 2 safety issue because under extreme assumptions inadequate pumping capabilities could lead to an uncontrolled release of radioactive tank waste.

Each identified leaking tank will be pumped until it meets the criteria for interim stabilization specified in the *Hanford Facility Agreement and Consent Order* (Tri-Party Agreement): i.e., pumping rate falls to less than 0.19 liters (0.05 gallons) per minute, or the pumpable volume is reduced to less than 19,000 liters (5,000 gallons) of supernate and 190,000 liters (50,000 gallons) of pumpable interstitial liquid. The objective of the activities required to resolve this safety issue is to be in position to begin pumping within seven days of a tank being identified as an assumed leaker.

4.2.4.3 Work Completed to Date. The following activities have been accomplished in support of resolving this safety issue:

- New submersible jet pumps and jumper assemblies were fabricated.
- Operational test procedures were issued and performed on emergency pumping equipment, and the emergency pumping trailer (weight factor instrument enclosure) was completed.
- The 241-C Tank Farm double contained receiver tank was repaired, restoring emergency pumping capabilities to six tanks.
- 241-S Tank Farm transfer lines failed a pressure test resulting in four more tanks with inadequate emergency pumping capabilities (see Table 1-1).
- The double contained receiver tank in 241-U tank farm was restored to operating condition. This activity completed a safety initiative as well as a Tri-Party Agreement Milestone, see background above.
- An addendum to the single-shell tank safety analysis report to allow overground waste transfers.
- Completed fabrication of overground transfer line for emergency pumping of leaking single-shell tank and completed mounting of appropriate equipment on emergency pumping trailer. These activities restored emergency pumping capability to four 241-S Farm tanks and Tank 241-BX-106 that had failed transfer lines and completed a safety initiative as well as a Tri-Party Agreement Milestone, see background above.
- Issued detailed procedures for emergency pumping. This completed a Tri-Party Agreement Milestone, M-41-02-T03.
- Completed preparations for improved single-shell tank emergency pumping capabilities. this completed a Tri-Party Agreement Milestone, M-41-02.

These completed activities resulted in the above ground transfer system being in place for emergency pumping, and all double-contained receiver tanks being operational.

4.2.4.4 Work Required to Resolve the Safety Issue. Near-term (fiscal year 1995) plans maintaining emergency pumping equipment in operating condition.

The actions taken to improve response time to an identified leaker include:

- Development of the engineering change notices to upgrade the existing wheeled emergency jet pump control station so it is ready for immediate use if emergency pumping is required on two tanks simultaneously.
- Maintenance of a "certified" staff for emergency pumping, in both the east and west tank farms, so that pumping will not be delayed while personnel are trained.
- Issue and maintain updated emergency pumping guide to assure that essential data is readily available.
- Procure mobile high-level liquid waste transport cask.
- Design and build loading/unloading facilities for high-level liquid waste cask.

Westinghouse Hanford Company recently completed Interim Stabilization, through emergency pumping, of Tank 241-T-111 which was determined to be an assumed leaker in the first quarter of 1994. Replacement of pumps and jumpers which were removed from the "emergency pumping" supplies to expedite the pumping of Tank 241-T-111 will be replaced during fiscal year 1995.

4.2.4.5 Cost and Schedule. The total cost for resolution of this safety issue is complicated by interaction with the resolution of other safety issues (see background and Description 4.2.4.1). The estimated cost for preparation of single-shell tank emergency pumping capabilities is on the order of $12 million. This figure includes emergency pumping of Tank 241-T-111, replacement of equipment used during this event, and addition of inhibitors to five single-shell tanks to reduce the risk of tank failure.

Important milestones are listed in Table 4-12.

Table 4-12. Milestones Associated with Safety Issue 2-4.

Milestone	Description	Schedule
--	Prepare improved single-shell tank emergency pumping capability	03/95
--	Issue detailed emergency pumping procedures	03/95
--	End of issue	03/95
T2A-96-123	Delivery of Mobile High-Level Liquid Waste Transport Cask	01/96

4.2.4.6 Alternate Strategies or Treatments. No alternate strategies have been identified.

4.2.5 Safety Issue 2-5: Tank Vapor Release

4.2.5.1 Background and Description. Since 1987, workers at the Hanford Site waste tank farms have reported strong odors emanating from the tanks (Osborne and Huckaby 1994). The Tank Vapor Issue Resolution Program was established in 1992 to resolve the health and safety issues related to noxious gases and vapors associated with the high-level radioactive storage tanks at the Hanford Site (Osborne and Huckaby 1994).

Early characterization methods development shows that each tank may contain as many as 60 chemical constituents in the vapor space. This revelation has driven a requirement for extensive vapor database development. Complete characterization of all Hanford tanks and the deployment of microclimatic weather stations will generate hundreds of thousands of data points which must be correlated and analyzed. Vapor database development is, therefore, a critical component of tank vapor issue resolution.

To resolve the safety issue, the hazards of potentially toxic tank vapors and implementing corrective actions commensurate with the level of hazard in each tank and/or tank farm will be evaluated. In-tank source sampling of ferrocyanide and Organic Watch List tanks and all 241-C Farm tanks will be performed. Hazardous vapor screening will be conducted for all remaining tanks. Tank vapors will be analyzed to assess their potential as sources for industrial hygiene issue resolution.

For a period of 33 years (1946-1979), Tank 241-C-103 received about 30 types of waste from various sources, both directly and as a receiving tank in a tank cascade (Jungfleisch 1987; Carothers 1988). According to Jungfleisch, the wastes added to Tank 241-C-103 included wastes generated from four primary recovery processes, two secondary recovery processes, evaporators, in-tank solidification processes, semi-works operations, decontamination operations, N Reactor, Pacific Northwest Laboratory, and both in-process and in-tank waste scavenging. Tank 241-C-103 was also an accumulator tank for metal waste from other tanks (before processing for uranium recovery) and for supernatants from other tanks (before processing for uranium and/or cesium recovery). Data on N Reactor waste and Pacific Northwest Laboratory waste was lacking because of the then-proprietary nature of those operations. However, it is likely that Tank 241-C-103 contains tributyl phosphate, normal paraffinic hydrocarbons, and various radiation-induced degradation products.

After July 1979, no wastes were transferred into or out of Tank 241-C-103. At present, Tank 241-C-103 is designated as an organic tank and is on the Organic Watch List (Strachan et al. 1993). It is estimated that the tank contained 235,000 liters (62,000 gallons) of sludge and 503,000 liters (133,000 gallons) of aqueous supernatant liquids (Hanlon 1995). Additionally, between 3.8 and 5 centimeters (1.5 and 2.0 inches) of organic liquid cover the waste surface. This organic liquid is composed principally of Tributyl phosphate and normal paraffinic hydrocarbon.

Gases that pose health hazards may be present in waste tank vapor spaces (e.g., ammonia) and, ultimately, the work spaces. Such vapors have been found in Tank 241-C-103. Nineteen exposure events, involving 34 people at the Hanford Site, occurred between July 1987 and May 1993. A number of people have reported ill effects, including headache, burning sensation in nose and throat, nausea, and impaired pulmonary function, while working around waste tanks on the Hanford Site. As indicated in the *Program Plan for the Resolution of Tank Vapor Issues*, WHC-EP-0562 (Osborne 1992), musty and foul odors, including the smell of ammonia, have been reported emanating from several single-shell tanks. All of the vapor exposures involved first aid medical consultation, and two cases resulted in significant amounts of lost time to workers. Ten of these vapor exposure events, involving 18 people, were associated with the 241-C Tank Farm (many of these involved Tank 241-C-103). A program plan (Osborne 1992) was developed which focused on Tank 241-C-103 as a pilot program. A revision to the original program plan (Osborne and Huckaby 1994) has been developed to apply these technologies generically to the remaining tanks.

On May 27 and 28, 1992, Westinghouse Hanford Company hosted a tank vapor sampling conference attended by consultants from various national laboratories. The group defined a two-phase course of action to characterize tank vapors, beginning with Tank 241-C-103. Characterization of vapors in other 241-C Farm tanks is to follow. Five conferences have been held to date.

Vapor Exposure History

The vapor exposure events are described in the following summaries (Osborne and Huckaby 1994):

- **July 1987** - An exposure to three individuals working on a portable exhauster occurred at Tank 241-C-103. This exposure resulted in significant lost time to two of the workers.

- **July 1987** - A vapor exposure incident was reported involving two operators moving a filter housing from Tank 241-C-106 to Tank 241-C-103.

- **January 1989** - An operator involved in routine duties in the 241-C tank farm reported a vapor exposure incident.

- **August 1989** - A technician involved in a routine surveillance in the 241-C tank farm reported a vapor exposure incident. Post-incident analysis indicated Tank 241-C-103 as the source of the vapor.

- **March 1991** - A technician near a pit for Tank 241-C-103 reported a vapor exposure incident.

- **September 1991** - Three workers performing maintenance activities on Tank 241-C-103's activated charcoal filters experienced a vapor exposure incident.

- **September 1991** - A vapor exposure incident occurred involving one construction worker, who was excavating in the 241-C tank farm.

- **September 1991** - A vapor exposure incident occurred involving two insulators installing a greenhouse in the 241-C tank farm.

- **September 1991** - A vapor exposure incident occurred involving two construction personnel working outside the 241-C tank farm gates.

- **May 1992** - Two Health Physics technicians were affected by vapor while working at the 241-C vault, which was downwind of Tank 241-C-103.

Tank Farm Operations management's response to these events included: (1) initiation of forced ventilation of tank headspaces; (2) provisions for respiratory protection for workers within the tank farm and within specified boundaries; (3) initiation of area Industrial Hygiene monitoring; and (4) installation of filtration devices on tank vent lines. The activated carbon filters on Tank 241-C-103, for example, were installed in December 1989, with the rationale that this tank was the prime source of noxious vapors and that ammonia was the major contributor. Many corrective actions were assigned to organizations that had neither the budget nor the expertise to complete the actions, and progress in resolving the vapor issues has been limited by other tank farm issues with higher priorities (e.g., the episodic gas releases in 241-SY-101 and the ferrocyanide issues).

The sporadic timing and various locations of vapor exposure incidents have meant that these occurrences have historically been treated as isolated incidents. A January 28, 1992 battery acid fume exposure incident, however, prompted a complete reassessment of management responses to these types of potential worker exposure incidents in general. Although this vapor exposure incident was not linked to a waste tank fugitive vapor emission, it highlighted the need for a comprehensive, dedicated program to resolve the vapor exposure issues.

The use of supplied air for an indefinite period to maintain worker safety in certain tank farms is unsatisfactory. However, until the noxious vapors are identified and measured, and a more appropriate solution to the exposure problem in found, conservative safety measures will remain in effect in areas of tank farms with the highest exposure potential.

One of the key elements required to minimize worker exposure to noxious vapors is the positive identification of the noxious vapors in the source. This can only be done by a reasonably complete qualitative and quantitative characterization of the waste tank vapors, both organic and inorganic species.

No comprehensive site-specific health and safety plan[5] existed in January 1992 dealing with and minimizing vapor-related Industrial Hygiene concerns. An active Industrial Hygiene monitoring program was clearly needed to help identify problems before they compromised workers' health; procedures were also needed for dealing with vapor-related incidents if and when they occurred. For the Industrial Hygiene air monitoring strategy to be effective, source term vapor information from the in-tank characterization effort is essential to correctly target worker exposure assessments.

Because of a trend identified in the vapor exposure incidents, Tank 241-C-103 is considered the "worst case" tank and is the near-term focal point of this program plan. Sampling and analytical methodology development accomplished in the pilot characterization of Tank 241-C-103 will be used as the basis to characterize the remainder of the Hanford Site waste tanks. The comprehensive tank farm site-specific health and safety plan is the cornerstone of the Westinghouse Hanford Company Industrial Hygiene program.

Safety initiatives have been developed to track progress in dealing with some major elements of the tank vapor release safety issue as follows:

- **Safety Initiative 2i,** resolve flammability issues associated with Tank 241-C-103 (complete);

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[5]The Tank Farm Health and Safety Plan, WHC-SD-WM-HSP-002 (1003), has been implemented in the tank farm complex.

- **Safety Initiative 2m,** sample and characterize tank vapors from Tank 241-C-103 (complete);
- **Safety Initiative 2n,** complete engineering evaluation of alternatives for treatment of Tank 241-C-103 vapor space (complete);
- **Safety Initiative 2o,** Sample and characterize remaining suspect tanks by June 1995;
- **Safety Initiative 2p,** provide vapor monitoring equipment with alarm capability and/or ventilation upgrades to tanks where warranted by April 1997.

Scope Change from 1991 report to 1993 report. The tank farms and number of tanks having a potential for release of harmful vapors were identified. Fifteen of the 18 tank farms and 69 of the 177 tanks were identified and listed in the 1993 report as being revised from the 1991 report.

Scope Change from 1993 report. The list of tanks have been revised again since the 1993 report. Forty five suspect tanks, shown in Table 4-13, have been identified for initial priority vapor headspace characterization (organic, ferrocyanide, 241-C-Farms, and tanks with a history of vapor problems). One hundred thirty two tanks are to be safety screened for hazardous vapor. Design and fabrication of development mobile laboratories, as stated in the 1993 report, will not be completed. However, a new sampling system will be designed and fabricated.

Table 4-13. Safety Issue 2-5 Tanks.

Tank Farm/Tank	Watch List Status	Other Related Safety Issue
241-A Tank Farm		
Tank 241-A-101	Organic	1-3
241-AX Tank Farm		
Tank 241-AX-102	Organic	1-3
241-B Tank Farm		
Tank 241-B-103	Organic	1-3
241-BX Tank Farm		
Tank 241-BX-102	Ferrocyanide	1-2
Tank 241-BX-104		
Tank 241-BX-106	Ferrocyanide	1-2
241-BY Tank Farm		
Tank 241-BY-103	Ferrocyanide	1-2
Tank 241-BY-104	Ferrocyanide	1-2
Tank 241-BY-105	Ferrocyanide	1-2
Tank 241-BY-106	Ferrocyanide	1-2

Table 4-13. Safety Issue 2-5 Tanks.

Tank Farm/Tank	Watch List Status	Other Related Safety Issue
Tank 241-BY-107	Ferrocyanide	1-2
Tank 241-BY-108	Ferrocyanide	1-2
Tank 241-BY-109		
Tank 241-BY-110	Ferrocyanide	1-2
Tank 241-BY-111	Ferrocyanide	1-2
Tank 241-BY-112	Ferrocyanide	1-2
241-C Tank Farm		
Tank 241-C-101		
Tank 241-C-102	Organic	1-3
Tank 241-C-103	Organic	1-3
Tank 241-C-104		
Tank 241-C-105		
Tank 241-C-106	High Heat	1-4
Tank 241-C-108	Ferrocyanide	1-2
Tank 241-C-109	Ferrocyanide	1-2
Tank 241-C-110		
Tank 241-C-111	Ferrocyanide	1-2
Tank 241-C-112	Ferrocyanide	1-2
241-S Tank Farm		
Tank 241-S-102	Organic/Flammable	1-1, 1-3
Tank 241-S-111	Organic/Flammable	1-1, 1-3
241-SX Tank Farm		
Tank 241-SX-103	Organic/Flammable	1-1, 1-3
Tank 241-SX-106	Organic/Flammable	1-1, 1-3
241-T Tank Farm		
Tank 241-T-107	Ferrocyanide	1-2
Tank 241-T-111	Organic	1-3
241-TX Tank Farm		
Tank 241-TX-105	Organic	1-3
Tank 241-TX-118	Ferrocyanide/Organic	1-2, 1-3
241-TY Tank Farm		
Tank 241-TY-101	Ferrocyanide/Organic	1-2, 1-3
Tank 241-TY-103	Ferrocyanide	1-2
Tank 241-TY-104	Ferrocyanide	1-2

Table 4-13. Safety Issue 2-5 Tanks.

Tank Farm/Tank	Watch List Status	Other Related Safety Issue
241-U Tank Farm		
Tank 241-U-103	Organic/Flammable	1-1, 1-3
Tank 241-U-105	Organic/Flammable	1-1, 1-3
Tank 241-U-106	Organic	1-3
Tank 241-U-107	Organic/Flammable	1-1, 1-3
Tank 241-U-111	Organic	1-3
Tank 241-U-203	Organic	1-3
Tank 241-U-204	Organic	1-3

Schedule Change From 1991 to 1993 Report. According to the 1993 report, resolution of this safety issue was delayed nine months, from September 1997 to June 1998, due to inadequate resources in fiscal year 1992.

Schedule Change From 1993 Report. The 45 suspect tanks will be characterized by November 30, 1995. The schedule for the remaining 132 tanks is November 30, 1997. The task, complete first modular vapor treatment system, has been re-scheduled from September 1994 to June 1995. The task, recommend resolution of tank vapor safety issue for all remaining tanks, has been re-scheduled from June 1998 to November 1997.

4.2.5.2 Priority and Strategy. The concern that a flammability hazard exists in Tank 241-C-103 arises from two possible scenarios. First, the layer of organic liquid could potentially ignite and result in a "pool" fire. Second, if a very dense aerosol compound primarily of organic droplets exists, the available fuel in the headspace could support flame propagation in upper regions of the headspace. Either scenario could result in an increase in the pressure within the tank, a breech of the tank, and subsequent release of radiological contamination to the atmosphere and/or ground. Since the risk and potential damage of a fire in Tank 241-C-103 have not been thoroughly evaluated, the presence of the organic liquid layer in the tank has been declared an unreviewed safety question. Resolution and closure of this organic layer "pool" fire unreviewed safety question are outside the scope of the Vapor Program, and are the responsibilities of the Waste Tank Organic Safety Program (see Section 4.1.3). Based on the above, this safety issue meets priority 2 criteria because of its potential to release vapors containing radionuclides into the atmosphere which may pose a potential personnel hazard to workers and exceed regulatory limits.

The strategy for resolving the tank vapor safety issue involves four phases. Phases 1 and 2 dealt with resolving the safety issue for Tank 241-C-103. Phases 3 and 4 resolve the safety issue for 241-C Farm tanks and remaining tanks, respectively.

Resolution of the tank vapor release safety issue includes evaluation and definition for tank vapor safety and in-tank resolution with treatment. Evaluation and definition of the problem includes: (1) vapor sampling of underground waste storage tanks; (2) characterization of tank vapors for chemical constituents, flammability, and aerosol issues; (3) epidemiology studies; (4) area monitoring of Tank 241-C-103 for noxious vapors; (5)

reduction of respiratory protection in tank farms; and (6) design of treatment systems for tank vapors. The workscope will be implemented in a phased approach: Phases 0, 1 and 2 address the characterization strategy for Tank 241-C-103 and the development of analytical methods for analyzing toxic vapors. Phase 3 deals with the resolution of the vapor release problem in 241-C Tank Farm, and Phase 4 deals with resolution of any vapor release problems in the remaining suspect tank farms. Initially, several vapor sampling techniques will be used simultaneously such as SUMMA(R) canisters, sorbent tubes, and direct gas chromatography/mass spectrometer. A noxious odor advisory system pilot program has been implemented. Vapor sampling characterization studies; model development for air dispersion plume within 100 meters of the tank; microclimatic characterization; epidemiology study of past vapor exposures; and prospective occupational exposure studies will also be conducted.

Reports of illness experienced by people working near Tank 241-C-103 have led to a need to determine if the symptoms are related to material coming from the tank. This determination involves a number of steps, including (1) analysis of material in the tank headspace to establish maximum concentrations of materials available for release from the tank; (2) analysis of volatile materials released through the high-efficiency particulate air filter on the tank exhaust port; (3) determination of routes and levels of fugitive emissions from the tank; (4) evaluation of the toxicologic potential (including the exposure potential) of the headspace constituents and the materials released from the tank; (5) area monitoring; and (6) breathing zone monitoring.

When sufficient data has been obtained for the above areas, it will be possible to determine what, if any, control and monitoring measures are necessary. In the interim, Westinghouse Hanford Company Emergency Safety, and Quality has adopted the American Industrial Hygiene Association sampling strategy (AIHA 1991) to monitor personnel exposure to tank farm vapors. The sampling results will be used to ensure workers' protection in and around the tank farm area. As additional in-tank characterization of analytes of toxicologic interest are identified by the Toxicology Review Panel, the air sampling approach will be reassessed.

4.2.5.3 Work Completed to Date

Work Completed Prior To the 1993 Report;

- A technical program plan was issued (Osborne 1992).
- A health and safety plan to evaluate hazards, risks, and worker exposures was issued.
- A tank vapor sampling team was assembled and a vapor sampling conference was held.
- Noxious Odor Advisory System Pilot Program was initiated.
- A vapor sampling system was completed.
- Completed Tank 241-C-103 Phase 1A vapor sampling.

Work Completed Since the 1993 Report;

- **Safety Initiative 2i**, resolve flammability issues associated with Tank 241-C-103 was completed on January 31, 1994.

- **Safety Initiative 2m**, M-40-06, sample and characterize tank vapors from Tank 241-C-103. All phases are complete. A report was issued on June 30, 1994. The flammability of Tank 241-C-103 was measured in December 1993 and the flammability report issued in January 1994 reported the tank at 4-8% of the lower flammability limit.

- **Safety Initiative 2n**, Complete engineering evaluation of alternatives for treatment of Tank 241-C-103 vapor space was completed on June 30, 1994.

- Revision 1 of the technical program plan was issued (Osborne and Huckaby 1994).

- Five vapor sampling team conferences have been held to date.

- Completed Aerosol Flammability Study for Tank 241-C-103. Report issued January 31, 1994.

- Completed Vapor Sampling Characterization for all tanks in 241-C Farm (October 1994).

- Developed SUMMA(R) Analysis Capability at Pacific Northwest Laboratory for Vapor Characterization (September 1994).

4.2.5.4 Work Required to Resolve the Safety Issue. Near-term plans include initiatives, such as epidemiological studies, toxicology, analytical methods development, portable weather stations, and technical integrating contractor concepts. Also, a new vapor sampling system will be designed and fabricated.

Long-term plans will focus on developing analytical methods for analyzing vapors and developing and installing vapor treatment systems on tanks that release vapors. Phase 3 (241-C Farm) vapor sampling and Phase 4 (remaining suspect tanks) will be completed, and routine periodic sampling will be initiated. The remaining 132 tanks will be safety screened for hazardous vapors.

4.2.5.5 Cost and Schedule. The estimated total cost for resolution of this safety issue is on the order of $8.3 million. Key milestones established by the Tank Vapor Resolution Program are given in Table 4-14.

4.2.5.6 Alternate Strategies or Treatments. In-tank resolution with treatment workscope includes alternate treatment approaches which will be evaluated based on the information generated in previous tasks. Alternatives will include one or a combination of the following: do nothing; develop work practices; treat by passive ventilation; treat by active ventilation; chemically treat; and/or remove waste from tank. For whatever corrective action is chosen, construction, instrumentation, and installation design may be required. Depending on the action, functional design criteria, conceptual design report, and final design documentation may be required. Cost and schedule will vary depending on the action required.

Table 4-14. Milestones Associated with Safety Issue 2-5.

Milestone	Description	Completion Date
--	Recommend resolution of tank vapor safety issue for 241-C-103 (Tri-Party Agreement Milestone M-40-07).	06/95
T2B-95-121	Design and fabrication of vapor treatment system in Tank 241-C-103.	06/95
T2B-95-111	Sample and characterize remaining suspect tanks (Safety Initiative 2o).	06/95
T2B-95-103	Complete first modular vapor treatment system, commence operation of vapor treatment system on Tank 241-C-103	06/95
--	Complete second and third vapor treatment systems.	09/95
T2B-95-134	Alter personal protection equipment requirements as necessary.	09/95
T2B-95-163	Complete tank farm vapor exposure pathway workbook and 241-C Farm Estimate.	09/95
T2B-95-136	Characterize vapor headspace of remaining suspect tanks (Pacific Northwest Laboratory).	09/95
T2B-95-135	Characterize vapor headspace of remaining suspect tanks (Oak Ridge National Laboratory).	09/95
T2B-95-119	Sample vapor headspace of remaining suspect tanks.	09/95
T2B-96-101	Complete vapor sampling and characterization of all Organic Watch List tanks (Tri-Party Agreement Milestone M-40-08).	11/95
T2B-96-100	Complete vapor sampling and characterization of all Ferrocyanide Watch List tanks (Tri-Party Agreement Milestone M-40-03).	11/95
--	Complete occupational health and safety administration vapor characterization of 241-B, -BX, and -BY Tank Farms.	06/96
T2B-97-115	Provide vapor monitoring equipment with alarm capability and/or ventilation upgrades to tanks where warranted (Safety Initiative 2p).	04/97
--	Recommend resolution of tank vapor safety issue for high hazard tanks.	06/97
--	Recommend resolution of tank vapor safety issue for all remaining tanks.	11/97

4.2.6 Safety Issue 2-6: Inadequate Response Time to a Leaking Double-shell Tank

4.2.6.1 Background and Description. In 1991 the Department of Energy issued a report to Congress (see Section 1.5) that identified the *"Response Time to a Leaking Double-shell Tank"* as a priority 2 safety issue. This issue was identified due to marginal emergency pumping capability for a leaking double-shell tank.

4.2.6.2 Priority and Strategy. Inadequate response time to a leaking double-shell tank is a priority two safety issue. In the event of a leaking double-shell tank, inadequate response time creates a situation that could potentially lead to an uncontrolled release of radioactive material.

In response to the identification of this safety issue, in the 1991 Department of Energy report to Congress, the Tank Farm Operations and Maintenance program element of the Tank Waste Remediation System has developed measures for double-shell tank emergency pumping preparations. The purpose of these measures is to decrease the time required to respond to a leaking double-shell tank. Activities identified to accomplish this objective include:

- Development of a double-shell tank emergency pumping plan (completed).
- Preparation of design and procurement documentation for equipment identified for emergency pumping.
- Development of transfer procedures to accomplish the pumping activity and maintain the equipment.

Tank Farms Operations and Maintenance plans are to have the ability to begin emergency pumping operations within 30 days of identifying a leak.

4.2.6.3 Work Completed to Date. A double-shell tank emergency pumping plan was developed which includes the steps to be performed with existing equipment and conditions to make an emergency transfer from a double-shell tank in the event of a confirmed leak. In addition, the plan makes several recommendations for modifications and upgrades of existing facilities and equipment that will improve the ability and shorten the time required for completion of emergency pumping activities in double-shell tanks. The double-shell tank emergency pumping plan was completed in September 1994, and a memo identifying equipment necessary to expedite double-shell tank waste transfer was completed in November 1994.

4.2.6.4 Work Required to Resolve the Safety Issue. Equipment required for emergency pumping of a leaking double-shell tank has been identified for procurement in 1995. Designs will be completed and issued for equipment identified in this listing. Using approved designs and vendor files, preventative maintenance procedures will be developed, as appropriate, for these items to be stored until needed.

Emergency transfer procedures will be developed using the equipment identified in the *Double-Shell Tank Emergency Pumping Plan*. Procedures will be developed for the transfer of waste from non-Watch List tanks in 241-AW, 241-AP, 241-AN, 241-AY, and 241-SY tank farms. The transfer procedures will provide routes and methods of transfer.

4.2.6.5 Cost and Schedule. Tank Farm Operations and Maintenance plan is to have double-shell tank emergency pumping capability by the end of 1995. Cost estimates developed for double-shell emergency capability are split into costs for developing emergency pumping capability and costs for maintaining the capability. The cost to develop the needed capacity is estimated to be on the order of $1.5 million; the cost for maintenance of double-shell tank emergency pumping capabilities is estimated through fiscal year 2015 to be on the order of $9 million. Important milestones are listed in Table 4-15.

Table 4-15. Milestones Associated with Safety Issue 2-6.

Milestone	Description	Completion Date
T2A-95-262	Issue approved tank farm specific procedures.	05/95
--	Prepare fabrication documentation, certified vendor information, and maintenance procedures	06/95
--	Prepare design and procurement documentation for equipment identified to emergency pump double-shell tanks	09/95
T2A-95-263	Double-shell tank emergency pumping readiness. Issue transfer procedures from non-Watch List tanks, vendor information and maintenance procedures to maintain readiness of equipment.	09/95
--	Procure emergency pumping capability for double-shell tanks.	12/95
--	Procure and fabricate new double-shell tank emergency pumping equipment.	12/95
--	Maintain emergency pumping capability through 2015	2015

4.2.7 Safety Issue 2-7: Storage of High-Level Waste in Tanks with No Secondary Containment

4.2.7.1 Background and Description. Between 1943 and the mid-1960s, 149 tanks with no secondary containment were constructed. The oldest of the single-shell tanks have been in use for nearly 50 years. These single-shell tanks contain various combinations of sludge, saltcake, and drainable liquid. Sixty-seven of these tanks have leaked or are assumed to have leaked (Hanlon 1995).

The tanks contain drainable liquid; there is liquid standing above the solids, as well as liquid contained within the sludge and saltcake. Most of this liquid can be pumped out of the tank. With the pumpable liquids removed from the single-shell tanks, very little liquid should remain to potentially leak to the ground. The remaining solids are relatively immobile. After the tanks have been interim-isolated, the remaining solids will be left in place in the single-shell tanks until a final disposal method for single-shell tank waste is implemented in compliance with the Tri-Party Agreement.

One hundred and six single-shell tanks have been interim-stabilized, with most of the drainable liquid pumped out and transferred to the double-shell tanks (Hanlon 1995). Forty-three tanks have not been interim stabilized (Hanlon 1995). Tank 241-C-106 will not be interim stabilized due to high heat concerns (see Section 4.1.4). Interim-stabilization is scheduled to be completed by the end of fiscal year 2000, in accordance with Tri-Party Agreement Milestone M-41-00. (Note: Pumping will be completed in 1999.)

Tri-Party Agreement Milestone 41-01-T02 calls for the complete removal of pumpable liquids from five tanks. This milestone is to be accomplished by November 1995.

4.2.7.2 Priority and Strategy. *Storage of High-Level Waste in Tanks with No Secondary Confinement* is a priority two safety issue. Because the single-shell tanks do not have secondary confinement, they represent a situation where some of the conditions potentially could lead to an uncontrolled release of radioactive material. A breach in tank integrity due to corrosion, a seismic event, or other source could lead to such a release. However, leak detection and emergency pumping capabilities would have to fail to have an uncontrolled release of radioactive material. The likelihood of such an event is small.

The strategy for resolving this safety issue is to remove all pumpable liquid (to the extent possible) and isolate the tank from further activity until final waste retrieval can be accomplished. Removal of drainable liquid is accomplished through interim stabilization of the tanks. "Interim stabilized" is an administrative designation which indicates a tank contains less than 190,000 liters (50,000 gallons) of drainable interstitial liquid and less than 19,000 liters (5,000 gallons) of supernatant liquid. Interim stabilization is sometimes achieved through jet pumping of a tank. A tank is isolated from further activity through intrusion prevention. "Intrusion prevention" is an administrative designation reflecting the completion of the physical effort required to minimize the addition of liquids to an inactive tank. Under no circumstances are electrical or instrumentation devices disconnected or disabled during the intrusion prevention process. Interim stabilization and intrusion prevention of a tank minimize the chance of a leak by reducing drainable liquid in the tank and eliminating the possibility of inadvertent addition of liquid, which could then leak, to the tank.

As indicated above, intrusion prevention and interim isolation are methods to mitigate the safety issue. Resolution will not be achieved until 2024 when all the waste has been retrieved from the single-shell tanks.

4.2.7.3 Work Completed to Date. One-hundred and eight single-shell tanks have been interim stabilized. Tanks 241-T-111 and 241-BX-111 are the only tanks that have been interim stabilized since the issuance of the 1993 report on status of safety issue resolution at the Hanford Site. There are several reasons interim stabilization was not performed during this time. The tank farms were on stand-down for much of this time. The effects of interim stabilization on tanks with other safety issues was/is being reviewed. However, other tasks related to interim stabilization were completed during the stand-down in the tank farms. These tasks include:

- Completion of safety analysis report to allow alternative methods for transfer of radioactive waste within single-shell tank farms. This completed Tri-Party Agreement Milestone M-41-02-T01.

- Completion of a detailed schedule showing positive and negative impacts of the 1993 tank farms stand-down on the interim stabilization program. This completed Tri-Party Agreement Milestone M-41-04.

- Completion of pertinent portions of the nuclear operator systems class and on-the-job training that relate to the operator routines and liquid level monitoring. Documentation of operator completion of training was provided to the Washington State Department of Ecology and the United States Department of Ecology.

- Initiated interim stabilization of three additional single-shell tanks. This completed Tri-Party Agreement Milestone M-41-01-T01.

- Initiated interim stabilization of two additional single-shell tanks. This completed Tri-Party Agreement Milestone M-41-01-T03.

- Completion of the draft curriculum for the upgraded maintenance training program and an implementation schedule for that training by the U.S. Department of Ecology. This documentation was provided to the U.S. Environmental Protection Agency and Washington State Department of Ecology, completing the Tri-Party Agreement Milestone M-41-06.

- Completion of safety studies and analyses on interim stabilization of remaining Watch List tanks. Reports were provided to the Washington State Department of Ecology and the U.S. Environmental Protection Agency in December 1994, completing the Tri-Party Agreement Milestone M-41-06.

4.2.7.4 Work Required to Resolve the Safety Issue. Work required to mitigate the safety issue until it can be resolved through waste retrieval includes the interim stabilization and intrusion prevention of 41 single-shell tanks (Tank 241-C-106 will not be interim stabilized due to high heat concerns, see Safety Issue 1-4). All tanks that have not been interim stabilized (and therefore can not be intrusion prevented) have been partially interim isolated. Partial interim isolation indicates the completion of physical effort required for intrusion prevention, except for isolation of risers and piping that is required for jet pumping or for other methods of stabilization.

Activities related to interim stabilization include: preparing unreviewed safety screenings/evaluations; monitoring safety reviews and tank monitoring data for impact on stabilization activities; preparation of work packages; repairing/replacing and calibrating existing equipment, instrumentation, and alarms; evaluating and repairing/replacing utilities; design and procurement of materials and equipment; troubleshooting and resolution of operating problems during pumping; failure analysis; technical analysis of liquid volumes and tank status; pre- and post-pumping in-tank photographs; technical support in the response to and evaluation of unplanned events and process upsets; and identifying more cost effective ways to perform the work.

The schedule for interim stabilization is dictated by Milestone M-41-00 of the Tri-Party Agreement (Ecology et al. 1994). The milestone is shown in Table 4-16.

Table 4-16. Milestone M-41-00 Description and Schedule.

Milestone	Description	Completion Date
M-41-00	Complete single-shell tank interim stabilization. Complete interim stabilization activities for all single-shell tanks except 241-C-106 (to be retrieved in accordance with milestone M-45-03). Complete intrusion prevention for all single-shell tanks except 241-C-106.	9/00

Table 4-16. Milestone M-41-00 Description and Schedule.

Milestone	Description	Completion Date
M-41-00 (continued)	The completion of this milestone is dependent upon the following assumptions: 1. Safety studies will be completed with objective of allowing pumping in accordance with interim milestones. 2. Work Commences in the tank farms on October 1, 1993, for interim stabilization preparations, as required by the milestone schedules. During the stand down in the tank farms, schedules for the following interim milestones may be affected: M-41-01, M-41-02, and M-41-16. Every effort will be made to recover the original schedule as specified below. Interim milestones for start of pumping and target milestones for completion for each group of tanks will be reviewed and affirmed annually with Washington State Department of Ecology and the U.S. Environmental Protection Agency. Upon start of the pumping, efforts to continue pumping will be continuously supported so that pumping is conducted as expeditiously as practical. If pumping is interrupted to a degree that jeopardizes the target milestone, the unit managers shall meet in the effort to agree on a recovery plan. If such an agreement cannot be made at the unit manager level, a formal recovery plan will be prepared and submitted to the Washington State Department of Ecology for approval that supports the major milestone date of 9/2000, if technically feasible.	

Additional key milestones for resolving *Safety Issue 2-7: Storage of High-Level Waste in Tanks with No Secondary Confinement* are shown in Table 4-17.

Table 4-17. Milestones Associated with Safety Issue 2-7.

Milestone	Description	Completion Date
T2A-97-102	Start interim stabilization of 4 Ferrocyanide Watch List tanks in the 241-BX/BY tank farms (TPA M-41-12).	08/95
T2A-95-188	Complete interim stabilization of 5 single-shell tanks (TPA M-41-01-T02).	11/95
T2A-96-101	Start interim stabilization of 7 non-Watch List tanks in the 241-S tank farm (TPA M-41-09).	01/96
T2A-96-102	Start interim stabilization of 2 Flammable Gas Watch List tanks in the 241-A/AX tank farms (TPA M-41-10).	04/96
T2A-96-103	Start interim stabilization of 4 Flammable Gas Watch List tanks in the 241-U tank farm (TPA M-41-11).	08/96

Table 4-17. Milestones Associated with Safety Issue 2-7.

Milestone	Description	Completion Date
2A-95-106	Start interim stabilization of 3 Organic Watch List tanks in the 241-U tank farm (TPA M-41-13).	08/96
T2A-95-105	Start interim stabilization of 1 non-Watch List tank in the 241-U tank farm (TPA M-41-08).	08/96
T2A-96-114	Complete intrusion prevention in 9 single-shell tanks.	09/96
T2A-96-100	Complete interim stabilization of 1 non-Watch List tank in 241-V tank farm (TPA M-41-08-T01)	04/97
T2A-96-112	Complete interim stabilization of 1 non-Watch List tank in the 241-U tank farm (TPA M-41-08-T01).	04/97
T2A-97-108	Complete interim stabilization of 7 non-Watch List tanks in the 241-S tank farm (TPA M-41-09-T01).	04/97
T2A-97-103	Start interim stabilization of 7 Flammable Gas Watch List tanks in the 241-S/SX tank farms (TPA M-41-14).	06/97
T2A-97-104	Start interim stabilization of 2 Organic Watch List tanks in the 241-S/SX tank farms (TPA M-41-15).	06/97
T2A-97-109	Complete interim stabilization of 4 flammable gas Watch List tanks in the 241-U tank farm (TPA M-41-11-T01).	09/97
T2A-97-112	Complete intrusion prevention in 4 single-shell tanks.	09/97
T2A-97-101	Complete interim stabilization of 4 Flammable Gas Watch List tanks in the 241-U tank farm (TPA M-41-11-T01).	09/97
--	Complete interim stabilization of 7 Flammable Gas Watch List tanks in the 241-S/SX tank farms (TPA M-41-14-T01).	12/97
T2A-97-110	Complete interim stabilization of 3 Organic Watch List tanks in the 241-U tank farm (TPA M-41-13-T01).	01/98
--	Start interim stabilization of 1 non-Watch List tank in the 241-T tank farm (TPA M-41-16).	03/98
--	Start interim stabilization of 1 Flammable Gas Watch List tank in the 241-T tank farm (TPA M-41-18).	04/98
--	Start interim stabilization of 1 Ferrocyanide Watch List tank in the 241-T tank farm (TPA M-41-17).	04/98
--	Complete interim stabilization of 1 Ferrocyanide Watch List tank in the 241-T tank farm (TPA M-41-17-T01).	05/98
--	Complete interim stabilization of 1 Flammable Gas Watch List tank in the 241-T tank farm (TPA M-41-18-T01).	07/98
--	Complete interim stabilization of 1 non-Watch List tanks in the 241-T tank farm (TPA M-41-16-T01).	08/98
--	Start interim stabilization of 1 Organic Watch List tank in the 241-C tank farm (TPA M-41-19).	09/98
--	Complete interim stabilization of 4 Ferrocyanide Watch List tanks in the 241-BX/BY tank farms (TPA M-41-12-T01).	12/97

Table 4-17. Milestones Associated with Safety Issue 2-7.

Milestone	Description	Completion Date
--	Complete interim stabilization of 2 Flammable Gas Watch List tanks in the 241-A/AX tank farms (TPA M-41-10-T01).	12/98
--	Complete interim stabilization of 1 Organic Watch List tank in the 241-C tank farm (TPA M-41-19-T01).	03/99
--	Complete interim stabilization of 2 Organic Watch List tanks in the 241-S/SX tank farms (TPA M-41-15-T01).	03/99
--	Issue draft curriculum and schedule for upgraded maintenance training.	09/98
--	Maintain interim stabilization capability through 2010.	2010
--	Safety issue resolved (Complete waste retrieval from all single-shell tanks. TPA M-45-00).	09/24

4.2.7.5 Cost and Schedule. The cost for interim stabilization and intrusion prevention of all remaining single-shell tanks as estimated by the Tank Waste Remediation System Technical, Cost, and Schedule baseline is on the order of $99 million. This includes maintaining the capability to interim stabilize tanks until the year 2000. The schedule for interim stabilization is given in the section above.

4.2.7.6 Alternative Strategy or Treatment. None identified.

4.2.8 Safety Issue 2-8: Potential for Nuclear Criticality in High Level Waste Tanks

4.2.8.1 Background and Description. In 1991, an Unusual Occurrence Report was filed involving nuclear criticality safety in Tank 241-C-104. Analysis of a core sample indicated 185 kilograms (407 pounds) of fissile material, which is greater than the criticality prevention specification of 125 kilograms (275 pounds). A review team discovered an error in the analysis, which, when corrected, indicated the tank contained only 56 kilograms (120 pounds) of plutonium. The team concluded that a nuclear criticality accident in the tank farm is probably not an imminent risk; however, the lack of definitive knowledge of the fissile material inventory and distribution within the tanks was identified as a primary concern. Historical records are incomplete and predictions based on these limited records often disagree significantly with sample information. A subsequent review of the safety analysis report conclusion that a criticality is "not credible" cannot be supported for a full range of potential tank constituents. As a result, an unreviewed safety question was declared.

The U.S. Department of Energy Nuclear Criticality Safety Review of Hanford High-Level Radioactive Waste Tank Farms issued several recommendations that need to be implemented to fully resolve this safety issue.

Recommendation B states, in part: *"Alternative measurement methods and analyses should be adopted to estimate fissile material inventories and distributions within the waste tanks...In addition to core sampling, alternative measurement techniques should also be considered."*

Recommendation I states, in part: *"Investigations of tank anomalies should include monitoring for short-lived isotopes to determine if a criticality occurred, and detection criteria should be developed to ensure that monitoring would detect in-tank criticality accidents."*

Efforts by the Waste Tank Safety Program to (1) gather additional data to evaluate the safety analysis report position that criticality is not credible; and (2) perform a risk assessment and determine controls that would be the basis of a revised safety analysis report to include a criticality event have been completed. The results of these activities provide a basis for resolving the unreviewed safety question. The Justification for Continued Operation resulting from the declaration of the unreviewed safety question was written by Westinghouse Hanford Company and approved for implementation by the Program Secretarial Officer on August 31, 1992. The justification for continued operation required further evaluation for stabilization and some waste-intrusive activities.

Two of Secretary O'Leary's safety initiatives are associated with the resolution of this safety issue. Both initiatives have been completed as indicated below:

- **Safety Initiative 2v,** upgrade the tank-waste-contents data base, safety documentation and risk assessment concerning credibility of a nuclear criticality by September 1993. This safety initiative was completed on November 3, 1993, per Westinghouse Hanford Company letter number 9207614.R3.

- **Safety Initiative 2w,** issue approved criticality safety analysis and, if needed, a control plan and unreviewed safety question was to be closed by March 1994 (Tri-Party Agreement Milestone M-40-11 completion date June 1994). This safety initiative was closed March 17, 1994, per U.S. Department of Energy memorandum from T.P. Grumbly to Manager of Richland Department of Energy Manager.

4.2.8.2 Priority and Strategy. Potential for Nuclear Criticality in High Level Waste Tanks is a Priority 2 safety issue because under extreme assumptions the tanks could achieve criticality which could potentially lead to an uncontrolled release of radioactive waste.

WHC-EP-0563, *Upgrade Activities for the Criticality Safety Program of Hanford High-Level Radioactive Waste Tank Farms* (Vail 1992), describes the plan for implementing resolution of the findings and recommendations identified by the review team of offsite experts, as well as the activities which were required to close the unreviewed safety question. Final closure of the unreviewed safety question was accomplished after completing a safety analysis which described the tank waste as being highly subcritical.

4.2.8.3 Work Completed to Date. Work completed towards resolution of this safety issue include activities that were specifically targeted for closure of the unreviewed safety question as well as activities towards resolution of the safety issue and findings and recommendations of the offsite expert review. Work completed prior to the 1993 status report include:

- Unreviewed Safety Question Resolution:
  - A Dose Consequence Analysis was issued.

- Resolution of safety issue and findings and recommendations of offsite review:
  - The Waste Tank Characterization Plan has been modified for consideration of criticality safety issues.

Since the 1993 report:

- Issued upgraded safety assessment concerning tank waste contents, *High Level Waste Tank Subcriticality Safety Assessment*" (Braun 1994).

- Issued approved criticality safety analysis

- Closed unreviewed safety question in March 1994 (Tri-Party Agreement Milestone M-40-11 completion date June 1994).

4.2.8.4 Work Required to Resolve the Safety Issue

- Resolution of findings and recommendations of offsite expert review:

- Alternative methods of evaluating the fissile material inventory and distribution in the tanks have been narrowed to four separate groups. This effort is continuing.

- Development of detection criteria for, and evaluation of, possible or expected 'signatures' of postulated criticality events.

Continuous air monitors capable of detecting and distinguishing short-lived isotopes have been identified by Westinghouse Hanford Company as technology capable of detecting a criticality event. Studies underway may show that alternate methods of measuring fissile material are not needed to store waste in a safe manner but will likely be needed during waste retrieval operations in those tanks with a high inventory of fissile material.

4.2.8.5 Cost and Schedule. The total life cycle cost for resolving the nuclear criticality safety issue is on the order of $6.3 million. Important milestones are listed in Table 4-18.

Table 4-18. Milestones Associated with Safety Issue 2-8.

Milestone	Description	Completion Date
--	Complete a quantitative risk assessment of a criticality in a waste tank	06/96
T2B-95-155	Complete fissionable material measurements on 6 tanks	06/96
T2B-96-351	Issue report on evaluation of the need for methods of criticality event detection	08/96

Table 4-18. Milestones Associated with Safety Issue 2-8.

Milestone	Description	Completion Date
--	Complete measurements utilizing alternative methods of measuring fissile material in at least 6 tanks	09/96
T2B-95-162	Issue evaluation report on alternate measurement technology for fissionable material	09/96
--	Issue a report on criticality event characterization	12/96
--	Issue a report of an evaluation of the need for a criticality event monitoring system in tank farms	03/97
--	Issue a report providing recommendations of the viability for measuring fissile material in the waste tanks.	09/97
T2B-97-361	Issue revised safety analysis to include new data and analysis	09/97
T2B-97-360	Issue final report on criticality event characterization	09/97
--	Recommend resolution of nuclear criticality safety issue	09/99
--	Recommend closure of the criticality safety issue (TPA Milestone M-40-12)	09/99

4.2.8.6 Alternate Strategies or Treatments. No alternate strategies or treatments have been identified.

4.3 PRIORITY 3 SAFETY ISSUES

Priority 3 safety issues are those issues and/or situations that could lead to the future release of radioactive waste during five to thirty years of intermediate storage of high-level waste (prior to waste removal, treatment and vitrification.) There are seven Priority 3 safety issues at Hanford. They are:

- Insufficient Tank Safety Capacity to Handle Waste Resulting from Resolution of Existing Safety Issues (SI 3-1),
- Cracked Tank Farm Ventilation Header (SI 3-2),
- Insufficient Hydroxide Concentration in Tanks (SI 3-3),
- Inadequate Sealing of Single-Shell Tanks to Prevent Liquid Intrusions that could then Leak Contamination out of the Tank (SI 3-4),
- Inadequacies in Waste Transfer Line Leak Detection (SI 3-5),
- Excessive Unfiltered Airflow Passages Into Tanks (SI 3-6),
- Uncharacterized Corrosion of High Level Waste Tanks (SI 3-8), and

- Issues that would be numbered Safety Issue 3-7 and Safety Issue 3-9 do not apply to Hanford.

4.3.1 Safety Issue 3-1: Insufficient Tank Storage Capacity to Handle Waste Resulting from Resolution of Existing Safety Issues

4.3.1.1 Background and Description. Based on the *Waste Volume Projection Report* there may not be enough room in existing double-shell tanks to store wastes that could be generated as other safety issues are resolved (Koreski 1986). As a result, some activities could be halted unless new tanks that meet all regulations are provided by fiscal year 1999. One alternative is to provide additional double-shell tank storage capacity. The Multi-Function Waste Tank Facility, Westinghouse Hanford Company Project W-236A, will provide the new tank farms. Project W-236A is a 1993 Major Systems Acquisition (greater than $100 million price tag) scheduled for completion in fiscal year 1999. The new tanks will provide safe and environmentally compliant, encased interim storage for the Hanford Site high level waste. Waste to be stored in these tanks is projected to come from three sources (Goldberg 1994): (1) waste being generated as a result of normal operations; (2) waste generated during cleanup of facilities; and (3) waste stored in existing single and double-shell tanks on site that will be retrieved to resolve safety issues.

4.3.1.2 Priority and Strategy. Insufficient tank volume to handle waste from resolution of other safety issues is a Priority 3 safety issue.

Technical support for the Multi-Function Waste Tank Facility is provided by both ICF Kaiser Engineers Hanford and Westinghouse Hanford Company Central Engineering. Westinghouse Hanford Company Central Engineering supports ICF Kaiser design efforts by performing specialized engineering tasks in heat transfer, thermal hydraulics, materials studies, etc.

4.3.1.3 Work Completed to Date. To date, the Functional Design Criteria, Preliminary Safety Evaluation, Preliminary Safety Analysis Report, Action Description Memorandum, Advanced Conceptual Design Report, and supporting documents have been completed for Project W-236A. The project has been successfully validated by the Department of Energy. The definitive design of Project W-236A began in January 1993 and the detailed design of the Multi-Function Waste Tank Facility 200 West Area tanks began in May 1994. This site preparation Design Package - 200 East Package 25 was completed in early fiscal year 1995. Design packages for the site, tank construction, and demolition activities are complete as of early 1995.

The following Tri-Party Agreement milestones have been fulfilled:

- **M-31-00**, Complete conceptual design report for up to four tanks - completed two months early in July 1994.

- **M-31-01T**, Completed permitting strategy among signers of the Tri-Party Agreement in May 1992.

4.3.1.4 Work Required to Resolve the Safety Issue. Long-term plans include completing design, procurement and construction, permitting, safety and environmental documentation, and hot startup of the Multi-Function Waste Tank Facility in support of Tri-Party Agreement Milestone M-42-00.

4.3.1.5 Cost and Schedule. The cost and schedule are based on the *Overview of the Design and Operation of the Multi-Function Waste Tank Facility, Project W-236A* (Goldberg 1994). The total project cost for resolving this safety issue is on the order of $435 million. Approximately $421.3 Million will be capital funds distributed between project management, design, construction, and construction management. The remaining $13.7 million will be expense funds distributed among conceptual, research and development, *National Environmental Policy Act* documentation and other costs. Important Project W-236 milestones are listed in Table 4-19.

Table 4-19. Project W-236A Milestones.

Milestone	Description	Completion Date
T2C-95-702	Jumper design package/package 70 (delayed indefinitely, last package to be completed to minimize cost)	12/94
T2C-95-700	Administration building design package/package 30 (delayed indefinitely until start of construction is established)	12/94
T2C-95-705	Support facility design package/package 50	05/95
T2C-95-701	Construction fence design package/package 60	07/95
T2C-96-704	Support facility design package/package 55	01/96

Tri-Party Agreement Milestones have also been established for the Multi-Function Waste Tank Facility. They are listed in Table 4-20.

Table 4-20. Tri-Party Agreement Milestones for Project W-236A.

Milestone	Description	Completion Date
M-42-01-T02	Begin construction of the Multi-Function Waste Tank Facility 200W Area tanks (delayed due to constraints by Environmental Impact Statement)	09/94
M-42-02-T01	Begin construction of the Multi-Function Waste Tank Facility 200E Area tanks.	02/95
M-42-02-T02	Complete detailed design of the Multi-Function Waste Tank Facility 200E Area tanks.	01/96
M-42-01	Begin hot operations in the 200W Area tanks.	02/98
M-42-02	Complete construction of the Multi-Function Waste Tank Facility 200E Area tanks.	09/98
M-42-00	Provide additional double-shell tank capacity	12/98

4.3.2 Safety Issue 3-2: Cracked Tank Farm Ventilation Header

4.3.2.1 Background and Description. During the installation of a sampling port (welding) in an underground ventilation line for the 241-AZ Tank Farm, cracking was observed in the stainless steel pipe. This was discovered in May 1988. If the ventilation line fails, causing a ventilation failure, cooling of the tank contents would be severely hampered, which could result in a structural failure and a release of radioactivity to the environment. In addition, cracks elsewhere in the ventilation line could be releasing contamination to the soil. The cause of the problem is not fully understood at this time. Potential solutions to be implemented range from patching or replacing a section of the ventilation line to a major line item project for replacing the ventilation header.

Schedule Change From 1991 to 1993 Report. Resolution of this safety issue has been accelerated 21 months, from September 1997 to January 1996. This is due to a strategy that involves installing a new stainless steel ventilation header connecting AY and AZ tank farms. This is being accomplished as part of Project W-030, Tank Farm Ventilation Upgrade.

Schedule Change From 1993 Report. The schedule for completing Project W-030, which resolves the safety issue, was changed in September 1993. The definitive design schedule was changed from April 1994 to July 31, 1994. The complete construction schedule was changed from January 1996 to October 31, 1996. A start construction date of October 31, 1994 and a begin operations date of December 31, 1996 were added. All are now Tri-Party Agreement milestones.

4.3.2.2 Priority and Strategy. If the vent line fails causing ventilation loss, cooling of tank contents would be severely hampered and may cause a release to the environment. In addition, cracks elsewhere in the ventilation line could be releasing contaminants to the soil. Based on these potential occurrences, the safety issue meets the criteria of priority 3.

Efforts to resolve this safety issue have focused on development of a Line Item Project W-030 (Tank Farm Ventilation Upgrades). Completion of this project will provide the essential safety class systems necessary to provide safe and efficient storage of radioactive waste.

As part of this project a new buried stainless steel ventilation pipeline will connect the existing 241-AY and 241-AZ tank farms to a new ventilation building. The ventilation building will house treatment and filter equipment designed to remove radioactive and hazardous wastes to Department of Energy standards. This project replaces the cracked ventilation lines; thus, completion of this project will close out this safety issue.

4.3.2.3 Work Completed to Date. Work Completed Prior To the 1993 Report. None identified.

Work Completed Since the 1993 Report

Definitive design for Project W-030 was completed on May 20, 1994 and construction of the project started September 6, 1994. Each of these tasks were completed nearly two months ahead of the revised schedule.

4.3.2.4 Work Required to Resolve the Safety Issue. Plans call for completion of construction by October 31, 1996.

4.3.2.5 Cost and Schedule. Project W-030 capital cost is $24.6 million. Completion of this project resolves this safety issue. Important milestones are listed in Table 4-21.

Table 4-21. Milestones Associated with Safety Issue 3-2.

Milestone	Description	Completion Date
T2C-97-101	Complete construction of tank farm ventilation upgrades (Tri-Party Agreement Milestone M-43-01B).	10/96
T2C-97-117	W-030 Tank Farm Ventilation Upgrades, complete final safety analysis report.	12/96
T2C-97-102	Begin operations (Tri-Party Agreement Milestone M-43-01C).	12/96
T2C-97-100	Complete Project W-030, Tank Farm Ventilation Upgrades (Tri-Party Agreement Milestone M-43-01).	12/96

4.3.2.6 Alternative Strategies or Treatments. None identified.

4.3.3 Safety Issue 3-3: Insufficient Hydroxide Concentration in Tanks

4.3.3.1 Background and Description. The waste in Tank 241-AN-107 does not meet the tank farm composition operating specification for hydroxide ion (OH^-) concentration of 0.3 moles per liter (Molar). This tank was first identified as being out of operating specification range in 1985 and its has remained unchanged for nearly 10 years. The operating specification for hydroxide concentration is dependent upon both the tank temperature and nitrate concentration. At operating temperatures below 100 °C (212 °F) and a nitrate concentration greater than 3 Molar, the operating specification for hydroxide ion concentration is 0.3 Molar. At approximately 0.05 Molar, the hydroxide concentration of the waste in Tank 241-AN-107 is roughly an order of magnitude lower than specification. The composition operating specifications are designed to control corrosion of the tanks to acceptable levels. The low hydroxide condition of Tank 241-AN-107 waste does not present a general corrosion problem, but can potentially cause stress corrosion cracking. Measurements made by Pacific Northwest Laboratory of the corrosion potential of A537 steel in synthetic tank solutions, in actual waste samples, and in Tank 241-AN-107 using a corrosion probe show that the waste chemistry is in a region where stress cracking could occur. Laboratory measurements confirm that increasing the hydroxide concentration to 0.5 Molar decreases the corrosion potential to where stress corrosion cracking can be avoided.

Laboratory studies also indicate that the half-life of sodium hydroxide added to Tank 241-AN-107 waste is roughly 8,000 days (approximately 22 years). This low rate of hydroxide consumption is confirmed by actual waste samples; the hydroxide concentration in Tank 241-AN-107 has remained relatively stable since sampling was initiated in November 1984. Tanks 241-AN-102 and 241-AZ-102 have been identified as tanks needing further evaluation of hydroxide concentration.

4.3.3.2 Priority and Strategy. Insufficient hydroxide concentration is a Priority 3 safety issue because low hydroxide concentrations create an environment that could lead to tank corrosion. Excessive tank corrosion would jeopardize the integrity of the tank creating a situation that could lead to the future release of fission products.

In fiscal year 1992, an action plan for adding sodium hydroxide to Tank 241-AN-107 was prepared. The plan recommended a two phased approach for solving the hydroxide deficiency problem. Phase 1 would consist of adding concentrated sodium hydroxide to the liquid layer and mixing the contents with readily available equipment. Mixing would be done to the extent possible to avoid exceeding the 10 Molar hydroxide upper concentration specification anywhere in the tank. This phase would correct the waste chemistry in over 87% of the tank wall surface and minimize the area susceptible to stress corrosion cracking. If phase 1 does not resolve the safety issue, then phase 2 would be implemented.

Phase 2 consists of developing, demonstrating, and implementing a process to uniformly mix the total tank contents (solid and liquid layers) and adding the required hydroxide to bring the tank back within operating specification. Mixing presents an engineering challenge because both the 3,520,000 liters (930,000 gallons) supernatant liquid layer and 507,000 liters (134,000 gallons) solids layer will have to be uniformly mixed to ensure that the steel liner is exposed to proper chemistry. Alternative techniques are being reviewed to determine how sodium hydroxide can be added to the tank to ensure mixing in both the liquid layer and the underlying solids layer. This phase is complicated by the availability of only one pump pit, potential interference with 21 airlift circulators installed in the tank, and the need to ensure the structural integrity of in-tank components such as thermocouple trees.

One-twelfth scale mixing tests indicate that phase 1 sodium hydroxide addition/mixing activities will fully resolve the low hydroxide safety issue in Tank 241-AN-107. If this result is verified by evaluation of phase 1 effectiveness, the phase 2 operations will not be necessary.

4.3.3.3 Work Completed to Date. Fiscal years 1993 and 1994 accomplishments towards the resolution of the low hydroxide safety issue include the following activities:

- Identified methods for adding and mixing sodium hydroxide
- Sampled and analyzed liquid and solid layers
- Designed equipment, instrumentation, and electrical modifications
- Modeled mixer pump operation
- Conducted structural analysis of hydraulic loads
- Prepared safety and environmental documentation
- Procured and/or modified equipment
- Prepared procedures, modified tank riser, and conducted run-in test of tank pump.

4.3.3.4 Work Required to Resolve the Safety Issue. Phase 1 will continue in fiscal year 1995 by completing electrical upgrades and installing sodium hydroxide injection and mixing systems. Activities during fiscal years 1996 and 1997 include: procure sodium hydroxide, conduct training, add sodium hydroxide, complete mixing tank contents and evaluate the performance of the process. Also during fiscal year 1996, an assessment of sodium hydroxide addition requirements, if any, will be conducted for Tanks 241-AN-102 and 241-AZ-102.

Long term plans for development and implementation of Phase 2 (if required) is deferred beyond fiscal year 1999 because of insufficient resources in fiscal years 1996-1999. Project definition for Phase 2 will be initiated by conducting an engineering study to evaluate the alternatives and to identify the technology that needs to be developed before a final mitigation method is selected and implemented. Selection of a mitigation concept will be followed by conceptual design, definitive design, procurement, fabrication, construction, and implementation in Tank 241-AN-107. Completion of Phase 2 cannot be accurately predicted until after engineering studies are complete. If mitigation of the low hydroxide deficiency requires a construction line item, the term could be as long as seven years following completion of engineering studies.

4.3.3.5 Cost and Schedule. The cost for resolving this safety issue is estimated to be on the order of $7.9 million. Important milestones are given in Table 4-22.

Table 4-22. Milestones Associated with Safety Issue 3-3.

Milestone	Description	Completion Date
TW2-94-423	Complete installation of sodium hydroxide injection/mixing system in Tank 241-AN-107.	01/95
TW2-96-369	Complete assessment of sodium hydroxide addition requirements for Tanks 241-AN-102 and 214-AZ-102.	09/96
--	Complete phase 1 sodium hydroxide mixing operations in Tank 241-AN-107 and evaluate performance.	12/96
TW2-97-371	Complete Tank 241-AZ-102 caustic mixing operations and evaluate performance.	09/97

4.3.3.6 Alternative Strategies or Treatments. As an alternative to a Phase 2 construction line item, an assessment was completed during fiscal year 1994 to determine if the mixer pump employed during phase 1 could be modified to accomplish the phase 2 caustic addition. This could result in substantial savings and accelerate completion of phase 2 activities.

4.3.4 Safety Issue 3-4: Inadequate Sealing of Single-Shell Tanks to Prevent Liquid Intrusions That Could Then Leak Contamination Out of the Tank

4.3.4.1 Background and Description. The sealing (intrusion prevention) of single-shell tanks is a complex process that is designed to prevent intrusion of liquids (such as rainwater) from entering the tanks after drainable liquid has been removed. Intrusion prevention is a process of plugging or otherwise blocking pipelines leading into single-shell tanks, and sealing pump or valve pits that drain back into single-shell tanks, or installing barriers to avoid inadvertent liquid addition to a stabilized single-shell tank. In the past intrusion prevention, formerly known as interim isolation, has not been completely successful in preventing all intrusions into these tanks. An engineering study has recently been completed by Westinghouse Hanford Company and ICF Kaiser Hanford, that reviews past intrusion prevention practices and offers several recommendations to ensure the success of future intrusion prevention activities.

4.3.4.2 Priority and Strategy. The basis for this safety issue in the 1991 (Wilson and Reep 1991) report was the concern that tanks with inadequate intrusion prevention measures could experience increases in tank waste volume. This would negate stabilization efforts that reduce the tank volume to minimize the amount of waste in the tank that could be released to the environment in the event of a leak. The scope of the safety issue was to identify and correct inadequacies in the intrusion prevention process.

The 1993 report (Reep 1993) stated that the base costs for the intrusion prevention process had been removed and that the safety issue now addresses only additional methods to eliminate intrusions in single-shell tanks following completion of interim isolation. Currently the intrusion prevention process is part of the interim stabilization effort. Intrusion prevention of single-shell tanks supports Tri-Party Agreement Milestone M-41-00. Complete interim stabilization and intrusion prevention for all single-shell tanks except 241-C-106. This milestone is detailed in Section 4.2.7.4.

4.3.4.3 Work Completed to Date. There was no activity on this safety issue in fiscal years 1992 and 1993, due to the relatively low overall tank farm priority for technology improvements.

Westinghouse Hanford Company and ICF Kaiser Engineers Hanford recently finished a comprehensive engineering review of past practices to prevent liquid intrusions into interim stabilized tanks. The report also issued several recommendations for future activities which were not available at the time of this report.

4.3.4.4 Work Required to Resolve Safety Issue. The current schedule calls for intrusion prevention of 7 and 4 single-shell tanks in fiscal years 1996 and 1997, respectively, and intrusion prevention of all single-shell tanks (except 241-C-106) by the end of fiscal year 2000. The successful completion of this schedule requires that single-shell tanks be interim stabilized according to Tri-Party Agreement Milestone M-41-00.

4.3.4.5 Cost and Schedule. The costs associated with the resolution of this safety issue will be funded by the Tank Farm Single-shell Tank Stabilization Program. The projected cost for meeting the schedule presented below is on the order of $8.2 million, however, this figure does not include costs associated with support activities such as training and planning. Support costs for intrusion prevention are included in the costs for resolution of Safety Issue 2-7 (see Section 4.2.7.5). Important milestones are listed in Table 4-23.

Table 4-23. Milestones Associated with Safety Issue 3-4.

Milestone	Description	Completion Date
T2A-96-114	Complete intrusion prevention in 9 single-shell tanks	09/96
T2A-97-112	Complete intrusion prevention in 4 single-shell tanks	09/97
--	Safety issue resolved	09/00

4.3.4.6 Alternative Strategies and Treatment. None identified.

4.3.5 Safety Issue 3-5 and System Deficiency 4-8: Possible Inadequacies in Waste Transfer Line Leak Detection/Questionable Transfer Line Concrete Encasement Integrity

4.3.5.1 Background and Description. Safety Issue 3-5 and System Deficiency 4-8 have been combined for this report since both safety items are associated with waste transfer lines. Safety Issue 3-5 was a new safety issue identified in the 1993 report. System Deficiency 4-8 was formerly (In the 1991 report) priority 3 safety issue number 18, Transfer Line Concrete Encasement Integrity and Secondary Containment Compliance.

A network of underground pipelines are used to move waste between chemical processing plants, waste treatment facilities and underground storage tanks. Transfer lines are routed between various types of pits and diversion boxes and terminate inside those pits at nozzles to connect numerous transfer lines. For many years, concrete encasement was used as a secondary containment for transfer piping because it was substantially low in cost than double contained piping. Concrete containment is no longer acceptable to use by current regulations. *Resource Conservation and Recovery Act of 1976* regulations and current Department of Energy Orders call for secondary systems with leak detection devices having specific capabilities. It is not possible to meet these requirements with the current waste transfer system.

4.3.5.2 Priority and Strategy. The priority of this Safety Issue/System Deficiency is based on non-compliance with Resource and Conservation and Recovery Act of 1976 regulations, Department of Energy Orders, and nuclear codes and standards. Also, contaminants have leaked to the environment and many operations are restricted or not allowed. Based on the above, Safety Issue 3-5 meets priority 3 criteria.

Several actions have been initiated to correct tank farm waste tank transfer lines deficiencies and resolve the existing safety issue. Five major projects to upgrade the existing waste transfer systems in the 200 East and West Areas have begun. Double-shell transfer lines not being addressed by planned projects will be assessed for environmental compliance as described in Tank Waste Remediation System Transfer Facility Compliance Plan (Hanson 1994). In addition, there is an ongoing effort to assess the integrity of the existing waste transfer system. The assessments of the tanks are currently underway, and some of the preliminary work has been done on the ancillary equipment (Hanson 1994). The majority of the integrity assessment activities for the ancillary equipment will be coordinated with the currently planned projects. Specifics on how the integrity assessment will be performed can be found in the Tank Waste Remediation System Tank System Integrity Assessments Program Plan (Eacker 1991).

The five projects to upgrade the existing waste transfer system are summarized below. Collectively, these will replace the majority of the existing double-shell transfer lines. Transfer lines supporting the single-shell tank farms are not addressed by these projects because many of these lines are being isolated as the single-shell tanks are stabilized.

Project W-028: Aging Waste Transfer Lines

Project W-028 will provide a reliable long-term high-heat waste transfer system to connect aging waste tank farms with the cross-site transfer system as well as to B-Plant to support terminal cleanout. The new high-heat waste transfer system will consist of 5.030 kilometers (3.12 miles) of double-encased pipelines which connect the 241-AR-151 valve pit with B Plant and the cross-site transfer system. The project will be integrated with the replacement of the cross-site transfer system project. The integrated system will contain new diversion boxes for waste transfer flexibility, instrumentation, and auxiliary equipment for monitoring and leak detection.

Project W-058: Cross-Site Transfer System

Project W-058 will replace piping for the existing cross-site transfer system. A length of 10.4 kilometers (6.5 miles) of encased, cathodically protected pipelines will be designed and installed to withstand design basis seismic events. Encased pipelines will be constructed of stainless steel inner pipe and carbon steel outer encasement. Leak detection devices and pressure testing capabilities will be provided for the encased piping. If there is a failure of the primary piping, leakage into the encasement will drain to and be collected by stainless steel-lined concrete diversion boxes. The project also has booster pumps to allow pumping from the 200 West Area to the 200 East Area, diversion boxes to facilitate connection to existing and future facilities, and a backup flushing system.

Project W-087: 219-S Transfer System

Project W-087 will support retrieval of waste from the 219-S lab facility. The existing transfer lines are mostly direct buried lines that are deficient with current environmental regulations. The project will install transfer lines between the 219-S facility to the 244-S double contained receiver tank, through a diversion box added by the project. From the 244-S double contained receiver tank existing compliant lines will transfer the waste to the 241-SY tank farm.

Project W-211: Initial Tank Retrieval Systems

Project W-211 will provide systems for the retrieval of waste stored in ten double-shell tanks. These ten tanks include at least one tank from each of the six double-shell tank farms. To retrieve wastes, it is necessary to mix the solids and liquid contents prior to transfer to alternative storage, evaporation, pretreatment, or final disposal facilities. The Initial Tank Retrieval System will provide systems to mobilize the settled solids and to transfer wastes out of the tanks. The double-shell tanks have existing equipment in place that will require removal to allow installation of the new mixing and retrieval systems. Also upgrading the central pump pits will be required. The first phase of this project focuses on Tanks 241-SY-101 and 241-SY-103 and the second phase will provide retrieval systems for the remaining eight tanks covered by Project W-211. Emphasis will be placed on retrieval of waste from Watch List tanks.

Project W-314C: Waste Transfer System

Project W-314C, as currently proposed, provides upgraded transfer line segments in the 200 West and East Areas. The line segments will tie together processing plants and single-shell tanks to the double-shell tank system. A waste receiver facility will be located to service each of the following single-shell complexes: T-farms, U-farm, S-farms, B-farms, A-farms, and C-farm. The waste receiver facilities provide a 760,000 to 1,100,000 liter (200,000 to 300,000 gallon) staging area for waste being retrieved and routed from the single-shell farms.

In the 200 West Area three waste receiver facilities and two diversion boxes/pump stations and several transfer lines will be installed. This will support waste transfers from T Plant, Z Plant, and the single-shell tank farms; T-farms, U-farm and the S-farms. Transfers will led to the 241-SY valve pits where the waste can then be routed to the 200 East area via the replacement cross-site transfer system (Project W-058).

In the 200 East Area, two waste receiver facilities and several upgraded transfer lines are planned to be installed. This equipment will support waste retrieval from the single-shell tank farms; B-farms, C-farm, and the A and AX farms. The waste from the single-shell tanks will then be routed into the double-shell tank system where it can be stored and/or processed.

Project W-314C will also be evaluating the feasibility of upgrading the existing transfer lines and diversion boxes associated with the double-shell tank farm complexes in the 200 East Area. At this time the feasibility study is underway.

4.3.5.3 Work Completed to Date. The following work has been completed:

- Title I Report: WHC-SD-W058-DR-001, W-058 Design Report.
- Evaluation Report by CH_2M-Hill for Westinghouse Hanford Company, Evaluation of Hanford 200 Area Leak Detection for Project W-058, May 1994.
- The function design criteria, conceptual design report, and Title I design are complete for Project W-058.
- The functional design criteria and conceptual design report are complete for Project W-028.
- Completion of Tri-Party Agreement Milestone M-32-04-T04, Complete and Submit the Transfer Facility Compliance Plan.
- Completion of Project W-058 Engineering Study (WHC 1993b).
- Completion of Project W-314C Transfer System Upgrades Engineering Study (Anderson 1994).
- Completion of Conceptual Design Report Initial Tank Retrieval Systems Project W-211 (WHC 1994d).

- Completion of interface control document for Project W-314 that identifies interfaces among waste transfer line projects and between waste transfer line projects and other tank farm upgrade projects (McGrew 1994).

4.3.5.4 Work Required to Resolve the Issue. The work required to resolve this safety issue/system deficiency consists of completing the five projects discussed above, completing waste transfer system integrity assessments, and upgrading double-shell transfer lines not replace by planned projects to be in compliance with current regulations.

Work required to complete waste transfer integrity assessments can be found in *Tank Waste Remediation System Tank System Integrity Assessments Program Plan* (Eacker 1991). The tasks required to bring double-shell transfer lines not affected by upgrade projects into compliance are outlined as recommendations contained in *Tank Waste Remediation System Transfer Facility Compliance Plan*. Definitive design is in progress for Project W-028. Future plans call for project completion and operation of both Projects W-058 and W-028 in fiscal year 1998. Project W-314C is scheduled to be completed during fiscal year 2004.

4.3.5.5 Cost and Schedule. The cost for resolution of Safety Issue 3-5 and System Deficiency 4-8 is on the order of $100 million. The total projected cost includes: $52.7 million for Project; W-058; $16.2 million for Project W-028. Financial estimates for Projects W-314C, W-211, and W-087 were not available at the time this report was prepared.

The Tri-Party Agreement milestone for completion of Definitive Design for Project W-058 is August, 1995. Since it currently appears as though this milestone will be missed, redefining the milestone to allow phased design and construction is recommended. The "complete definitive design" milestone for the first phase of design could be met with this change. There are no Tri-Party Agreement milestones for Project W-028. Key milestones for resolution of this safety issue/system deficiency, as they now stand, are shown in Table 4-24.

4.3.5.6 Alternate Strategies or Treatments. None Identified.

Table 4-24. Milestones Associated with Safety Issue 3-5.

Milestone	Description	Completion Date
TW3-94-419	Award booster pumps contract (Not complete; 4 months behind schedule. Awaiting NEPA waiver from Department of Energy for advanced procurement of design).	06/94
TW3-94-414	W-028 obtain water and steam utilities concurrence	09/94
TW3-94-415	W-058 concurrence obtained for crossing (change request made for deletion of this milestone due to concurrence not being a one time request but rather an on-going part of the design).	09/94
T2E-95-106	Complete National Environmental Protection Act documentation for Project W-211	11/94
T2C-95-110	Start construction of W-058	01/95

Table 4-24. Milestones Associated with Safety Issue 3-5.

Milestone	Description	Completion Date
T2C-95-480	Provide Washington Department of Ecology the engineering study, and scope statement for Project W-314C (Tri-Party agreement milestone M-43-05-T01)	02/95
TDB-94-238	Complete Project W-211 Title I Design for 241-SY-101	02/95
T2C-95-481	Provide Washington Department of Ecology the functions and requirements for Project W-314C (Tri-Party agreement milestone M-43-05-T02)	05/95
T2E-95-107	Issue Key Decision 2 for all Project W-211 Tanks	05/95
T2C-95-410	W-058, issue Title II design media for Westinghouse Hanford Company review and approval	06/95
--	Complete definitive design for Project W-028	08/95
T1A-95-103	Complete initial retrieval design requirements document	08/95
T2C-95-109	Complete definitive design for Project W-058	08/95
T2E-96-105	Complete safety assessment for Project W-211	01/96
TDB-94-265	Complete preparation of Clean Air Act Permit application for Project W-211	02/96
T2C-96-592	Provide Washington Department of Ecology the conceptual design report for Project W-314C (Tri-Party agreement milestone M-43-05A)	05/96
T2C-96-604	Receive Department of Energy project validation to request congressional funding for Project W-314C (Tri-Party agreement milestone M-43-05-T06)	06/96
T2E-96-108	Complete *Resource Conservation and Recovery Act of 1976* Part B application for Project W-211	06/96
T2E-95-108	Start advance procurement for Project W-211	06/96
T2E-96-106	Complete Title 2 Design for Tank 241-SY-101	09/96
T2E-97-109	Issue Key Decision 3 for Tank 241-SY-101	12/96
T2E-97-110	Start onsite construction package 1 for Project W-211	01/97
--	Complete construction of Project W-028,	08/97
T2C-97-108	Complete construction of Project W-058 (Tri-Party Agreement Milestone M-43-07B)	08/97
--	Start operation of new waste transfer systems	02/98

4.3.6 Safety Issue 3-6: Excessive Unfiltered Airflow Passages into Tanks

4.3.6.1 Background and Description. All 28 double-shell tanks and 19 single-shell tanks are on active, interconnected ventilation systems that do not have filtered inlets (see Tables 4-25 and 4-26). This was an initial design feature of these tanks which was recognized as a potential problem by subsequent safety assessments. Any event within one of the tanks that causes air expansion in excess of the ventilation system capacity results in pressurization of that tank and, potentially, of the interconnected tanks. Under such conditions, potentially contaminated radioactive effluent could be forced out through ventilation system inlets, process drains, and instrument penetration ports. Methods to add filters to the inlets and isolate the non-gas-generating tanks from the gas-generating tanks, or to eliminate the gas-generating mechanism in the tanks, are being evaluated for implementation.

Table 4-25. Double-Shell Tanks With Unfiltered Air Inlets.

Tank Farm/Tank	Watch List Status	Other Related Safety Issue	Project
241-AN Tank Farm			
Tank 241-AN-101	None	None	W-314
Tank 241-AN-102	None	None	W-314
Tank 241-AN-103	Flammable Gas	1-1	W-314
Tank 241-AN-104	Flammable Gas	1-1	W-314
Tank 241-AN-105	Flammable Gas	1-1	W-314
Tank 241-AN-106	None	None	W-314
Tank 241-AN-107	None	3-3	W-314
241-AP Tank Farm			
Tank 241-AP-101	None	None	W-314
Tank 241-AP-102	None	None	W-314
Tank 241-AP-103	None	None	W-314
Tank 241-AP-104	None	None	W-314
Tank 241-AP-105	None	None	W-314
Tank 241-AP-106	None	None	W-314
Tank 241-AP-107	None	None	W-314
Tank 241-AP-108	None	None	W-314
241-AW Tank Farm			
Tank 241-AW-101	Flammable Gas	1-1	W-314
Tank 241-AW-102	None	None	W-314
Tank 241-AW-103	None	None	W-314
Tank 241-AW-104	None	None	W-314
Tank 241-AW-105	None	None	W-314
Tank 241-AW-106	None	None	W-314
241-AY Tank Farm			
Tank 241-AY-101	None	None	W-314, W-030
Tank 241-AY-102	None	None	W-314, W-030

Table 4-25. Double-Shell Tanks With Unfiltered Air Inlets.

Tank Farm/Tank	Watch List Status	Other Related Safety Issue	Project
241-AZ Tank Farm			
Tank 241-AZ-101	None	3-2	W-314, W-030
Tank 241-AZ-102	None	3-2	W-314, W-030
241-SY Tank Farm			
Tank 241-SY-101	Flammable Gas	1-1	W-314
Tank 241-SY-102	None	None	W-314
Tank 241-SY-103	Flammable Gas	1-1	W-314

Table 4-26. Single-Shell Tanks With Unfiltered Air Inlets.

Tank Farm/Tank	Watch List Status	Other Related Safety Issue	Project
241-A Tank Farm			
Tank 241-A-104	None	2-2	
Tank 241-A-105	None	2-2	
Tank 241-A-106	None	None	
241-C Tank Farm			
Tank 241-C-104	None	2-5	
Tank 241-C-105	None	2-5	
Tank 241-C-106	High Heat	1-4, 2-5	
241-SX Tank Farm			
Tank 241-SX-101	Flammable Gas	1-1	W-314
Tank 241-SX-102	Flammable Gas	1-1	W-314
Tank 241-SX-103	Flammable Gas	1-1, 1-3, 2-5	W-314
Tank 241-SX-104	Flammable Gas	1-1, 2-2	W-314
Tank 241-SX-105	Flammable Gas	1-1	W-314
Tank 241-SX-106	Flammable Gas/Organic	1-1, 1-3, 2-5	W-314
Tank 241-SX-107	None	2-2	W-314
Tank 241-SX-108	None	2-2	W-314
Tank 241-SX-109	Flammable Gas	1-1, 2-2	W-314
Tank 241-SX-110	None	2-2	W-314
Tank 241-SX-111	None	2-2	W-314
Tank 241-SX-112	None	2-2	W-314
Tank 241-SX-114	None	2-2	W-314

Schedule Change From 1991 to 1993 Report. According to the 1993 report, resolution of this safety issue slipped 3 years, from September, 1996 to September, 1999, to be consistent with planned ventilation upgrades on the organic, flammable gas, and Ferrocyanide Watch List tanks. Upgrades delays were due to design delays as a result of tank vapor concerns and subsequent diversion of funding for Tank 241-SY-101 mitigation demonstration.

Schedule Change From the 1993 Report. Current schedules are aligned with program schedules. Project W-314 introduces a new schedule.

Scope Change from 1991 report to 1993 report. None identified.

Scope Change from the 1993 report. Project W-314 was initiated in 1994 to provide ventilation upgrades to some of the tanks with unfiltered air inlets as shown by Tables 4-5 and 4-6 (some of which are on the Watch List and/or covered by other vapor related safety issues). The 1993 report indicated that ferrocyanide tanks were included on the schedule for resolving this safety issue. However, Tables 4-5 and 4-6 indicate that no ferrocyanide tanks have unfiltered air inlets and will not be referenced by this safety issue in this or future reports.

Resolution of this safety issue for the six double-shell tank and eight single-shell tank Watch List tanks was to be accomplished by installation of modular exhausters and inlet filters, as discussed in the 1993 report. These tanks have the greatest potential for releasing contaminated radioactive effluent, since they can pressurize due to potentially excessive pressures in the tank vapor space. The remaining 23 double-shell tanks and 11 single-shell tanks, which are not on the Watch List, were to be evaluated for the need to provide inlet filters and possibly modular exhausters.

The planned resolution of this safety issue was based on the assumption that only Watch List tanks (six double-shell tanks and eight single-shell tanks) needed upgrades to eliminate excessive unfiltered airflow passages into tanks. Future plans were tied to the ventilation upgrades of Flammable Gas (Section 5.1.1, 1993 report), Ferrocyanide (Section 5.1.2, 1993 report), and Organic (Section 5.1.3, 1993 report) Watch List tanks. However, Project W-314 will effectively resolve this safety issue for the double-shell tanks and select single-shell tanks by upgrading all double-shell tank annulus ventilation systems, primary ventilation systems in 241-AN, 241-AP, 241-AW, 241-SY double-shell tank farms (241-AY and 241-AZ are covered by Project W-030) and the SX-Farm ventilation system. Ventilation upgrades for the remaining single-shell tanks not included in the current scope of Project W-314 will be determined through a single-shell tank ventilation upgrades need analysis. This needs analysis is to be completed by March 31, 1997 as required by Tri-Party Agreement Milestone M-43-03.

4.3.6.2 Priority and Strategy. Discharge of radioactive effluents could occur through unfiltered tank inlets of all tanks on active ventilation systems. Due to their age, the existing ventilation systems are unreliable, difficult to maintain, and do not provide for adequate monitoring and confinement of tank emissions. Based on the above, this safety issue meets priority 3 criteria.

Currently, the strategy to resolve this safety issue, in part, is to complete Projects W-314 and W-030. Safety Issue 3-2 discusses the schedule and scope for Project W-030. Project W-314 will upgrade ventilation, instrumentation, waste transfer, and electrical systems for certain double-shell tanks and single-shell tanks. The ventilation upgrade will include filtered air inlets and sealing of leaks of tanks under this safety issue as shown in Tables 4-5 and 4-6. The part of the safety issue concerning Tanks 241-A-104, -105, -106 and Tanks 241-C-104, 241-C-105, 241-C-106 will be resolved as part of Safety Issue 2-5 discussed previously. In addition, resolution of this safety issue requires upgrades to the ventilation systems of the single-shell tanks identified in Table 4-6 that are not covered by Project W-314. Upgrades to these tanks will be identified in the needs analysis to be completed in fiscal year 1997.

4.3.6.3 Work Completed to Date. The work completed so far on Project W-314 includes the Design Requirements Document which consists of design constraints for the four project sub-elements. The Functional and Operational Requirements, Project Interface Document, and preliminary design drawings are in progress.

4.3.6.4 Work Required to Resolve the Safety Issue. Resolution of this safety issue requires completion of the ventilation upgrades portion of Project W-314 as well as ventilation upgrades required by Safety Issue 2-5 for the tanks not covered under W-314.

4.3.6.5 Cost and Schedule. The resolution of this safety issue is funded by many different accounts, including Project W-314 and W-030 and the Waste Tank Organic, Flammable Gas, and Vapor Issue Programs. Project W-030 costs and schedule are covered in Section 4.3.2.5 and the waste tank organic, flammable gas, and vapor issue program costs and schedules are discussed in Sections 4.1.3.5, 4.1.1.5, and 4.2.5.5, respectively. The cost and schedule for Project W-314 is based on preliminary planning. The total estimated cost for W-314, including ventilation upgrades, is between $900 million and $1.28 billion for engineering and construction, and approximately $175 million for other project costs. The cost of the double-shell tank ventilation upgrades is on the order of $330 million. Refined cost estimates will be available after completion of the Conceptual Design Report. The following are the current projected milestones for Project W-314 are shown in Table 4-27.

Table 4-27. Milestones for Project W-314.

Milestone	Description	Completion Date
T2C-95-513	Issue request to Department of Energy Richland Field Office for approval of architect-engineer/construction management letter order	05/95
T2C-95-510	Issue W-314 quality assurance program plan to Department of Energy Richland Field Office for approval	05/95
T2C-95-XXX	Submit W-314 validation package to Department of Energy Richland Field Office	05/95
T2C-95-501	Complete W-314 conceptual design requirements	05/95
T2C-95-502	Issue Final W-314 project plan to Department of Energy Richland Field Office for approval	06/95
T2C-95-504	Receive Department of Energy W-314 project validation	06/95

Table 4-27. Milestones for Project W-314.

Milestone	Description	Completion Date
T2C-95-503	Issue W-314 project management plan for Department of Energy Richland Field Office for approval	07/95
T2C-95-500	Approve/issue architect-engineer/construction management contract for W-314 advanced conceptual design/Title I design	09/95
T2C-96-511	Approve Key Decision 1 for Project W-314	12/95
T2C-96-506	Start W-314 preliminary design (Title I)	01/96
T2C-97-512	Issue key Decision 2 for Project W-314	12/96
T2C-97-507	Complete Title I design	01/97
T2C-97-508	Start Title II design	02/97
T2C-97-509	Issue final W-314 Preliminary Safety Analysis Report	06/97

4.3.6.6 Alternative Strategies or Treatments. In the interim, it could be beneficial to isolate the non-gas-generating tanks from the gas-generating tanks. If isolation is not practical, releases could be precluded from the interconnected non-gas-generating tanks by using inlet filters, or the gas-generating mechanism in the tanks could be eliminated. For the latter two alternatives, the application, if successful, could be applied to other tanks as well.

Tri-Party Agreement Milestones for completion of the four sub-elements of Project W-314 are shown in Table 4-28.

Table 4-28. Tri-Party Agreement Milestones for Project W-314 Subelements.

Milestone	Description	Completion Date
M-43-04	Complete Project W-314A integrated tank instrumentation system upgrades	06/02
M-43-02	Complete Project W-314B double-shell tank ventilation upgrades	06/02
M-43-05	Complete Project W-314C transfer system upgrades	06/04
M-43-06	Complete Project W-314D tank farm electrical upgrades	06/05

4.3.7 Safety Issue 3-7: Potential for Formation of Explosive Deposits

This safety issue does not apply to the Hanford Tank Farms.

4.3.8 Safety Issue 3-8: Uncharacterized Corrosion of High Level Waste Tanks

4.3.8.1 Background and Description. This issue, identified as a new safety issue in the 1993 report, is directly related to System Deficiency 4-5, Extended Tank Operating Life. While all corrosion mechanisms must be considered for all materials of construction, past Hanford, Savannah River, Idaho Falls, and West Valley site studies and historical experience show that the new studies on the Hanford Site need to focus on waste tanks, transfer systems, and selected support facilities and equipment steels. Research and operating experience suggest that the principal corrosion mechanisms of consequence for waste tank steels at the Hanford Site are stress corrosion cracking, pitting, and crevice corrosion (Anantatmula, et al. 1994). The principal difficulty in the prediction of corrosion vulnerability of Tank Waste Remediation Systems installations has been a large variance in waste chemistry and temperature. Compilation of site-relevant corrosion information is necessary to help in the design, operation, maintenance, and safety analysis of Tank Waste Remediation Systems installations.

The Hanford Waste Tank systems are primarily constructed of mild carbon steels and structural concrete both of which are subject to localized and uniform corrosive attack from the waste solutions, raw water flushes, and process chemistry additions as well as Hanford soils. Through a corrosion monitoring and control program, the useful life of these storage systems can be significantly increased to provide long-term interim storage and management of Hanford high-level wastes until disposal processes come on-line to remove these wastes from the waste tanks.

At the present time, there is a lack of definitive corrosion controls and current corrosion data for the Hanford Site waste tank facilities. This is particularly true for current operating conditions (Lindsay 1994). The Tank Waste Remediation Systems Corrosion Monitoring Program has three principal objectives:

- The compilation of existing Hanford Site relevant corrosion data,
- The generation of current Hanford Site corrosion data by monitoring present conditions in the Hanford waste tank systems, and
- The development and implementation of methods to control corrosion.

This corrosion data will be used in the design, operation, and maintenance of Tank Waste Remediation Systems installations. This information will also be useful to the Tank Waste Remediation Systems Life Management Program (see System Deficiency D-5) in establishing technically based service life predictions. A successful corrosion monitoring program will provide data necessary to implement corrosion controls that will significantly reduce risks to worker safety and the environment.

The program plan developed to resolve this safety issue applies to the following components of the Hanford Site waste tank systems, grouped by Corrosion Engineering functions (Lindsay 1994):

- Double-Shell Tanks
- Single-Shell Tanks

- Transfer Systems and Ancillary Equipment
  - Piping
  - Catch Tanks/Lift Stations
  - Pump Pits
  - Diversion Boxes

- Support Facilities and Equipment
  - 242-A Evaporator
  - 244-AR Receiver Vault
  - 204-AR Receiver Vault
  - 244-CR Receiver Vault
  - 244-U Double Contained Receiver Tank
  - 244-TX Double Contained Receiver Tank
  - 244-S Double Contained Receiver Tank
  - 244-A Double Contained Receiver Tank
  - 244-BX Double Contained Receiver Tank

This program does not apply to the W-236A Multi-Function Waste Tank Facility Project or the W-028/W-058 Transfer Line Upgrade Projects.

Safety initiatives have been developed to track progress in dealing with some major elements of the Uncharacterized Corrosion safety issue as follows:

- **Safety Initiative 5d,** complete corrosion studies of single-shell tanks to determine failure mechanisms and corrosion control options to minimize further degradation by June 1994 (complete).

Schedule Change from the 1993 Report. The 1993 report included some preliminary milestones. The milestones are now more definitive as the program plan was issued on schedule.

Scope Change from the 1993 report. There has not been a change in the activities scope, but the areas of responsibilities of the program plan have changed slightly as a result of the new program plan (e.g., support facilities and equipment). Single-shell tanks have been removed from consideration for corrosion monitoring and control, and single-shell tanks have been removed from service. Corrosion considerations for single-shell tanks will be handled by individual programs (Retrieval, Stabilization) as issues arise.

4.3.8.2 Priority and Strategy. Corrosion induced failure of tanks, piping, and other equipment could lead to emissions of radionuclides to the environment. Based on this, Safety Issue 3-8 meets priority 3 criteria.

4.3.8.2.1 Double-Shell Tank Corrosion Monitoring Strategy. A meeting of the Upgrades Technical Council on June 14-15, 1994, yielded two significant recommendations pertinent to the double-shell tank corrosion monitoring program (Lindsay 1994).

- Because it is not feasible to fully instrument all 28 double-shell tanks, available instrumentation should be clustered into a few carefully chosen tanks. More data on fewer tanks will be of greater benefit to the program than less data on many tanks.

- In-tank corrosion monitoring should not be the only source of corrosion evaluation. The program should also include laboratory studies. Laboratory studies provide a more cost-effective means of evaluating a wider variety of corrosive conditions and mechanisms.

In response to the Upgrades Programs Technical Council's recommendations, the following combination of in-tank and laboratory corrosion evaluations are planned.

- Instrument trees one and two will focus on real-time, in-line monitoring of pitting and cracking by specific technology, such as electric field monitoring or electrochemical noise.

- Corrosion instrument trees three and four will be designed for insertion into selected double-shell tanks. Existing design experience from other waste tank programs in Savannah River and West Valley will be utilized.

- Laboratory testing will include testing for stress corrosion cracking, pitting, and crevice corrosion. As data from the laboratory and in-tank studies are obtained and interpreted, it is expected that there will be recommendations for corrosion control modifications to tank operations (e.g., chemistry modifications or inhibitor additions).

4.3.8.2.2 Transfer System Corrosion Monitoring Strategy. Even though aging has resulted in the deterioration of Hanford Site transfer systems pipelines, insufficient information is available on which to base reliable life expectancy estimates. While it is impractical to fully instrument and examine the entire transfer system, several methods will be used to evaluate transfer lines for corrosion. Existing lines in operation will be monitored for corrosion using corrosion probes and coupons. Failed transfer lines will be excavated and examined to assess causes of failures. Spare jumpers will be retrieved and examined for signs of internal corrosion. Laboratory corrosion studies will also be initiated to better understand corrosivity under a variety of waste compositions and flush water solutions.

As information and data are obtained from laboratory and field studies, it is anticipated that recommendations such as chemistry modifications, operational technique, and/or inhibitor additions will be made. Recommendations will be supported by laboratory verification studies.

Cathodic protection exists on many transfer line systems. The cathodic protection systems mitigate external corrosion. Tank Waste Remediation Systems corrosion engineering will be responsible for the technical cognizance of the systems to ensure proper operation and maintenance.

4.3.8.2.3 Support Facilities and Equipment Corrosion Monitoring Strategy. A detailed program of inspections including visual and nondestructive examinations will be developed. Data retrieved from the tank corrosion studies and published experience from the chemical and petroleum industries will be used to recommend corrosion protection methods for the maintenance and reliability of the site support facilities and equipment.

4.3.8.3 Work Completed to Date.

- *Tank Waste Remediation Systems Corrosion Monitoring Program Plan* (Lindsay 1994) issued October 19, 1994.

- **Safety Initiative 5d,** complete corrosion studies of single-shell tanks to determine failure mechanisms and corrosion control options to minimize further degradation by June 1994.

- Completed 1994 annual cathodic protection survey in December 1994. A report on the survey will be issued in April 1995.

- A literature search was performed to support double-shell tank crack growth rate experiment design. Funding for completion of the experiment design is not available and the task will be suspended after issuing a report on the findings of the literature search.

4.3.8.4 Work Required to Resolve the Safety Issue. Work required to resolve the issue consists of obtaining data from field and laboratory studies, interpreting the results, and implementing mitigating actions (e.g., inhibitors). The work includes installing instrument trees; initiating laboratory, data, visual and nondestructive examinations; and cathodic protection upkeep.

4.3.8.5 Cost and Schedule. The cost and schedule are based on information contained in *Tank Waste Remediation Systems Corrosion Monitoring Program Plan,* (Lindsay 1994). The estimated cost for the proposed schedule in the Corrosion Monitoring Program for fiscal years 1995-1997 is on the order of $2 million. This schedule is shown in Table 4-29.

Table 4-29. Corrosion Monitoring Program Plan Schedule (Lindsay 1994).

Description	Completion Date
Double-shell Tank Major Milestones	
Initiate laboratory studies	02/95
Install first instrument tree in waste tank	08/95
Install second and third instrument tree	04/96
Install fourth instrument tree	01/97
Transfer System Major Milestones	
Cathodic protection system upgrade study	07/95
Complete 1995 annual cathodic protection survey report	12/95
Identify jumpers available for examination	04/96
Transfer line excavation plan	09/96
Complete 1996 annual cathodic protection survey report	12/96
Excavate transfer line	04/97
Complete 1997 annual cathodic protection survey report	12/97

Table 4-29. Corrosion Monitoring Program Plan Schedule (Lindsay 1994).

Description	Completion Date
Support Systems and Equipment Major Milestones	
Westinghouse Hanford Company supporting document describing results of facility walk-downs and useful life estimates based on current information	03/95
Letter report summarizing activities supporting Tank Waste Remediation Systems Plant	09/95

Completion of the program schedule is dependent upon function of the Corrosion Monitoring Program. Table 4-30 shows Westinghouse Hanford Company controlled milestones for funded activities for the Corrosion Monitoring Program is actively pursuing.

Table 4-30. Milestones for Funded Activities in the Corrosion Monitoring Program (WHC 1994a).

Milestone	Description	Completion Date
T2C-95-405	Complete engineering design for cathodic protection upgrades	04/95
T2C-95-403	Complete pitting test plan	05/95
T2C-95-402	Complete preliminary constant elongation rupture test studies	05/95
T2C-95-408	Complete annual corrosion program report	09/95
--	Safety issue resolved	12/97

4.3.8.6 Alternative Strategies or Treatments. None identified.

4.4 SYSTEM DEFICIENCIES

System deficiencies are additional areas of concern identified by the U.S. Department of Energy High Level Waste Tanks Task Force. Many of them are related to or overlap portions of safety issues. There are nine system deficiencies. They are:

- Insufficient Tank Contents Characterization (4-1)
- Inadequate Safety Documentation (4-2)
- Deficient Maintenance and Upgrade of Facilities (4-3)
- Deficient Instrument Upgrades in Single and Double-Shell Tanks (4-4)
- Extended Tank Operating Life (4-5)
- Deficient Conduct of Operations (4-6)
- Lack of Plant-Essential Drawings (4-7)
- Questionable Transfer Line Concrete Encasement Integrity (4-8)
- Detection in Double-Shell Tanks (4-9)

4.4.1 System Deficiency 4-1: Insufficient Tank Contents Characterization

4.4.1.1 Background and Description. Knowledge of the chemical contents of the single-shell and double-shell tanks is necessary to ensure safe storage and to achieve final disposal of the tank waste. In the past, in-tank core sampling and characterization have focused on assaying selected chemicals and radionuclides necessary to support operations and future eventual disposal of the waste, rather than the total chemical content and waste stability of the tank contents. A better understanding of tank contents is required to assess the chemical and radiological hazards that may be present, to better understand the mechanisms by which the tank contents will interact with new wastes, to prepare any necessary interim remediation measures for the identified safety issues, to prepare all the tanks for final disposal, and to support the design of waste treatment and disposal facilities. Additional in-tank measurements, core sampling, and comprehensive studies of basic tank chemistry will be necessary.

Many substantial changes have occurred in the Tank Waste Remediation System Tank Characterization Program since the 1993 report was issued. The Tri-Party Agreement was renegotiated in 1994, resulting in the integration of tank characterization plans with the sampling and subsequent characterization reports issued for each tank. The tank characterization plan with its associated sampling and analyses plan represent implementation documentation of the sampling and analytical requirements identified in applicable data quality objectives for the individual tank to be characterized. The characterization plan coordinates the efforts of different programs (e.g., Waste Tank Safety Program and Waste Retrieval Program) to optimize the number of samples necessary to adequately represent the tank contents, efficiently and cost effectively fulfilling the analytical requirements of each program. The requirements for each program are established through the data quality objective process (see Section 1.7.5).

The analytical results from the laboratory are validated, as directed, and released in a data package. The tank characterization report combines process knowledge, historical characterization results, and the analytical data to develop a comprehensive view of tank chemistry. The *Tank Characterization Reference Guide* explains the purpose, evolution, and format of the tank characterization reports (De Lorenzo et al. 1994).

The renegotiated Tri-Party Agreement also resulted in the deletion of several interim milestones under milestone M-10-00 and the addition of milestone M-44-00 which now governs tank characterization completion. A schedule for tank sampling for fiscal years 1995-1997 has been issued. This schedule presents a sequence tentative for tank sampling to resolve high priority safety issues and other critical data needs (e.g. evaporator feed tank contents) in an optimal manner.

Characterization efforts needed to adequately analyze potential remediation actions for Priority 1 safety issues will be completed first. These efforts include in-tank core, auger, and grab sampling, vapor sampling, and non-sampling characterization methods, such as characterization through historical tank content estimates.

4.4.1.2 Priority and Strategy. The overall strategy for resolving this system deficiency is to meet the Tri-Party Agreement commitment for tank characterization (M-44-00). In addition, support for other Tank Waste Remediation System requirements will be met, including waste tank safety, waste retrieval, waste pretreatment, low-level waste vitrification, and high-level waste vitrification. The strategy also includes enhancing and expanding the analytical capacity of facilities at the Hanford Site, increasing the number of auger, grab, and vapor samples used for tank characterization, and by increasing the rate of in-tank core sampling by employing four core sample trucks and crews.

4.4.1.3 Work Completed to Date. Work completed to increase the tank characterization during fiscal years 1991-1994 includes:

- Completed Tri-Party Agreement Interim Milestone M-10-04 by obtaining 4 core samples from Single-Shell Tanks 241-B-202 and 241-B-201.

- Completed Tri-Party Agreement Interim Milestone M-10-05, Issued *Integrated Plan - Sampling and Analysis of Hanford Site Wastes Measuring Greater than 10 mRem per Hour.*

- Completed Tri-Party Agreement Interim Milestone M-10-06 by obtaining 20 core samples from seven single-shell tanks by September 1992 (241-T-107, 241-B-111, 241-C-112, 241-BX-107, 241-T-104, 241-C-109, 241-T-111, 241-C-110, and 241-S-104).

- Completed Tri-Party Agreement Interim Milestone M-10-13-T2, completed research and development and Installation of Both Hard Saltcake Sampler and the Improved Hydrostatic Balance System, by 12/92.

- From mid-1985 through January 1994, 35 single-shell tanks and 12 double-shell tanks have been core sampled. This includes three single-shell tanks (241-T-107, 241-T-105, and 241-T-102) core sampled in fiscal year 1993. During fiscal year 1994, two single-shell tanks (241-C-108 and 241-C-111) and one double-shell tank (241-SY-103) were core sampled.

- Issued eight validated data packages for eight single-shell tanks through May, 1993.

- The *Tank Waste Remediation Systems Tank Waste Characterization Plan* was issued and has been revised once (Bell 1993). Issued fourteen validated and eight unvalidated data packages for single-shell tanks, and four validated and four unvalidated data packages for double-shell tanks from April 1993 through January 1995. The plan outlines analytical requirements for the core samples to be obtained in fiscal year 1993.

- Restoration of rotary mode core sampling capability.

- Procurement of a modular exhauster for use with rotary mode core sampler equipment.

- Completed Tri-Party Agreement Interim Milestone M-44-03, submitted three tank characterization reports for initial evaluation and approval.

- Completed Tri-Party Agreement Interim Milestone M-44-04, completed input of characterization information for 3 high-level waste tanks to electronic database(s), by January 1994.

- Completed Tri-Party Agreement Interim Milestone M-44-07, completed all fiscal year 1992 and 1993 core sample analyses and completed validation of the resulting data.

- Completed Tri-Party Agreement Interim Milestone M-44-01A by submitting annual draft copies of the Tank Waste Remediation System Tank Waste Analysis Plan's and Tank Characterization Plan's revisions, updates, and additions to the Washington State Department of Ecology and U.S. Environmental Protection Agency.

- Completed Tri-Party Agreement Interim Milestone M-44-02A by submitting annual *Tank Waste Analysis Plan* to the Washington State Department of Ecology and U.S. Environmental Protection Agency for approval.

- Twenty tank characterization reports for the following tanks were issued during fiscal year 1994:

Double-shell Tanks	Single-shell Tanks
241-AP-101	241-B-111
241-AP-102	241-B-110
241-AP-103	241-B-201
241-AP-105	241-BX-107
241-AP-106	241-C-110
241-AP-107	241-S-104
241-AW-102	241-T-102
241-AW-105	241-T-104
241-AW-106	241-T-105
	241-T-107
	241-T-111

The characterization of these twenty high-level waste tanks fulfilled the following Tri-Party Agreement Interim Milestone:

M-44-05: Issue 20 tank characterization reports in accordance with the approved tank characterization plans. If an approved tank characterization plan is not issued, the tank characterization reports must be approved by Washington State Department of Ecology and U.S. Environmental Protection Agency.

M-44-06: Complete input of characterization information for 20 high-level waste tanks in electronic database(s).

4.4.1.4 Work Required to Resolve the System Deficiency. In July 1993, the Defense Nuclear Facilities Safety Board issued the *Recommendation 93-5 Implementation Plan* regarding the need to accelerate the characterization of waste in the Hanford high-level waste tanks. An implementation plan to resolve the Defense Nuclear Facilities Safety Board recommendation was accepted by the Defense Nuclear Facilities Safety Board in

March 1994. This plan called for establishing a characterization basis within approximately six to eight months and defined a course of action that would be pursued until the basis was established, including taking and analyzing two or more core samples from each tank. The *93-5 Implementation Plan* requires the sampling and analyzing of all 177 high-level waste tanks by October 1996. Due to delays with core sampling and equipment, staffing, and lack of a sufficient technical basis; the appropriate number of samples required cannot be accurately established.

The logic underlying the characterization process was recently developed. It is currently planned that a safety characterization basis, or master tank characterization plan for safety screening and issue resolution, will be issued in June 1995; followed by a safety plus waste disposal tank characterization plan in August 1995. In support of these plans, a potential alternative logic to that defined in the original Defense Nuclear Facilities Safety Board *93-5 Implementation Plan* to address the characterization required to identify and resolve safety issues will be developed.

The Characterization Program encompasses all aspects of sampling and analysis of single-shell tank and double-shell tank waste, including core, supernate, auger, and vapor samples. The primary objective of the characterization program is to provide required data to support the safe storage of Hanford tank waste. Sampling for retrieval, pretreatment, processing, and final disposal will be performed, but laboratory analytical work accomplished by the Characterization Program will be limited to those analytes required to support interim safe storage of the tank wastes, as well as those established by involved programs through formal data quality objectives. Characterization requirements established through a formal data quality objective process will be accelerated and targeted in a phased strategy consistent with Tank Waste Remediation System scheduled program needs. Sampling tools and analytical methods will be developed as required to satisfy data quality objective requirements. In addition, historical process and sampling data are being compiled and analyzed to provide a best "historical" estimate of tank contents. There is also an effort to combine historical data with post 1989 analytical data to present a "consolidated best estimate" of tank contents. The results of this effort will be documented both in reports and will be available via a networked database. Technology needed to support near term characterization as well as hardware needs are covered in this activity.

4.4.1.5 Cost and Schedule. The Characterization Program is responsible for managing the tank waste characterization efforts necessary to support safe operations, storage, and disposal of tank wastes. The Characterization Program provides leadership to establish technical bases, identify field sampling needs, evaluate data, recommend actions, provide laboratory analysis guidance, and manage technical activities associated with tank waste characterization, all of which are needed to implement the Tank Waste Remediation System Program Mission.

The cost for the Tank Waste Remediation System characterization is broken down by millions per fiscal year in Table 4-31. These budget numbers are as of 01/95 budget exercises per the U.S. Department of Energy, Richland Operations Office. They do not represent *Multi-Year Work Plan* numbers.

Table 4-31. Cost Breakdown for System Deficiency 4-1: Insufficient Tank Contents Characterization.

Fiscal Year	Millions of Dollars
1995	79.2
1996	72.2
1997	50.0
1998	45.0
1999	35.0
2000	30.0
2001	15.0
Total	**326.4**

Note: These numbers represent planned funding for the out years. The Characterization Program schedule is included in the *Multi-Year Work Plan*.

The characterization program will continue until 2020 to provide characterization services for wastes generated during the Hanford mission. The schedule for sampling activities is issued in a separate document. The sampling required to support characterization is frequently reviewed to reflect potential changes in tank prioritization and changes issued in a revised tank sampling schedule when appropriate. The most recent tank sampling schedule determines the sampling activities for fiscal years 1995 - 1997. The Tri-Party Agreement specifies the schedule for the completion of characterization under Milestone M-44-00 which is repeated on Table 4-32.

Table 4-32. Schedule for Completion of Tri-Party Agreement Milestone M-44-00 (Ecology 1994).

Milestone	Description	Completion Date
M-44-00	Issue tank characterization reports based on process knowledge, prior characterization data, and validated empirical data acquired after May 1989 for 177 Hanford high-level waste tanks. Provide offsite access to electronic database(s) containing tank characterization information through the Tank Characterization Database and Hanford Environmental Information System through the Tank Waste Information Network System or approved analogues for 177 high-level waste tanks.	09/99
	All issued tank characterization reports will be updated quarterly as needed due to addition and/or removal of tank wastes and as new information is obtained.	
	Validated data packages are to be placed in the administrative record.	

Other milestones set to resolve System Deficiency 4-1: *Insufficient Tank Contents Characterization* include those shown in Table 4-33.

Table 4-33. Milestones Associated with System Deficiency 4-1.

Milestone	Description	Completion Date
N/A	Update characterization data catalog	01/95
T2D-95-103	Draft tank characterization technical basis strategy document	02/95
T2D-95-113	Establish data control measures	02/95
T2D-95-120	Historical tank content estimate NE & SW quadrants	03/95
--	Historical model verification data quality objective	04/95
T2D-95-104	Final tank characterization technical basis strategy document	05/95
T2D-95-100	Prepare draft tank Waste Analysis Plan - Fiscal Year 1996 update (TPA M-44-01B)	05/95
--	Submit a draft copy of the Tank Waste Remediation System Tank Waste Analysis Plan and Tank Characterization Plan revisions, updates, and additions annually to Washington State Department of Ecology and U.S. Environmental Protection Agency (TPA M-44-01B through M-44-01F).	05/95, 96, 97, 98, 99
T2D-95-105	Tank characterization technical basis release	07/95
T2D-95-101	Prepare final tank Waste Analysis Plan - Fiscal Year 1996 update (TPA M-44-02B)	
--	Submit Tank Waste Analysis Plan annually to Washington State Department of Ecology and U.S. Environmental Protection Agency for approval (TPA M-44-02B through M-44-02F).	08/95, 96, 97, 98, 99
--	Review/update data quality objective strategy/style guide	09/95
--	Deliver new/updated data quality objectives	09/95
T2D-95-102	Issue 30 tank characterization reports (TPA M-44-08)	09/95
T2D-95-102	Data accessibility improvement plan	09/95
--	Finish fiscal year 1995 tank characterization plans	09/95
--	Supporting documents for historical tank content estimate NW quadrant	09/95
--	Issue 40 tank characterization reports in accordance with the approved tank characterization plans. Complete input of characterization information for 40 high-level waste tanks to electronic database(s) (TPA M-44-09).	09/96
--	Issue 40 tank characterization reports in accordance with the approved tank characterization plans. Complete input of characterization information for 40 high-level waste tanks to electronic database(s) (TPA M-44-10).	09/97
--	Issue 30 tank characterization reports in accordance with the approved tank characterization plans. Complete input of characterization information for 30 high-level waste tanks to electronic database(s) (TPA M-44-11).	09/98

Table 4-33. Milestones Associated with System Deficiency 4-1.

Milestone	Description	Completion Date
--	Issue 14 tank characterization reports in accordance with the approved tank characterization plans. Complete input of characterization information for 14 high-level waste tanks to electronic database(s) (TPA M-44-12).	09/99
--	Safety issue resolved	09/99

4.4.1.6 Alternative Strategy or Treatment. The alternative to characterizing each tank is to design retrieval, pretreatment, and disposal system for the worst case tank contents. This alternative is extremely cost prohibitive and is not the preferred path forward.

4.4.2 System Deficiency 4-2: Inadequate Safety Documentation

4.4.2.1 Background and Description. Multiple safety analysis reports, operational safety requirements, and hazard identification and evaluation reports currently exist for the single-shell tanks, double-shell tanks, aging waste facilities, and the two waste evaporator facilities. These documents present a fragmented and potentially incomplete envelope for the safe operation of the waste tanks and need to be updated. Activities associated with safety analysis report upgrades have increased significantly to meet new U.S. Department of Energy Orders and Westinghouse Hanford requirements for format, content, review, and approval. Significant changes have occurred in the requirements for the preparation, format and content, and risk assessment methodologies associated with safety analysis reports since the preparation of the existing documentation (safety analysis reports issued before 1987). Although evidence of safely designed facilities seems to be represented in the current safety analysis reports it is not done with the rigor or completeness now felt appropriate. Therefore, major upgrades are required for the tank farm safety analysis reports and related safety documentation to meet new U.S. Department of Energy Orders.

Tank farm facility safety analysis and safety documentation upgrades are performed by the Tank Waste Remediation System Safety Analysis and Engineering function. The Safety Analysis Report required by U.S. Department of Energy Order 5480.23 documents the results of the safety analysis. The Safety Analysis Report has four purposes and objectives: (1) provide the bases for approval of new facilities and operations, major modifications thereto, and eventual decommissioning; (2) define and control the safety bases and commitments; (3) support U.S. Department of Energy and contractor management safety oversight of facilities and operations; and (4) provide the analytical rationale for operations as delineated in technical safety requirements (DOE Order 5480.22). The safety basis to be analyzed in the Safety Analysis Report includes management, design, construction, operation, and engineering characteristics necessary to protect the public, workers, and the environment from the safety and health hazards posed by the Tank Farm Facility.

It is expected that the existing safety analysis reports can be consolidated, upgraded, and reissued as four upgraded safety analysis reports; one for double-shell tanks and aging waste facilities, one for single-shell tanks, and two for waste evaporator facilities. Current work in progress includes comment incorporation on the Hazards and

Accident Safety Analysis which presents a consolidated accident safety envelope for single-shell tanks, double-shell tanks, and aging waste facilities. In addition, Double-Shell Tank and Aging Waste Facilities safety analysis report chapter writing is ongoing with a draft expected to be issued by the end of fiscal year 1995.

There are four Secretary O'Leary safety initiatives associated with inadequate safety documentation, three of which have been completed.

- Accept Interim Safety Basis by November 1993. This safety initiative was completed on December 9, 1993 per Department of Energy Headquarters memorandum from T.P. Grumbly/T. O'Toole to Manager of Department of Energy Richland.
- Approve broad based environmental assessment by December 1993. This safety initiative was completed on February 25, 1993 per U.S. Department of Energy Headquarters memorandum from T. O'Toole to T.P. Grumbly.
- Revise Tank Farms safety and hazards analysis by July 1994. This safety initiative was completed July 29, 1994 per Westinghouse Hanford Company letter number 9455115.
- Formally delegate authority to U.S. Department of Energy Richland Operations for approval of Safety Analysis Reports by November 1993. Partial delegation was approved on July 28, 1994. Additional activities required for full delegation need to be identified and scheduled.

4.4.2.2 Priority and Strategy. The strategy implemented to resolve this system deficiency was to establish an interim safety bases for operating the tank farm facilities while upgrading the various facility safety analysis reports. The approach is to consolidate the current 15 safety analysis reports covering the tank farm facilities into four comprehensive safety analysis reports. Two of these are the double-shell tank/aging waste facility and single-shell tank safety analysis reports.

The objective is to upgrade tank farm facility safety analysis reports and operational safety requirements to reflect their current status and configuration, and to redefine their safety envelopes. The objective is also to upgrade the safety analysis reports to be in compliance with the most recent U.S. Department of Energy Orders: 5480.21 (Unreviewed Safety Questions), 5480.22 (Technical Safety Requirements), and 5480.23 (Nuclear Safety Analysis Reports).

This objective was met with July 1994 submittal of the Accident and Hazards Analysis. This document is currently being revised based on U.S. Department of Energy-Richland Field Office comments.

4.4.2.3 Work Completed to Date. Fiscal year 1993 and 1994 accomplishments include the following:

- Submittal of an implementation plan for U.S. Department of Energy Orders 5480.21 and 5480.23.

- Preparation of interim operational safety requirements for tank farm facilities.
- Interim safety basis was accepted by the U.S. Department of Energy in November 1993.
- Broad based environmental assessment was approved by the U.S. Department of Energy December 1993.
- Tank Farms safety and hazards analysis was revised in July 1994.
- Tank Farm Facilities Safety Analysis Documentation Program Plan was issued in September 1994.
- Double-shell tank upgraded safety envelope documentation was issued in July 1994 with the Accident and Hazards Analyses.
- Issued aging waste facility/double-shell tank/single-shell tank radionuclides and chemical inventory.
- Single-shell tank upgrades safety envelope documentation was issued in July 1994, with the Accident and Hazards Analysis.
- Issued report on single-shell tank accelerated safety analysis follow-on activities in july 1994.

4.4.2.4 Work Required to Resolve the System Deficiency. Major activities planned for the fiscal year 1995 include:

- Resolve Department of Energy Richland Tank Operations and Independent Review Team (comprised of personnel from various DOE sites) Comments on the Accelerated Safety Analysis submittal of Interim Chapter 3.
- Revise the Interim Operational Safety Requirements (aging waste facility/double-shell tanks/single-shell tanks) to incorporate the Accelerated Safety Analysis and comments for U.S. Department of Energy review.
- Revise and issue the Interim Safety Basis document incorporating the Accelerated Safety Analysis after Department of Energy comments are resolved.
- Complete high priority accelerated safety analysis follow-on tasks.
- Submit first draft of the Double-shell Tank (including aging waste facility) Safety Analysis Report to functional review on August 30, 1995.
- Issue 242-A Evaporator Final Safety Analysis Report annual update.

Fiscal Year 1996 activities include:

- Revise and issue the interim safety bases document.

- Issue interim operational safety requirements revisions and updates.
- Issue Westinghouse Hanford Company approved Double-Shell Tank and Aging Waste Facilities. Safety Analysis Report to the Department of Energy Richland Office for approval.
- Continue single-shell tank graded Safety Analysis Report.

Fiscal Year 1997 activities include:

- Issue Interim Operational Safety Requirements Revisions and Updates.
- Issue Safety Document Updates.
- Complete Single-shell Tank Graded Safety Analysis Report.
- Department of Energy Richland Office approval of the Double-Shell Tank/Aging Waste Facilities Final Safety Analysis Safety Report.

4.4.2.5 Cost and Schedule. The cost estimates developed for revising the tank farm facility safety documentation are broken down into several activities (Primavera Project Planner Cost Loading Report, Run 1142, April 14, 1994). All required safety documentation will be completed by June 1998. The total cost for safety documentation, including revisions and updates through the year 2027, is on the order of $80 million. The activity breakdown, cost and completion dates are shown in Table 4-34.

4.4.2.6 Alternative Strategies or Treatment. No alternatives have been identified.

Table 4-34. Schedule and Costs for Activities Associated with System Deficiency 4-2.

Activity	Completion Date	Cost (millions)
Issue double-shell tank/aging waste facility final safety analysis report/technical safety requirements	06/98	6.8
Issue/revise single-shell tank final operational safety requirements	09/98	0.7
Safety issue resolved	09/98	
Implement aging waste facility interim/final operational safety requirements	09/99	7.5
Implement double-shell tank interim/final operational safety requirements	09/99	13.9
Implement single-shell tank interim operational safety requirements	09/00	18.0
Issue other tank farm safety analysis reports	09/07	2.8
Maintain/update 242-A evaporator final safety analysis report	09/07	3.1
Issue double-shell tank/single-shell tank safety analysis report annual updates	09/27	16.7

Table 4-34. Schedule and Costs for Activities Associated with System Deficiency 4-2.

Activity	Completion Date	Cost (millions)
Maintain tank farm safety basis	09/27	2.1
Maintain tank farm safety basis	09/27	
Issue double-shell tank/single-shell tank safety analysis report annual updates	09/27	

4.4.3 System Deficiency 4-3: Deficient Maintenance and Upgrade of Facilities

4.4.3.1 Background and Description. Past maintenance practices have not adequately sustained tank farm facilities and equipment; many facilities and equipment are old (approaching 50 years of age), degraded, and unreliable. As many facilities do not meet current design requirements, a major upgrade (repair and/or replace) effort is required to place existing equipment in acceptable condition and to bring all equipment and facilities into compliance with current regulatory requirements.

4.4.3.2 Priority and Strategy. *Deficient Maintenance and Facility Upgrades of the Tank Farms* has been identified as a system deficiency because the tank farms operating conditions (at the time the system deficiency was identified) were such that continued safe operations of the farms could not be ensured.

The strategy for resolution of this system deficiency is to pursue an aggressive program to improve tank farm maintenance and to make major upgrades to the tank farm infrastructure and hardware. This strategy requires the cooperation of the Tank Farm Upgrades Program Element and the Tank Farm Operations and Maintenance Program Element. Tank Farm Operations and Maintenance will reduce the backlog of maintenance activities and provide support services for the operations of the tank farms. Tank Farm Upgrades will support projects required to improve the tank farm infrastructure to a safe operating condition.

4.4.3.3 Work Completed to Date. A comprehensive effort was initiated in fiscal year 1992 to restore the plant safety systems to a functional level and to upgrade and/or replace existing tank farm infrastructure system and components. Since that time, significant progress has been made to enhance maintenance and to upgrade facilities. During fiscal year 1992, the 241-A and 241-AN Tank Farms were targeted for major upgrades and reduction of corrective maintenance backlogs. Specific accomplishments included the following:

- The original backlog for 241-AN farm was 112 items. Special emphasis planners walked down 77 of the 112 packages. This resulted in the completion of 51 work packages and the resolution or cancellation of 26 others, thus reducing the backlog to 35 packages, a reduction of 69%.

- The original backlog for A farm was reduced by 88 packages, a reduction of 48%.

Fiscal year 1993 accomplishments included:

- New compressors were installed in 241-AW, -U, -T, and -SX Tank Farms and the 241-CR Vault [Completed except for 241-U].
- A new roof was installed on 209E Building.
- A heating, ventilation, and air conditioning system was installed in the 272-AW and 272-WA Maintenance shops.
- Control room alarms for the 241-C Farm were completed.
- The 241-C Farm control room facility was restored.
- The 242-S Evaporator control room was upgraded.

Fiscal year 1994 accomplishments include the following:

- Implemented maintenance zones at tank farms. This resulted in the following:
  - 30% reduction in total work backlog.
  - 50% reduction in classical corrective maintenance backlog.
  - 53% reduction in productivity.
  - 94% essential equipment operational.
  - Performance to plan of the week schedule > 90%.
  - Work suspensions reduced to 10% (from 40%).
  - "Past due" preventive maintenance backlog reduced to zero.
  - $2.5 million cost savings validated by the Department of Energy.
- Restored level indication in all underground storage tanks.
- Installed new liquid level indicators in Tanks 241-C-103, 241-S-111, 241-T-107, 241-SX-106, 241-S-103, 241-S-106, 241-S-107, 241-SY-102, 241-T-102, 241-BX-106, 241-U-103, 241-U-105, 241-U-106, 241-U-107, 241-U-109, 241-SY-101, 241-SY-103, 241-C-106, and 241-T-109.
- Installed standard hydrogen monitors in Tanks 241-SY-101 and 241-SY-102.
- Completed installation of the Tank Monitor and Control System in nine tanks in T farm.
- Installed a video camera in Tank 241-SY-103.

4.4.3.4 Work Required to Resolve the System Deficiency. The Tank Farm Upgrades Program will work with Tank Farm Operations and Maintenance to resolve this system deficiency. Tank Farm Upgrades is currently involved in major projects to upgrade ventilation, electrical, instrumentation, transfer, and mechanical systems. Projects are also underway to upgrade equipment and facilities. Facility and equipment upgrades performed by Tank Farm Upgrades are too numerous to list individually; therefore, a summary of the work to be performed as part of major projects is given below.

Instrument and Control/Electrical Upgrades

- Upgrade/replace alarm panels, control room equipment and generators, site electrical assessments, and in-tank monitoring and control systems. Add the capability for portable terminal entry of tank operator rounds information.

- Install liquid level gauges.

- Complete miscellaneous small projects as identified to increase productivity and support safe conduct of operations.

- Complete Project W-314, Tank Farm Restoration and Safe Operations Major Systems Acquisitions.

- Complete re-instrumentation of the 200 Area Tank Farm single-shell and double-shell tanks.

- Supplement the Computer Automated Surveillance System and augment the Surveillance Analysis Computer System with the Tank Monitoring and Control System.

- Evaluate double-shell tank ventilation upgrades the primary and annulus ventilation systems in all existing double-shell tanks, and evaluate of the 241-A-105, 241-SX farm, and double contained receiver tanks.

- Upgrade electrical systems to modify voltage lines and/or equipment; replace substation equipment, motor control centers, backup generators and low voltage alternating current/direct current distribution systems; and provide structures to house the electrical equipment.

- Evaluate and replace selected waste transfer systems to ensure compliance with *Resource Conservation and Recovery Act of 1976* containment and leak detection requirements and to extend the transfer system's life.

Mechanical Upgrades restoration/remediation of equipment and facilities including the following:

- Compressors and compressed air systems,

- Design and construction of long-length equipment transfer port, storage facility, and controlled storage yard,

- Modification of a cold test facility for development testing and operator training,

- Design and construction of modification of facilities to minimize effluent waste water generation,

- Heating, ventilation, and air conditioning engineering design and replacement of tank farm passive vent systems,

- Develop protocol and hardware for cradle-to-grave approach to the disposal of long-length contaminated equipment,

- Develop engineering for transfer pumps, and

- Development of design guide for the equipment to be installed in tanks and development of generic engineered equipment to be used for tank farm transfer of liquid radioactive waste.

Miscellaneous small projects as identified to increase productivity and support safe conduct of operations.

Ventilation Upgrades, Project W-030

Ventilation upgrades to provide essential safety class systems for the 241-AY and 241-AZ tank farms. Upgrades and improvements will be made to the ventilation cooling, electrical standby power, and instrumentation/control systems.

Replacement of Cross-Site Transfer System, Project W-058

Connect the 200 West Area double-shell tanks with the 200 East Area double-shell tanks with transfer lines which meet operations needs and regulator requirements. Connect the 241-SY-A and 241-SY-B valve boxes in the 200 West Area with the 244-A double contained receiver tank in the 200 East Area with new, compliance transfer lines.

Aging Waste Transfer Line, Project W-028

Provide waste transfer system form the aging waste facility (241-AY and AZ) to the Multi-function Waste Tank Facility and *Resource Conservation and Recovery Act of 1976* compliance waste lines for B Plant.

Facility Upgrades

- Installation of 209E septic upgrades, General Plant Project W-364

- 241-SY and 241-C farm lighting and lighting system, Project W-280

- Centralized Maintenance Facility (Project W-226) for the packing of solid waste, where tools and equipment can be maintained/repaired and stored and contaminated tools and equipment can be decontaminated.

- Miscellaneous small projects as identified to increase productivity and support safe conduct of operations

Radiological Support Facility, Project W-188

Provide 10 radiologic support facilities at the major tank farm operations areas in the 200 Areas to support the continued operations requirements and future retrieval/decommissioning effort.

Multi-Function Waste Tank Facility, Project W-236A

See Section 4.3.1.

4.4.3.5 Cost and Schedule. The cost and schedule for each of the major projects mentioned above, as well as several others, are given in the *Tank Waste Remediation System Multi-Year Work Plan* (WHC 1994a). The instrumentation and control/electrical upgrades, mechanical upgrades, and facility upgrades are expected to be completed by 2005 at a cost of approximately $53, $60, and $42 million dollars, respectively. Ventilation upgrades are to be completed during fiscal year 1996 at a cost of approximately $2.4 million. The cross site transfer upgrades will be completed by the end of fiscal 1998 at a cost of $53 million. Aging waste transfer lines upgrades are to be completed during fiscal year 1997 at a cost of $16 million, and radiological support project W-188 is to be completed during fiscal year 1999 at an estimated cost of $31 million. The multi-year work plan also provides schedule and cost estimates for technical integration and planning and configuration management of the tank farm maintenance and upgrades activities. Technical integration and planning through fiscal year 2005 is estimated to be $23 million and configuration management for tank farm upgrades through 2005 is estimated at $26 million.

The detailed schedules for maintenance and upgrades activities are too numerous to contain in this document. Schedule information for these activities can be found in the *Tank Waste Remediation System Multi-Year Work Plan* (WHC 1994a). Tri-Party Agreement milestone M-43-00 (Ecology et al. 1994), Complete Tank Farm Upgrades, details numerous interim and target milestones for individual upgrade activities.

4.4.3.6 Alternate Strategies or Treatment. None identified.

4.4.4 System Deficiency 4-4: Deficient Instrument Upgrades in Single- and Double-Shell Tanks

4.4.4.1 Background and Description. Many tank instruments, such as liquid-level gauges, leak detection systems in process pits, and radiation monitors, are inoperable and require service or replacement. In addition, spare parts for much of the aging equipment are no longer available, furthering the need for replacement of this equipment. Tank monitoring instrumentation must be upgraded to meet today's safety and operating requirements. This system deficiency focuses on upgrades to single and double-shell tanks that are associated with existing safety issues. In particular, tanks on the Watch List are the emphasis of this system deficiency.

4.4.4.2 Priority and Strategy. Deficient instrument upgrades in the single-shell and double-shell tanks constitute a situation in which an unsafe operating condition could go undetected in the waste tanks. Therefore, deficient instrumentation upgrades have been identified as a system deficiency that could potentially lead to unsafe operations in the tank farms.

The strategy for resolving this system deficiency is to provide continuous monitoring of all single-shell and double-shell tanks that have the potential for release of high-level waste due to uncontrolled increases in temperature or pressure (i.e., those identified by Westinghouse Hanford Company as 'Watch List Tanks'). Continuous monitoring provides the capability to detect the onset of an out-of-specification condition to provide early warning of unacceptable tank content behavior. Upgraded instrumentation is needed as soon as possible and must be maintained operational until waste can be removed for treatment and solidification. Enhancements are needed in the areas of temperature measurement, liquid-level monitoring, gas flow rates, in-tank gas analysis, surface-level measurements, tank pressure measurements, visual observation, tank integrity, waste crust topography, specialized in situ chemical and radiological analysis, and noxious gas monitoring. This strategy requires near-term upgrades to the tank farm instrumentation, data acquisition and data reporting systems, with a focus on surveillance parameters to verify and maintain tank systems.

The primary objective is to implement short term upgrades to the instrumentation that will provide immediate improvement in the monitoring of parameters required to assess the safe operating condition of the waste tanks. The upgrades are prioritized on a tank basis. The priority for any one tank is determined by considering the following:

- The hazard posed (i.e., Watch List tank or other safety consideration),
- The condition of the existing instrumentation and data acquisition equipment, and,
- For data acquisition, the location relative to other tanks being upgraded.

The priority for upgrade of instrumentation for any one tank depends on the type of instrumentation. For example, the priority for receiving a surface level gauge on a particular tank may be different than the priority for upgrading the temperature monitoring. As a result, it is not always possible to upgrade the data acquisition and the level monitoring simultaneously. The inclusion of a tank for a particular instrument upgrade in any one year is a reflection of the tank priority based on the above parameters. As implementation progresses, priorities will be modified as a result of new information on the tank status and as a result of any work restrictions and regulatory requirements.

The instrumentation upgrades are focused on improved temperature sensing, gas monitoring, and level monitoring. The data acquisition upgrade involves expanding an existing system recently installed for monitoring of temperatures in the ferrocyanide (FeCN) tanks. In addition, improvements will be made in manual data collection by implementing use of a portable data entry terminal. Data management will be improved by continuing the implementation of the Surveillance Analysis Computer System. This system will archive data, allow user access, and provide data analysis tools.

The resolution of this system deficiency involves many program elements of the Tank Waste Remediation Systems. The safety programs for each of the priority 1 safety issues must be involved in the upgrades of tanks specific to each safety issue. These efforts are integrated with those of the tank farm operations and upgrades program elements.

4.4.4.3 Work Completed to Date.

Work completed prior to the 1993 report:

- Installed four new thermocouple trees in ferrocyanide tanks.
- Installed a new multi-function instrument tree in Tank 241-SY-101.
- Tested an Infrared Camera in a non-Watch List tank to determine if the technology is feasible to detect hot spots in a ferrocyanide tank.
- Connected the Tank Monitor and Control System to an additional five 241-BY Farm tanks, one 241-TX Farm tank, and three 241-TY Farm tanks. Fourteen of the ferrocyanide tanks are now on this system.
- Installed a hand held data acquisition system in 241-S and SX farms.
- Installed a gas monitor in Tank 241-SY-101.
- Repaired 92 thermocouple elements in nine ferrocyanide tanks. Twenty-two of the ferrocyanide tanks now have a thermocouple tree with one or more operational thermocouples within the waste. The other two tanks (241-BY-111 and 241-BY-112) have a thermocouple probe installed in a liquid observation well for temperature measurement capability.
- Issued a tank farm instrumentation upgrade plan which addressed near-term instrumentation requirements and identified measurement parameters.

Work completed since the 1993 report:

- Issued Revision 1 of tank farm instrumentation upgrade plan.
- Installed a multi-function instrument tree in Tank 241-SY-103.
- Tested/Repaired thermocouple tree in high heat Tank 241-C-106.
- Installed gas monitoring units on remaining six flammable gas double-shell tanks.
- Completed monitoring upgrades for the 241-SY Tank Farm.
- Installed new instrument tree with replaceable temperature-sensing elements in two ferrocyanide tanks.
- Installed new instrument trees in two assumed leaker tanks in April and November 1994.
- Installed heated vapor sampling tanks in two assumed leaker tanks.
- Completed installation of new instrument trees in ten non-leaking ferrocyanide tanks.

- Completed fabrication of all additional instrument trees for assumed leaker ferrocyanide tanks.
- Completed connection of all ferrocyanide tanks to the continuous Tank Monitoring and Control System.
- Completed installation of new thermocouple tree in organic Tank 241-TX-118 (also a ferrocyanide tank).
- Connected high heat Tank 241-C-106 to the continuous Tank Monitoring and Control System.
- Replaced the liquid-level indicator in high heat Tank 241-C-106.
- Installed three liquid observation wells during fiscal year 1994.
- Installed 2-camera system in 241-SY-101

Long-term plans include connecting all Watch List tanks to the Tank Monitoring and Control System, continued installation of thermocouple probes, liquid level indicators, multi-function instrumentation trees, and modular gas devices in Watch List tanks (except high-heat).

4.4.4.4 Work Required to Resolve System Deficiency 4-5. Work required to resolve this safety issue can be found in the work required to resolve priority 1 safety issues (see Sections 4.1.1.4, 4.1.2.4, 4.1.3.4, and 4.1.4.4) and under the work required to resolve System Deficiency 4-3, *Deficient Maintenance and Facility Upgrades* (see Section 4.4.3.4).

4.4.4.5 Cost and Schedule. The schedule and cost for instrumentation upgrades in the single-shell and double-shell tanks are difficult to estimate due to the large number of Tank Waste Remediation Systems program elements involved (e.g., safety programs, tank farm upgrades, tank farms operations and maintenance, etc.). Therefore, the reader is referred to sections mentioned above in Section 4.4.4.4.

The schedule for several upgrades of instrumentation for high priority tanks (Westinghouse Hanford Company identified 'Watch List Tanks') is specified by Tri-Party Agreement Milestone M-40-00 (Ecology et al. 1994), Mitigate/Resolve Tank safety issues for High Priority Watch List tanks. This milestone will be reviewed on an annual basis to identify schedule enhancements (Ecology et al. 1994). The interim milestones that apply to instrumentation upgrades are listed in Table 4-35.

Table 4-35. Milestones Associated with System Deficiency 4-4.

Milestone	Description	Completion Date
M-40-02	Upgrade temperature monitoring capabilities in ferrocyanide tanks. Install and operate upgraded temperature monitoring capabilities in ferrocyanide tanks.	04/95
M-40-10	Complete vapor monitoring for all flammable gas generating tanks. This includes the design, procurement, and fabrication of required monitoring systems.	01/97

Table 4-36 lists key milestones for System Deficiency 4-4, *Deficient Instrument Upgrades in Single-Shell and Double-Shell Tanks*.

Table 4-36. Milestones Associated with System Deficiency 4-4.

Milestone	Description	Completion Date
T2B-95-490	Install two of seven new thermocouples	04/95
T2B-95-107	Install gas monitors in potential flammable gas tanks (Safety Initiative 2h)	04/95
T2B-95-118	Implement moisture monitoring of ferrocyanide tanks with neutron probe	09/95
T2B-95-100	Upgrade temperature monitoring capability for ferrocyanide tanks	09/95
T2B-95-113	Complete installation of thermocouple trees in remaining ferrocyanide tanks and connect them to the Tank Monitoring and Control System	09/95
T2B-96-303	Install gas characterization system in Tank 241-SY-103	01/96
T2B-96-302	Install 241-SY tank farm data acquisition and control system 2A	02/96
T2B-96-308	Fabricate and install gas characterization system in Tank 241-AW-101	09/96
T2B-96-110	Complete installation of pressure monitoring systems and monitor five organic tanks	09/96
T2B-96-112	Install moisture monitoring and control system in an organic tank	09/96
T2B-96-113	Complete readiness review moisture monitoring and control demonstration	09/96
T2B-96-364	Install liquid level monitoring system for one tank	09/96
T2B-96-357	Complete liquid observation well installation and data collection	09/96
T2B-96-109	Initiate installation of thermocouple trees in organic tanks	10/96
T2B-96-307	Install 241-AW tank farm data acquisition and control system 2B	01/97
T2B-96-315	Install gas characterization system in Tank 241-AN-104	03/97
T2B-96-314	Install data acquisition and control system 2C	08/97
T2B-97-102	Complete upgrade on in-situ infra-red camera system	09/97
T2B-97-112	Complete installation of pressure monitoring system and monitor remaining tanks	09/97
T2B-97-117	Install new thermocouples and connect Tank Monitor and Control System to remaining organic tanks	09/97
T2B-97-374	Install liquid level monitoring system for all tanks	09/97

The cost for resolving this system deficiency is incorporated into the cost for Tank Farms Operations and Maintenance program element. However, cost estimates for instrumentation upgrade tasks were unavailable at the time this document was prepared.

4.4.5 System Deficiency 4-5: Extended Tank Operating Life

4.4.5.1 Background and Description. The Hanford radioactive waste storage tanks must be structurally qualified to safely withstand long term operating demands. These demands include elevated temperatures, hydrostatic pressure, waste chemistry, ventilation system pressures, and the soil backfill load. For the double-shell tanks that store liquid waste solutions, the anticipated mission time for storage use exceeds the published useful or design lives. For the single-shell tanks, now used primarily for interim storage of salt cake wastes, there are deficiencies in the technical basis for the Operating Safety Requirements. For example, more comprehensive structural evaluations should be conducted to account for single-shell tanks being in continuous service since construction 30-50 years ago. Also, limited seismic analyses have been conducted for the Hanford waste tanks.

4.4.5.2 Priority and Strategy. Structural qualification of the Hanford Site waste tank structures for their long term operating demands reduces the potential for development of more serious safety concerns. The operating life of the tank was identified as a system deficiency by the U.S. Department of Energy High Level Waste Tank Task Force in 1992 (DOE 1992).

In the early 1980s a decision was expected by the late 1980s regarding how to dispose of single-shell tank waste. Final disposal was expected to begin in the 1990's. This decision does not now appear to be likely until the late 1990's. For double-shell tanks the final decision (to retrieve the waste) was to have been implemented before the end of the design life of the double-shell tanks (DOE 1980). An assessment of the risks associated with continued storage of waste in the single-shell tanks was conducted, and the risks were determined to be acceptable (Quinn et al. 1980).

A Hanford waste storage tank structures Life Management Program was created (Shogren and Sindelar 1994). Its objective is to conduct structural evaluations and surveillance to qualify the tank structures for extended lives under long term temperatures, soil loads, potential corrosion, and other demands with few uncertainties and with high confidence levels. It could also investigate and explore options to provide new replacement double-shell tanks, and to expedite final waste disposal.

The tank structural Life Management Program activities will:

- Establish the present structural condition or status for the double-shell tanks and single-shell tanks.
- Develop comprehensive structural and corrosion acceptance criteria for double-shell tank and single-shell tank useful lives.
- Determine and conduct the structural analyses, including seismic, and corrosion evaluations necessary to predict tank structural performance and changes in condition due to continued operation.

- Plan and implement the double-shell tank structural and corrosion surveillance and condition surveys which are feasible, capable, and necessary: (1) to show conformance with the useful life acceptance criteria, and (2) to provide early detection of potential impending structural problems. Surveillance will include video and ultrasonic examinations of portions of the double-shell tank primary steel tanks.

- Determine and account for the dependency double-shell tank operating life extensions will have on the tank farm support systems, including ventilation, electrical, instrumentation, and waste transfer systems.

- Determine the options and requirements for double-shell tank operating life extensions.

Schedule Change From 1991 to 1993 Report. According to the 1993 report, resolution of this safety issue slipped two years, from 09/96 to 09/98, due to insufficient resources in fiscal year 1992 and 1993.

Schedule Change From the 1993 Report. The schedule changed for issuing the program plan from 12/93 to 06/94.

Scope Change from 1991 report to 1993 report. None identified.

Scope Change from the 1993 report. The objectives and goals of the Life Management Program have not changed. Information from the Double-Shell Tank Integrity Assessment Program and the corrosion monitoring and corrosion control program are incorporated into the Life Management Program tasks (Shogren and Sindelar 1994).

4.4.5.3 Work Completed to Date.

Work Completed Prior To the 1993 Report:

- The criteria for in-depth review of tank physical condition was issued in DOE/RL-91-15.

- A summary status report on seismic evaluations of Hanford Site tanks was issued (Becker 1990).

- A double-shell tank structural inspection plan (Blackburn 1992), a parametric analysis of double-shell tanks (Shurrab et al. 1991), and a double-shell tank soil-structure interaction analysis (Giller et al. 1991) were issued.

Work completed since the 1993 Report:

- The program plan, *Plan for the Tank Waste Remediation System Life Management/Aging Management Program* was issued June 30, 1994.

- Issued Tank Waste Remediation System Corrosion Monitoring Program Plan (Lindsay 1994).

- Conducted and reported on double-shell tank closed circuit television visual examinations performed in the tank annuli.

- Documented non-destructive examination equipment development and implementation plans for double-shell tanks.

4.4.5.4 Work Required to Resolve the System Deficiency. Future plans includes:

- Develop acceptance criteria, conduct structural analyses (including seismic), plan structural surveillance and condition surveys, and initiate possible corrosion evaluations necessary for the tank integrity assessments specified in the tank life management program. The tank farm support systems upgrades program is to be implemented.

- Implement surveillance and condition surveys. Complete initial tank integrity assessments. Validate the results. Determine options for double-shell tank and single-shell tank operating life extensions.

- Implement life extension options.

4.4.5.5 Cost and Schedule. The cost and schedule are based on the Plan for the Tank Waste Remediation System Life Management/Aging Management Program (Shogren and Sindelar 1994). The Life Management Program is anticipated to cover approximately a 40 year period at an estimated cost of $26 million. This estimate is based on the Life Management/Aging Management Program Plan schedule shown in Table 4-37. Conformance with this schedule is dependent upon Department of Energy approval and funding. Table 4-38 shows Westinghouse Hanford Company controlled milestones for funded activities the Life Management/Aging Management Program is actively pursuing. The funding for double-shell tank integrity assessments has been suspended. Therefore, the schedule for these activities will be not met. The impact on the Life Management/Aging Management Program has not been determined.

Table 4-38 lists key milestones for the resolution of System Deficiency 4-5.

Table 4-37. Life Management/Aging Management Plan Program Schedule (Shoren and Sindelar 1994).

Schedule	Description
09/94	Issue waste tank structural acceptance criteria
09/95	Initial heat transfer and structural analyses
09/95	Structural surveillance and condition survey updates
09/96	Complete heat transfer and structural analyses
09/97	Complete seismic analyses
09/98	Issue double-shell tank life management options
09/98	Issue single-shell tank life management options

Table 4-38. Milestones for Funded Program Activities (WHC 1994a).

Milestone	Description	Completion Date
T2C-94-427	Submit to Washington State Department of Ecology a final plan and schedule for completion of the double-shell tank integrity assessments (Tri-Party Agreement Milestone M-32-04)	06/94
T2C-95-406	Complete electronic engineering bibliography	03/95
T2C-95-409	Complete support facilities useful life estimate	03/95
T2C-95-404	Complete double-shell tank structural assessment	04/95
T2C-95-112	Complete double-shell tank integrity assessments - ultrasonic equipment performance test	04/95
T2C-95-111	Complete double-shell tank integrity assessments - engineering task plan	05/95
T2C-95-113	Double-shell tank integrity assessments - double-shell tank ultrasonic inspection	09/95

4.4.5.6 Alternative Strategies. An alternative for the resolution of this system deficiency is to replace tanks periodically. This is considered viable but not cost effective compared with the current program. Accelerating final disposal is another alternative; however, it is not necessary if the tanks have sufficient remaining performance life to serve through final disposal.

4.4.6 System Deficiency 4-6: Conduct of Operations Deficient

4.4.6.1 Background and Description. In several reviews performed prior to 1992, tank farm conduct of operations was considered to be poor. Improved procedures and training in this area are being implemented. Ultimately, the training will meet U.S. Department of Energy requirements for accreditation.

Safety initiatives have been developed to track the progress of some major elements of the conduct of operations system deficiency. These safety initiative are as follows:

- **Safety Initiative 1a** - Affect an orderly administrative hold and establish a policy for allowed work during the administrative hold by August 1993 (completed).

- **Safety Initiative 1b** - Develop plan of action for release of work during administrative hold and for resumption of work by September 1993 (completed).

- **Safety Initiative 1c** - Complete training of new tank farm supervisors by September 1993 (completed).

- **Safety Initiative 1d** - Complete the recertification of incumbent tank farm operators (supervisors) using new training materials by December 1994 (completed).

Schedule Change From the 1993 Report. The milestone for safety initiative 1d, supervisor training, was moved from 3/95 to 12/94.

Scope Change from the 1993 report. None identified.

4.4.6.2 Priority and Strategy. During the last several years during the tank farm project organization has made major improvements in conduct of operations. Experience has shown that efforts toward improving performance in this area are much more productive if the supporting programs and initiatives are properly sequenced and focused on a limited number of high-priority objectives. In order to ensure that future efforts are the most productive and yield maximum improvements in the facilities safety posture given current and projected resource limitations, a detailed *Conduct of Operations Compliance Plan* was completed. The plan for upgrading conduct of operations is included in the *Tank Farms Restoration and Upgrades Program Plan* (Bigbee and Bouchey 1993).

The tank farm conduct of operations compliance plan ties together all of the ongoing infrastructure restoration programs (procedures, drawings, safety basis, etc.), the tank farm training program, and all other initiatives that relate directly to conduct of operations. This program achieves the best possible improvement in overall plant safety while utilizing all available resources in the most cost-effective manner.

An operations manager/supervisory training and certification program was initiated. This program includes an eight-week fundamental classroom instruction course, managerial and leadership training, and plant specific classroom and on-the-job instruction for qualification in specific job tasks/routines. The final certification process for the managers and supervisors includes an oral board evaluation and confirmation of qualification by tank farm management.

One hundred and twenty tank farm procedures have been upgraded to a commercial format to comply with U.S. Department of Energy Orders and conduct of operations requirements. Procedure upgrades include plant operating procedures; data, log, and operating round sheets; emergency response and alarm procedures; operating safety requirements surveillance procedures; and facility administrative procedures. To assist with this task, a *Writers Guide* was completed in March of 1991. This guide was based on the U.S. Department of Energy's Writers Guide Criteria (DOE 1991b).

4.4.6.3 Work Completed to Date.

- **Safety Initiative 1a** - Affect an orderly administrative hold and establish a policy for allowed work during the administrative hold by August 1993.

The Tank Waste Remediation Systems organization accomplished an orderly administrative hold by reducing ongoing work to the minimum required to meet legal (e.g., Tri-Party Agreement) obligations and to maintain an adequate level of safety with regard to the workers, the public, and the environment. Most tank farm operations and maintenance personnel were removed from the tank farms to attend training and upgrade sessions. Personnel remaining on duty in the tank farms were qualified for their work and were sufficient to meet the minimum obligations and to maintain a safe facility.

Tank farm management established a policy for allowed work that focused on maintaining a safe facility and meeting all legal obligations. A work control team of senior personnel was established to evaluate each proposed work item, shift round, and surveillance task. The control basis was that the work item must be required to maintain the safety basis in the tank farms, required to meet an OSD or occupational safety requirement, required by the Tri-Party Agreement, etc. In addition, if significant cost would be incurred later by deferring the work now, the work item could be allowed.

The Administrative Hold goal was to reduce daily work activity to the minimum acceptable level in order to establish a base from which work and tank farm activity could be added in a controlled manner and not exceed the ability of tank farm personnel to operate safely and in accordance with Conduct of Operations principles and practices.

- **Safety Initiative 1b** - Develop plan of action for release of work during administrative hold and for resumption of work by September 1993.

In addition to the work control team described above, tank farm management established a work screening and release team. This team reviewed the work packages and procedures to ensure that they were complete, that they incorporated all required safety and quality requirements, that required materials were prepared, and that personnel were trained for the work. Also, a senior management review team was assembled to review preparatory briefings, procedures, and dry runs for field activity. Procedures were scrubbed thoroughly, and often rewritten, by teams composed of operators, supervisors, engineers, health physics technicians, and other knowledgeable personnel to ensure technical accuracy, adequate safety, proper operational controls, and field workability.

These same processes were continued during the first several months of the recovery period as additional work was allowed following demonstrated successful activity. The goal was to integrate improved training, improved procedures, improved control of work and field activity into an increasingly higher standard of Conduct of Operations.

- **Safety Initiative 1c** - Complete training of new tank farm supervisors by September 1993.

Prior to the administrative hold, tank farm management devised a plan to effect a step change in conduct of operations by hiring experienced operations personnel who were highly trained and experienced in conduct of operations and training them in tank farm facilities and operations. Ex-Naval Nuclear personnel and commercial nuclear industry experienced personnel were recruited for tank farm training. The certification process included classroom work, field work, extensive on-the-job-training, and oral examinations. A sufficient number of these personnel completed the training by the end of September to place a certified shift manager on each shift, in addition to assigning some to maintenance and to production control.

- **Safety Initiative 1d** - Complete the recertification of incumbent tank farm operators (supervisors) using new training materials by December 1994.

During and subsequent to the Administrative Hold, new training materials were developed and an improved training program was put into place to certify incumbent tank farm operators in the skills required for their work. The training included one-on-one training with experienced operators, performance evaluations, and examinations. The end goal was to have certified operators in the tank farms. This goal was achieved.

Also, the incumbent shift supervisors (managers) attended the same training and qualification program the new shift managers attended and certified for work in the tank farms. Additional personnel are currently being trained under this training and qualification program.

4.4.6.4 Work Required to Resolve the Issue. Work required to resolve the issue includes completing the milestones shown under cost and schedule, below.

4.4.6.5 Cost and Schedule. The cost and schedule are based on *Tank Waste Remediation System's Multi-Year Program Plan* as submitted to the Department of Energy in September 1994. This activity should be complete in fiscal year 1995 with estimated costs of $1.2 million for the year. The total life cycle cost for resolving this system deficiency is on the order of $18 million. Important milestones are listed below.

Schedule	Milestone Description
9/95	Procedure Upgrades Complete

4.4.6.6 Alternative Strategies or Treatments. N/A

4.4.7 System Deficiency 4-7: Lack of Plant-Essential Drawings

4.4.7.1 Background and Description. The double-shell tank and single-shell tank farm drawings have not been maintained in an "as-built" state in compliance with U.S. Department of Energy Orders. It is estimated that a large percentage of the 21,000 drawings pertinent to the tank farms require upgrading. Operations, facility, and equipment upgrades and the safety issue efforts may be adversely impacted and/or delayed due to the lack of essential drawings.

Safety initiatives have been developed to track progress in dealing with some major elements of the Lack of Plant-Essential Drawings system deficiency as follows:

- **Safety Initiative 4c,** complete accelerated walkdowns and field verify essential drawings by September 1996.

Schedule Change From 1991 to 1993 Report. None identified.

Schedule Change From the 1993 Report. The schedule was revised to as-build a minimum of 150 essential and support drawings in fiscal year 1995. The remaining essential and support drawings will be completed by October 1996.

Scope Change from 1991 report to 1993 report. None identified.

Scope Change from the 1993 report. In the previous revision to this document, component labeling was tied to drawing upgrade efforts. The work to label tank farm equipment is not under the Safety Initiative 4c42 and is tracked separately. Since the last report, an internal memo was issued on February 28, 1995 to the Department of Energy Richland Office requesting authorization to combine field verification and H-14 as-built system based on drawing programs. This approval has not yet been approved by the Department of Energy Richland Office.

4.4.7.2 Priority and Strategy. Because actual plant configuration may be unknown and/or not documented, operation, maintenance, and facility and/or equipment upgrades could be compromised. The lack of configuration has potential impacts on safety analyses upgrades, remediation efforts, Tri-Party Agreement milestones, and could lead to an operating error or injury. Based on these potential impacts, this issue meets system deficiency criteria.

4.4.7.3 Work Completed to Date. Prior to the 1993 report of the approximately 1,200 essential and support drawings, 43% (520 drawings) were as-built. In addition, component labeling of double-shell tank farm facilities was initiated in fiscal year 1992.

The work completed since the 1993 report consists of a document listing all the essential and support drawings was released and has been continued to be updated. This document, *"Tank Farm Essential Drawing Plan"*, WHC-SD-WM-PC-002 contains a list of approximately 1200 drawings essential to the operation of the tank farms. In addition, a Safety Initiative Milestone, Safety Issue 4c42 was set for September 30, 1996 to complete the field verification program. Of the approximately 1200 essential and support drawings, 65% (778 drawings) have been as-built. Labeling occurred in fiscal year 1994. Tank farms 241-AN (95% of the components labeled), 241-AW (80%), 241-AP (25%) and 241-SY (1%) were labeled.

4.4.7.4 Work Required to Resolve the System Deficiency. In fiscal year 1995 a minimum of 150 essential and support drawings will be as-built. The remaining essential and support drawings will be completed by October 1996. Of the 1,200 essential and support drawings there are approximately 140 drawings that cannot be as-built, such as drawings of printed circuit boards, computer hardware and logic diagrams.

4.4.7.5 Cost and Schedule. The cost and schedule are based on Target Level funding contained in the WBS-SP-1101, the Work Breakdown Structure Dictionary. The total life cycle cost estimate for resolving this system deficiency is $8.6 million. The important milestones are listed in Table 4-39.

Table 4-39. Milestones Associated with System Deficiency 4-7.

Schedule	Description
09/95	Complete a minimum of 150 essential or support drawings
09/96	Complete a minimum of 130 essential or support drawings required to complete the safety issue

4.4.7.6 Alternative Strategies or Treatments. N/A

4.4.8 System Deficiency 4-8: Questionable Transfer Line Concrete Encasement Integrity

This topic has already been addressed in Section 4.3.5.

4.4.9 System Deficiency 4-9: Leak Detection in Double-Shell Tanks

4.4.9.1 Background and Description. The first double-shell tanks at the Savannah River Site were built and put into service in the early 1950's storing liquid radioactive waste. Soon leaks from the carbon steel primary tanks or shells were detected by the operating leak detection systems that were installed during construction. Later, remote photography in the tank annuli located leaks on the outside of the primary tank walls. Photographs showed linear salt encrustations along some of the fabrication welds for the primary shells. Subsequently, double-shell tanks constructed at the Savannah River Site have heat treat stress relieved carbon steel primary tanks. Liquid waste from the leaking double-shell tanks has been transferred to the stress relieved double-shell tanks. No additional double-shell tank leaks at Savannah River Site have occurred.

Questions have been raised about the likelihood of and the ability to detect leaks of liquid radioactive waste from the Hanford Site double-shell tanks. The Hanford double-shell tanks have all been constructed since the late 1960's. The carbon steel primary shells were heat treat stress relieved during construction. A recent review of construction specifications and construction field reports indicated that the stress relieving process was conducted as specified. This review was discussed with the U. S. Department of Energy High Level Waste Tank Structural Integrity Panel. There are primary tank leak detection systems for the Hanford double-shell tanks. These include conductivity probes in the annulus, liquid level monitoring in the primary tank and radiation continuous air monitors in the annulus ventilation system outlet flow. Further, outside the secondary tank bottoms, there are (redundant) leak collection systems and detection pits. As such, the leak detection systems provide 100% coverage of the tanks and are designed to operate 100% of the time. No leaks in the Hanford double-shell tank primary shells have been detected.

Videotaped remote closed circuit television inspections were recently conducted in the Hanford double-shell tank annuli for portions of the primary and secondary shells. These inspections show no evidence of leaks. Follow on closed circuit television inspections in the double-shell tank annuli can be made for comparison and to expand the coverage.

A robotic ultrasonic inspection system is being developed for use in the Hanford double-shell tank annuli. It will be used to conduct ultrasonic examinations of portions of the primary and secondary shells. This system is scheduled in fiscal year 1995 to be completed, operationally tested in a tank mockup, and initially used. Guidelines for ultrasonic examinations of the double-shell tanks are being developed with tank structure integrity panel participation.

4.4.9.2 Priority and Strategy. Direct, full time leak detection capability for the Hanford Site double-shell tanks is necessary to assure and confirm confinement of the stored liquid waste. The double-shell tank leak detection systems were identified as a system deficiency in 1992 by the U.S. Department of Energy High Level Waste Tank Task Force (DOE 1992).

The strategy for system deficiency resolution is to issue a recommendation that this system deficiency be closed, conditional upon the completion of written detailed reports, with Department of Energy High Level Waste Tank Structural Integrity Panel concurrence which establish:

- The leak detection systems in the double-shell tanks do and will continue to operate 100 percent of the time, except for minimum outages for maintenance, calibration, and repairs.

- The closed circuit television inspection system and abilities needed to use it in the double-shell tanks annuli are readily available.

- The development, operational testing, and operation or use of the robotic ultrasonic examination system for the double-shell tanks proceeds on a prompt and reasonable schedule.

This recommendation is based on the demonstration that the Hanford double-shell tank leak detection systems provide 100 percent effective coverage. The likelihood of leaks developing in the stress relieved primary shells is remote. The partial coverage completed closed circuit television inspections and the ultrasonic examinations will establish and maintain a technical baseline representing the overall condition or integrity of the primary and secondary shells.

4.4.9.3 Work Completed to Date. Closed circuit television surveillance of the double-shell tanks has been conducted with no indication of leakage.

4.4.9.4 Work Required to Resolve Issue. The recommendation for final closure of this system deficiency must be prepared. Written detailed reports should be prepared, and made readily available which document that the double-shell tank leak detection systems provide 100 percent coverage for the primary steel shells. Also, the reports should explain that closed circuit television and ultrasonic examinations provide partial coverage, with long intervals between examinations. These examinations establish and maintain a technical baseline representing the condition of the primary and secondary shells, but are not intended for leak detection. Concurrence from the Department of Energy Tank Structural Integrity Panel for the reports and conclusions should be requested. Development has began on an ultrasonic inspection system for the double-shell tank steel shells.

4.4.9.5 Cost and Schedule. The cost and schedule for preparing the recommendation to close this system deficiency, and the supporting documentation have not been developed.

4.4.9.6 Alternative Methods. No alternative methods have been identified.

5.0 COST AND SCHEDULE SUMMARY

Figure 5-1 summarizes the costs and end dates associated with the mitigation and/or resolution of the safety issues and system deficiencies. Cost are shown for all issues and deficiencies but Safety Issue 3-6, *"Excessive Unfiltered Air Flow Passages Into Tanks."* The total cost for all issues except Safety Issue 3-6 is about $1.9 billion.

Schedule dates from the 1993 Status Report are indicated with a triangle. Changes to these dates (see Table ES-1) are indicated with a small diamond. To date, one item has been resolved, System Deficiency 4-9, *"Leak Detection in Double-Shell Tanks."* The last safety issue to be resolved will be Safety Issue 2-2, *"Storage of High Level Waste in Tanks That Have Leaked."* This issue will end in 2018.

Figure 5-1. Cost and Schedule Summary for Waste Tank Safety Issue and System Deficiency Resolution.

Activity Name	1993 Finish Date	New Finish Date	Cost $M
SUMMARY SCHEDULE			
SI-1-1 HIGH FLAMMABLE GAS CONCENTRATIONS	11/30/1999	9/30/2001	280.0
SI-1-2 POTENTIALLY EXPLOSIVE MIXTURES OF FERROCYANIDE	9/30/1998	9/30/1997	29.3
SI-1-3 POTENTIAL FOR RUNAWAY ORGANIC/NITRATE REACTIONS	9/30/2001		90.0
SI-1-4 CONTINUED COOLING REQUIRED FOR HIGH HEAT GENERATION IN TANK 241-C-106	9/30/1998	9/30/1997	77.5
SI-2-1 INADEQUATE SINGLE SHELL TANK LEAK DETECTION	9/30/1998		2.7
SI-2-2 STORAGE OF HIGH LEVEL WASTE IN TANKS THAT HAVE LEAKED (Cost is Part of SI-2-7)	6/30/2018	9/30/2024	
SI-2-3 INABILITY OF TANKS TO WITHSTAND A DESIGN BASIS EARTHQUAKE - Cost and Schedule are per System Deficiency SD-4-5,			
SI-2-4 INADEQUATE SINGLE SHELL TANK PUMPING CAPABILITIES	9/30/1994	3/31/1995	12.0
SI-2-5 TANK VAPOR RELEASE	6/30/1998	11/30/1997	8.3
SI-2-6 INADEQUATE RESPONSE TIME TO A LEAKING DOUBLE SHELL TANK	9/30/1995	12/31/1995	1.5
Maintain Emergency Pumping Capability through 2015			9.0

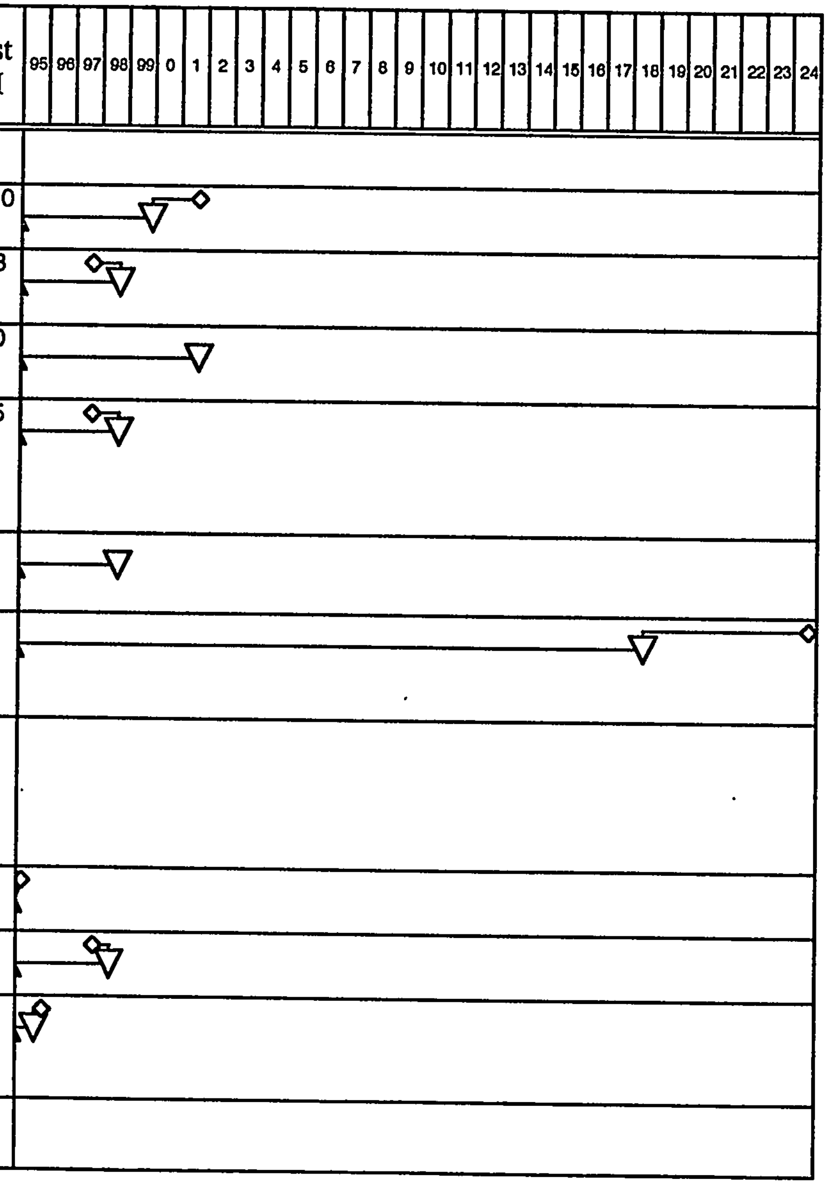


Figure 5-1. Cost and Schedule Summary for Waste Tank Safety Issue and System Deficiency Resolution.

Activity Name	1993 Finish Date	New Finish Date	Cost $M
SI-2-7 STORAGE OF HIGH LEVEL WASTE IN TANKS WITH NO SECONDARY CONTAINMENT	6/30/2018	9/30/2024	99.0
SI-2-8 POTENTIAL FOR NUCLEAR CRITICALITY IN HIGH LEVEL WASTE TANKS	9/30/1999		6.3
SI-3-1 INSUFFICIENT TANK STORAGE CAPACITY TO HANDLE WASTE FROM RESOLVING EXISTING ISSUES	12/31/1999	12/31/1998	435.0
SI-3-2 CRACKED TANK FARM VENTILATION HEADER	1/31/1996	12/31/1996	24.6
SI-3-3 INSUFFICIENT HYDROXIDE CONCENTRATION IN TANKS	9/30/2006	9/30/1997	7.9
SI-3-4 INADEQUATE SEALING OF SINGLE SHELL TANKS TO PREVENT LIQUID INTRUSIONS	9/30/2007	9/30/2000	8.2
SI-3-5 POSSIBLE INADEQUACIES IN WASTE TRANSFER LINE LEAK DETECTION (ALSO SYSTEM DEFICIENCY 4-8)	10/31/1997	2/28/1998	69.0
SI-3-6 EXCESSIVE UNFILTERED AIR FLOW PASSAGES INTO TANKS (Cost Not Available)	9/30/1999	6/30/2005	
SI-3-7 POTENTIAL FOR FORMATION OF EXPLOSIVE DEPOSITS - This Issue does not apply to Hanford's Tank Farms			
SI-3-8 UNCHARACTERIZED CORROSION OF HIGH LEVEL WASTE TANKS	10/30/1994	12/31/1997	4.0
SD-4-1 INSUFFICIENT TANK CONTENTS CHARACTERIZATION	9/30/1998	9/30/1999	326.4

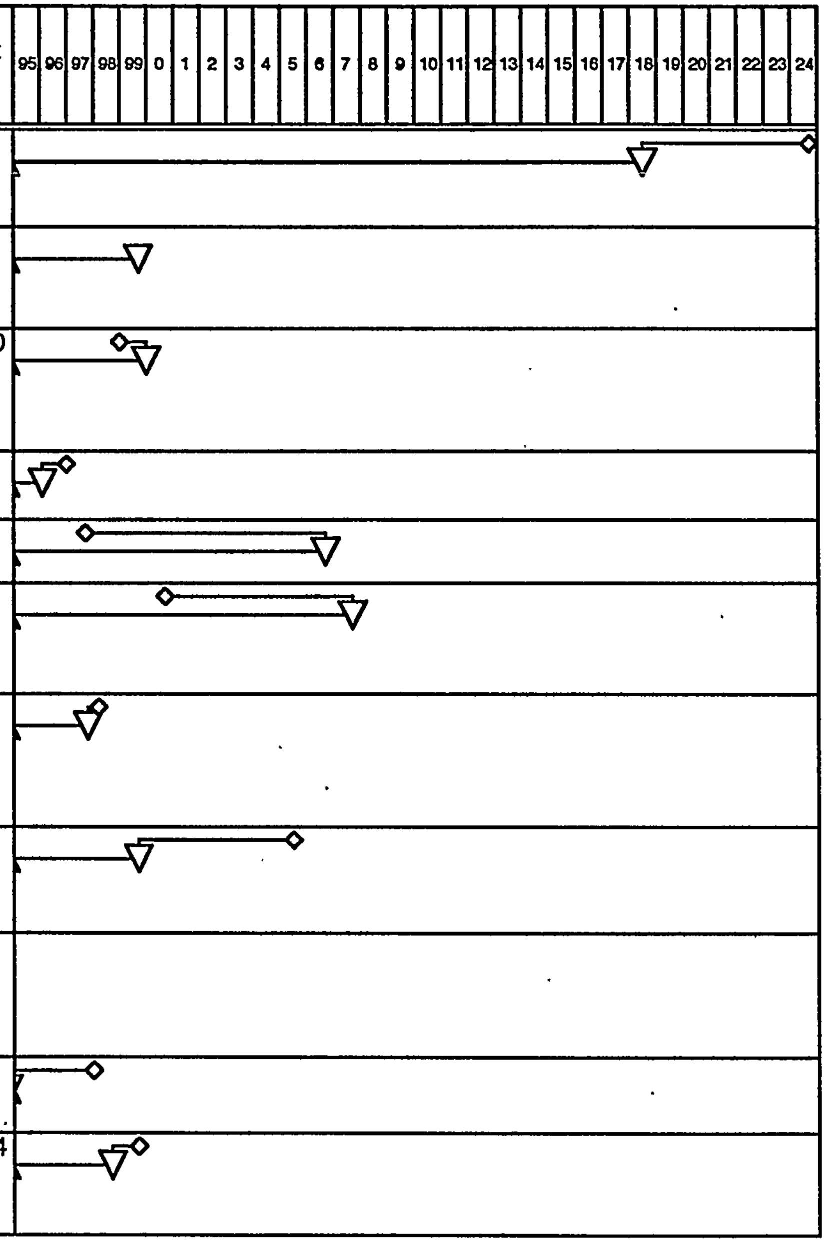
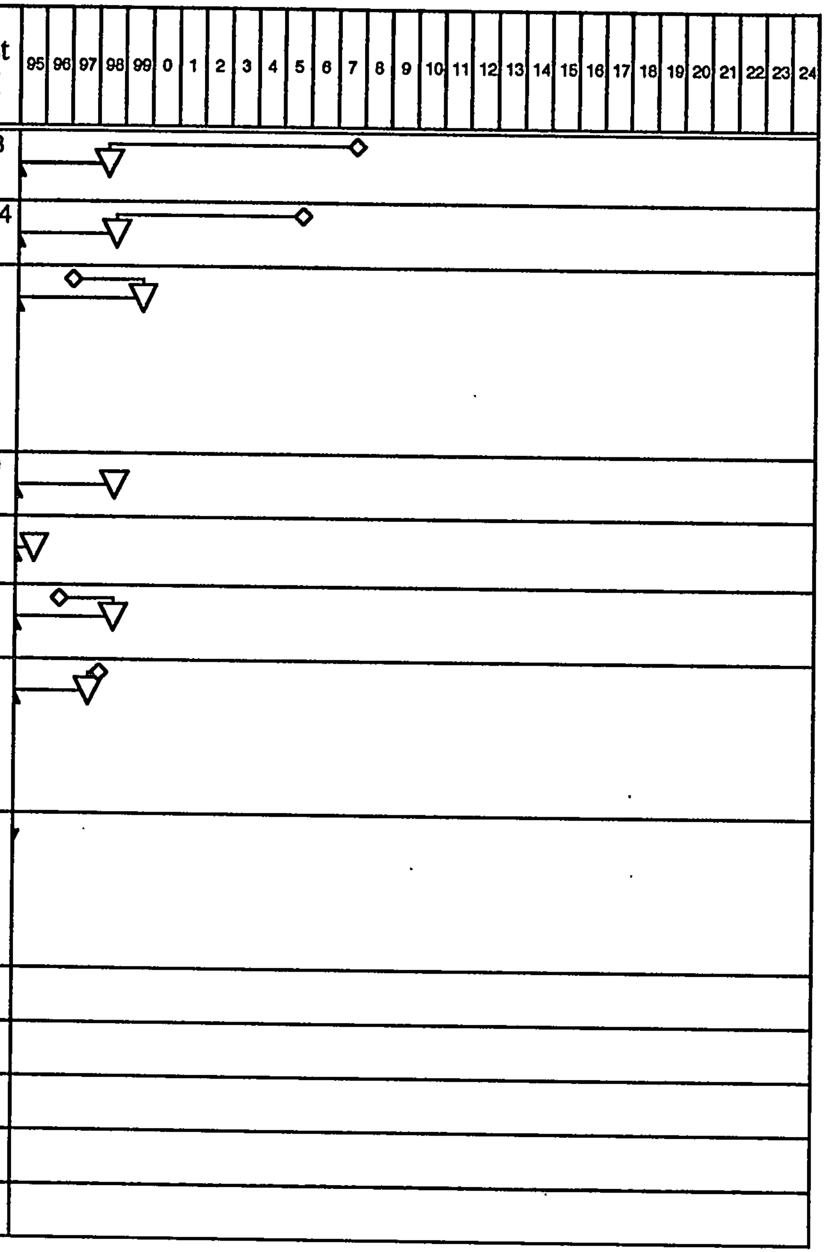


Figure 5-1. Cost and Schedule Summary for Waste Tank Safety Issue and System Deficiency Resolution.

Activity Name	1993 Finish Date	New Finish Date	Cost $M
SD-4-2 INADEQUATE SAFETY DOCUMENTATION	5/30/1998	9/30/2007	52.8
SD-4-3 DEFICIENT MAINTENANCE AND UPGRADE OF FACILITIES	9/30/1998	9/30/2005	306.4
SD-4-4 DEFICIENT INSTRUMENT UPGRADES IN SINGLE AND DOUBLE SHELL TANKS (Cost Included in Priority 1 Safety Issues and in System Deficiency SD-4-3)	9/30/1999	1/30/1997	
SD-4-5 EXTENDED TANK OPERATING LIFE	9/30/1998		26.0
SD-4-6 DEFICIENT CONDUCT OF OPERATIONS	9/30/1995		18.0
SD-4-7 LACK OF PLANT-ESSENTIAL DRAWINGS	9/30/1998	9/30/1996	8.6
SD-4-8 QUESTIONABLE TRANSFER LINE CONCRETE ENCASEMENT INTEGRITY - This topic is addressed as part of Safety Issue 3-5.	10/30/1997	2/28/1998	
SD-4-9 LEAK DETECTION IN DOUBLE SHELL TANKS (Cost included in System Deficiency 4-5) - Deficiency Closed 9/94.	9/30/1994		



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APPENDIX A

WASTE TANK SAFETY ISSUE RESOLUTION LOGIC

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APPENDIX A

WASTE TANK SAFETY ISSUE RESOLUTION LOGIC

This appendix provides the lower-level details of the logic for resolution of waste tank safety issues summarized in Section 2.2, Overview of Tank Safety Issue Resolution Logic. The logic was developed from a concept paper prepared by Science Applications International Corporation, Germantown, Maryland (SAIC 1991).

Figure A-1 through A-7 provide the overall waste tank safety issue resolution logic at several levels of detail as shown in Table A-1. The top level (Level 1) logic is provided in Figure 2-1, Section 2.2.

Table A-1. Guide to Waste Tank Safety Logic Diagrams.

Logic Element	Level 1 Logic	Level 2 Logic	Level 3+ Logic
1.0	Figure 2-1	Figure A-1	Figure A-5
2.0	Figure 2-1	Figure A-2	None
3.0	Figure 2-1	Figure A-3	Figure A-6
4.0	Figure 2-1	Figure A-4	Figure A-7

The following sections describe the logic for resolution of tank safety issues.

A.1 EVALUATE AND DEFINE THE PROBLEM

A.1.1 Establish Preliminary Hypothesis

The objective of this task is to establish the priority of work to be accomplished based on review of historical data, synthetic waste studies, laboratory tests, monitoring data, mathematical modeling, and sensitivity analyses (Tasks 1.1.1 and 1.1.2, Figure A-5). Prioritizing the work is important to risk minimization because resources needed for obtaining data on the tanks and their contents are limited. Prioritizing the work ensures that tanks, or groups of tanks, posing the greatest risk are evaluated first.

A.1.2 Obtain Data on Tank and Contents

The objective of this task is to obtain sufficient data from waste samples, monitoring of tank parameters, and modeling (1.1.1, Figure A-5) to refine the hypothesis and mode (1.3) and define tank safety criteria (1.4), and to established a baseline preliminary risk assessment (Figure A-5). An evaluation of the tank safety envelop is made on available information to support entry into the tank to support collecting waste samples and for installation of monitoring equipment.

A.1.3. Refine Hypothesis/Model

The results of the sampling process on each tank provide validation of the preliminary hypothesis (1.1, Figure A-5). In some cases additional studies and sampling may be needed to validate the hypothesis and model. In such instances, tasks 1.1 through 1.3, Figure A-1 become interactive.

A.1.4 Define Tank Safety Criteria

After the tank model has been validated it may be used to define criteria for safe operation of the tank (Figure A-5). This information is used to determine if it is safe to stabilize and isolate those single-shell tanks on the Watch List not already stabilized and isolated. The criteria is also used as input to the following tanks:

- **Task 1.5 - Apply Criteria to Data by Tank (Figure A-5).** The output of this task is redefinition of the safety envelope (1.5.4) based on technical evaluations (1.5.1), hazards reassessment (1.5.2) and probabalistic risk assessment (1.5.3).

- **Task 1.6 - Revise Tank List (Figure A-5).** The output of this task is a revised list of tanks (1.6.4) having safety issues requiring resolution. Tanks can be added to the list (1.6.1) or removed from the list (1.6.2) based on documentation approved by appropriate authority (1.6.3).

- **Task 1.7 - Upgrade Equipment, Facilities and Safety Documentation (Figure A-5).** This task provides for upgrades to area gas monitoring (1.7.1), instrumentation (1.7.2), ventilation (1.7.3), redefinition of the safety envelope (1.7.4) based on Task 1.5, and determining control limits (1.7.5).

After sufficient evaluation and definition of the problem (1.0) to make an evaluation (2.1) on the disposition of the tank, or group of tanks, decisions can be made on the appropriate path to follow for resolution of the safety issue.

A.2 IMPLEMENT "ZERO" OPTION

The "zero" option path (Figure A-2) involves tanks which are determined to be minimal risk based on evaluation (2.1) of results from element 1.0. The disposition appropriate for each tank, or group of tanks, is determined based on redefinition of the safety envelope (1.5.4), revision of the tank list (1.6), and establishing control limits (1.7.5). Possible dispositions are:

- Removal from Watch List with no further actions required because the risk is minimal, either because it is "inherently safe" (e.g., there is not enough fuel in the tank to support an exothermic reaction), or it is "passively safe" (e.g., enough fuel is present, but so are sufficient diluents to preclude any significant reaction). Moisture control in ferrocyanide tanks is an example of the "zero" option.

- Removal from the Watch List after completion of upgrades (2.2.1, 2.2.2, and 2.2.3), redefinition of the safety envelope (2.2.4), and determining control limits consistent with "zero" option safety criteria developed in Task 1.4, Define Tank Safety Criteria.

- Determination that the "zero" option is not viable (2.3) in which case mitigation (3.0) or remediation (4.0) action will be required to resolve the safety issue.

A.3 IMPLEMENT MITIGATION

The mitigation path (Figure A-3) applies to tanks where the hazard can be controlled or eliminated by some method of in-tank treatment. An example is the installation of a mixed pump and mitigation test chamber in Tank 101-SY to demonstrate mitigation of that tank.

A.3.1 Identify Pathway to Hazard

A common approach in the process to identify pathways to hazards makes use of the fault tree and event tree theories used in nuclear and industrial safety work. In these theories, the events which lead up to an accident are considered as a sequence, and the removal of events or combinations of events which result in failure will either eliminate the accident or reduce its consequences to an acceptable level. The first step in the mitigation/remediation efforts, therefore, is the identification of the events or pathways (3.1, Figures A-3 and A-6) leading to an undesirable situation. When applicable, the various pathways suggested are evaluated in the laboratory and those which cannot be verified as valid are discarded.

A.3.2 Determine Approaches to Preempt Path

Techniques are sought to disrupt the process leading to an accident by eliminating either a key event or a combination of events along the path. A number of techniques are likely suggested. Those most promising of these will be verified as to their effectiveness in laboratory scale tests.

A.3.3 Recommend Mitigation Approach

A recommended mitigation approach (3.5) is selected based on evaluation of approached by criteria (3.3) and ranking of options by criteria (3.4, Figure A-6). Several approaches may be generated which show promise in addressing the identified tank problems. Following laboratory tests validating the principles involved, one or more approaches are selected for further development based upon their performance against certain selection criteria. The more important criteria would include the effects the approach might have upon the final treatment of the waste, the rapidity with which the approach could be implemented, and its potential for success. Other criteria could related to safety, environmental impacts and risks, oversight groups and the public, costs, and associated paperwork and regulatory requirements.

Evaluation of the competing approaches against the selection criteria is a pencil and paper effort, with no laboratory or modelling input required. This should be a group process, with expertise available on every dimension on which the approaches are being evaluated (e.g., technical feasibility and efficiency, cost, public acceptability). Generally, one promising approach to mitigation will go forward to pilot testing and preparation for implementation. In certain cases, though, the urgency of the situation will require that several approaches go forward in parallel in order to minimize the time required for resolution of the safety issues.

A.3.4 Implement Mitigation Approach

Implementation of the mitigation approach (3.6, Figure A-6) begins with a scaled proof of concept (3.6.1). This work demonstrates that the principles shown in the laboratory scale testing are also valid as the scale increases. An important part of this evaluation deals with the impact the approach will have on the integrity of the tank and on the final disposal. Failure of the approach on either of these two points would probably mean that the approach would be dropped from further consideration. Once again, it is likely that only one mitigation approach will be actively pursues at this point. However, the urgency of the problem may dictate that several approaches continue going forward in parallel in order to ensure that an effective and workable solution will be implemented in the shortest time possible time.

Once through the scaled proof concept (3.6.1), design (3.6.2) starts within the construction, instrumentation, and installation areas, as appropriate. Any necessary fabrication or materials and equipment purchases (3.6.3) would follow the design activity (3.6.1), as would the development of procedures to implement this approach (3.6.4). In parallel with these preparatory activities, safety and environmental documentation is prepared (3.6.5 and 3.6.6) to secure permission to operate within the affected tank(s). After all is in readiness, the mitigation approach is implemented (3.6.13).

A.3.5 Evaluate Results

After the mitigation option selected has been implemented (3.6), tank sampling or monitoring data will indicate whether or not the tank is now safe based on evaluation of results (3.8). If it is safe, the safety issue has been resolved. The tank can be removed from the Watch List and managed as a tank about which there are no safety concerns. If mitigation is not sufficient (3.9) to resolve the safety issue, then remediation (4.0) of the safety issues will be required.

A.4 IMPLEMENT REMEDIATION

The remediation path (Figure A-7) applies to a tank or a group of tanks where the hazard cannot be controlled or eliminated by in-tank treatment of the waste. To remediate at tank safety issues the waste must be removed from the Watch List tank and transferred to another location for treatment and storage. An example is the removal, treatment, and storage of waste from a Watch List tank prior to solidification in the Hanford Waste Vitrification Plant or Grout Treatment Facility (see Figure 1-1).

The logic steps for implementing remediation in Figure A-4 and A-7 are identical to the steps for implementing mitigation (Figure A-3 and A-6) except for the last step (4.9). If the selected remediation method is not successful (4.9) then another approach is selected for implementation (4.3 through 4.6). This process is continued until the safety issues for the tank or group of tanks if resolved.

Figure A-1. Level 2 Logic Diagram for 1.0 Evaluate and Define the Problem.

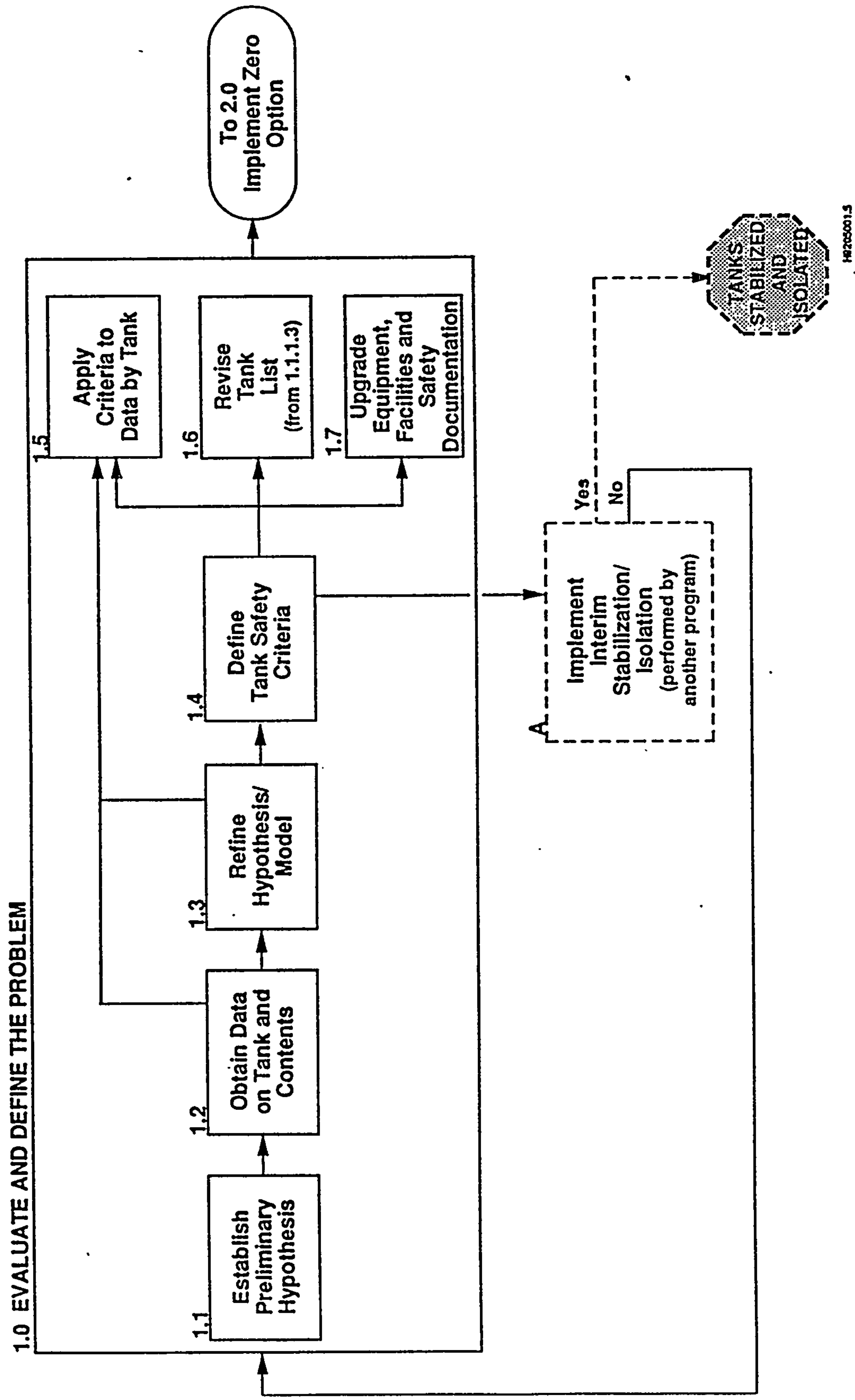


Figure A-2. Level 2 Logic Diagram for 2.0 Implement "Zero" Option.

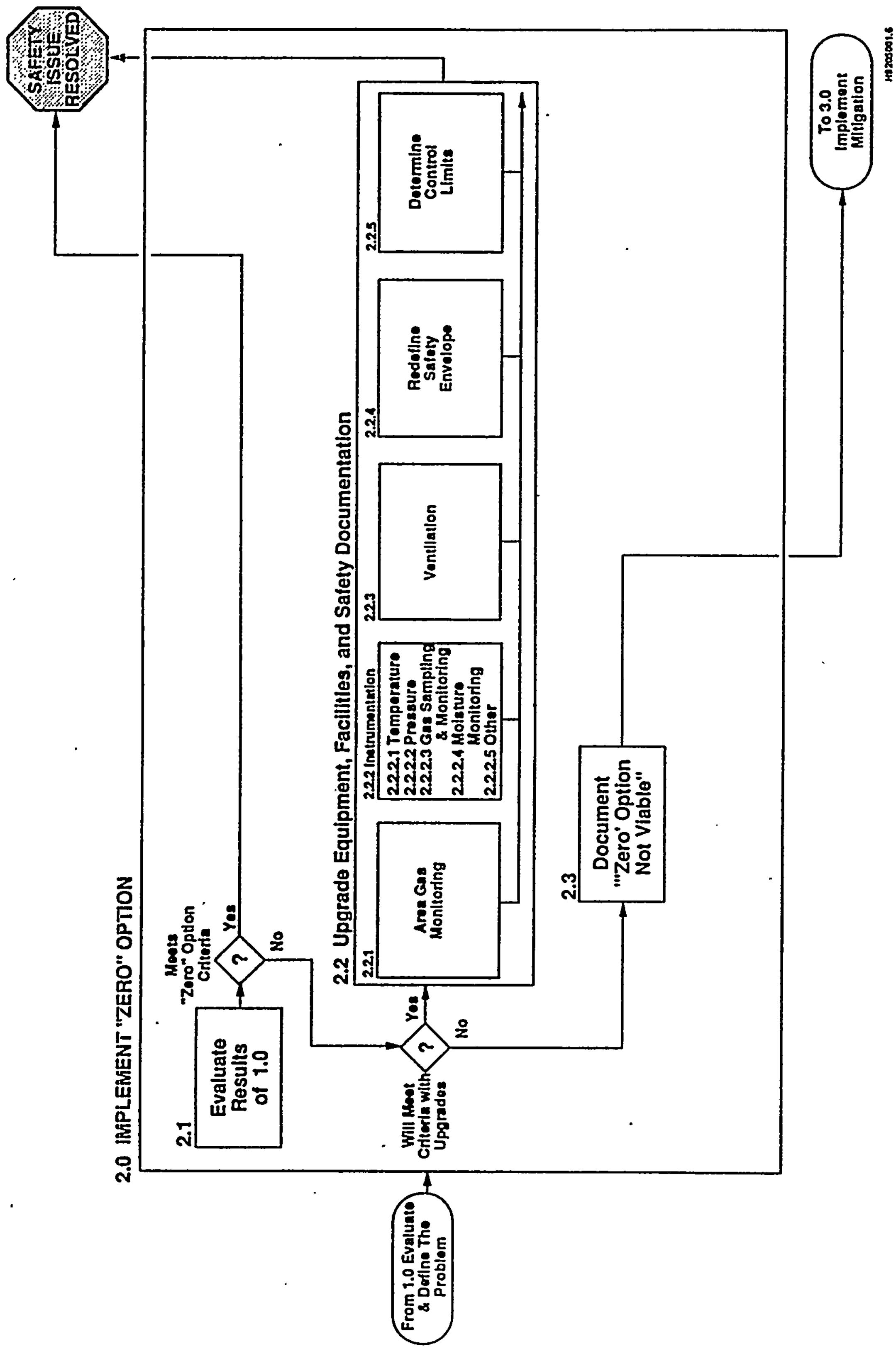


Figure A-3. Level 2 Logic Diagram for 3.0 Implement Mitigation.

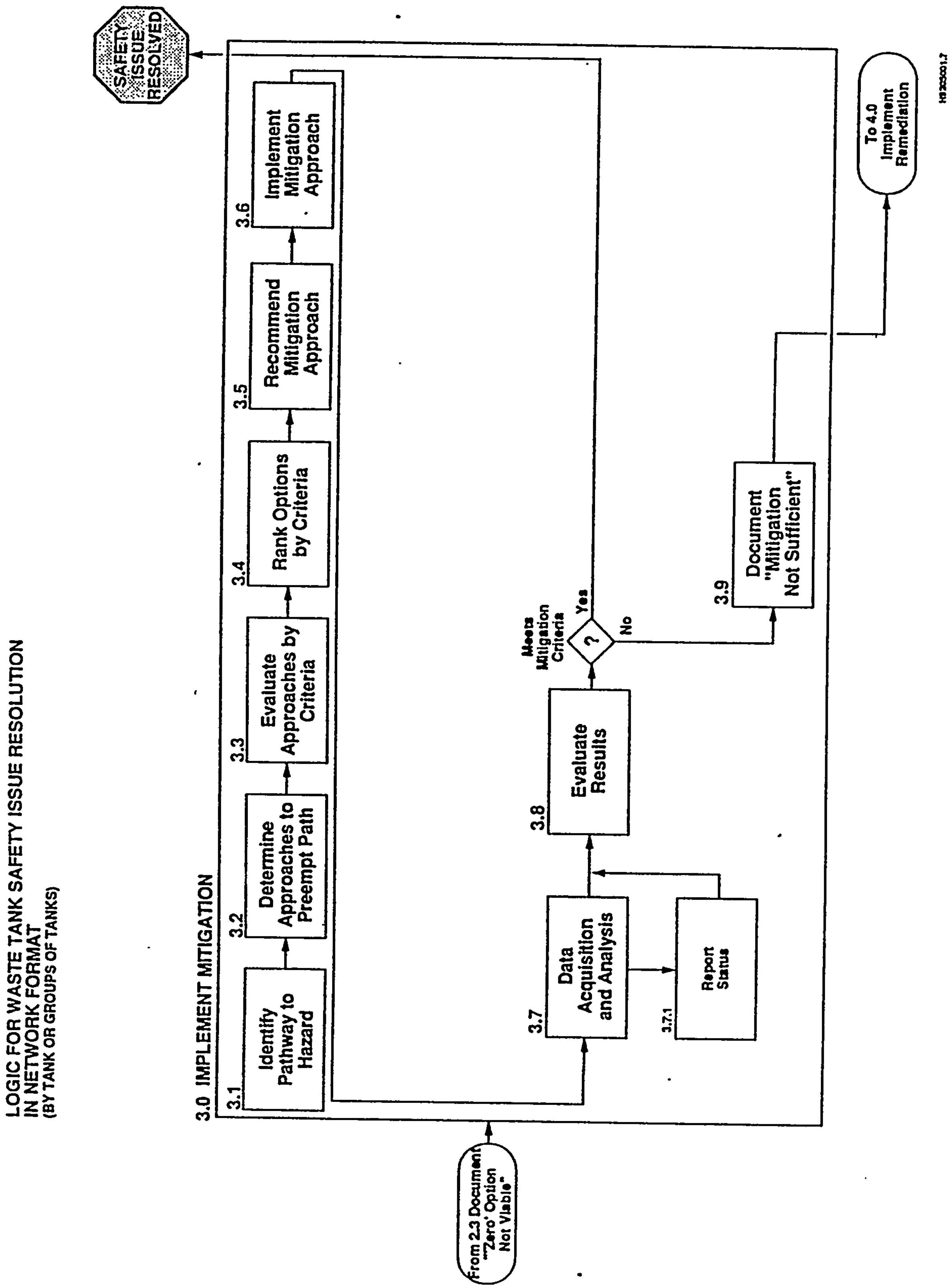


Figure A-4. Level 2 Logic Diagram for 4.0 Implement Remediation.

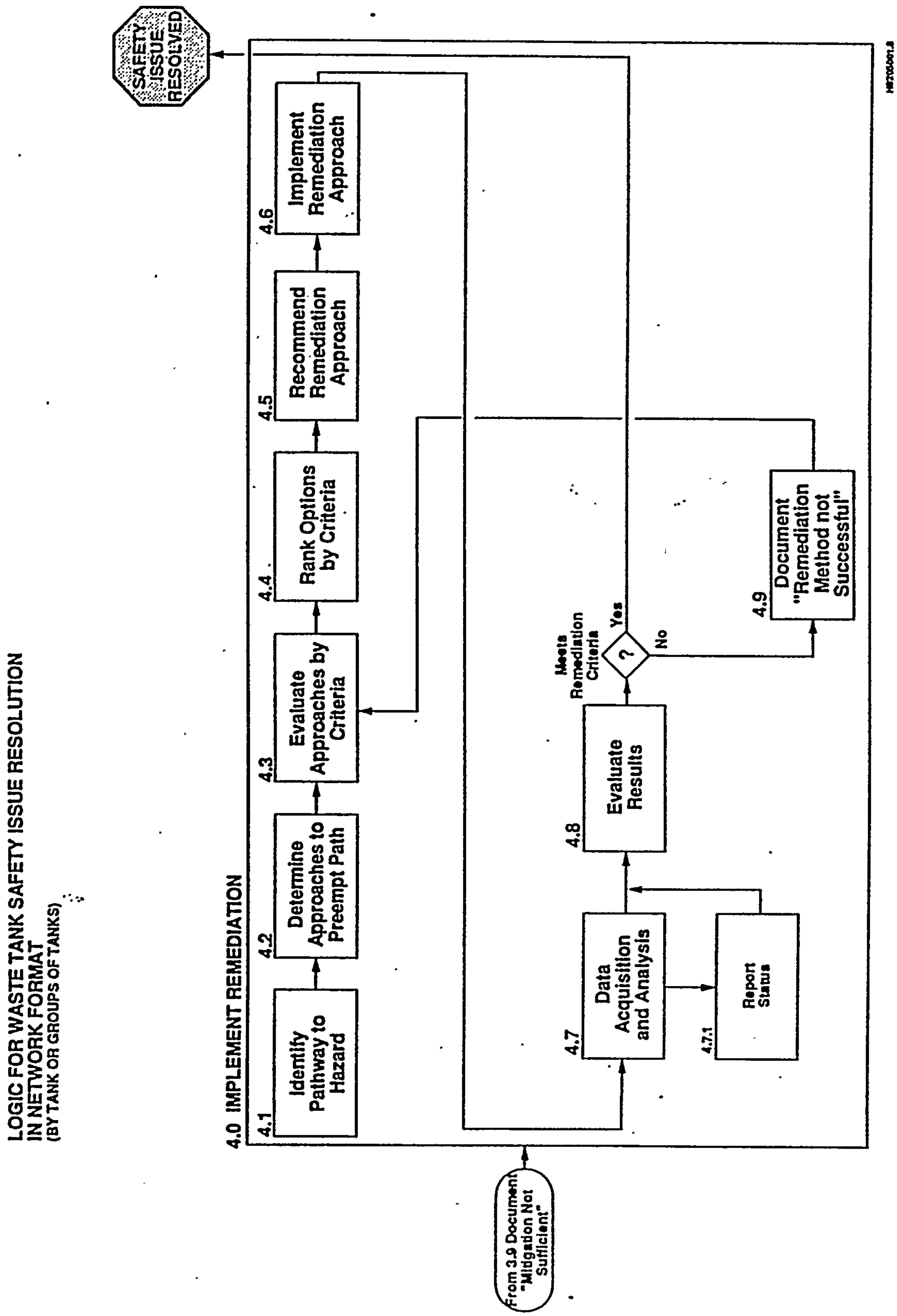


Figure A-5. Level 3/4 Logic Diagram for 1.0 Evaluation and Define the Problem (sheet 1 of 3).

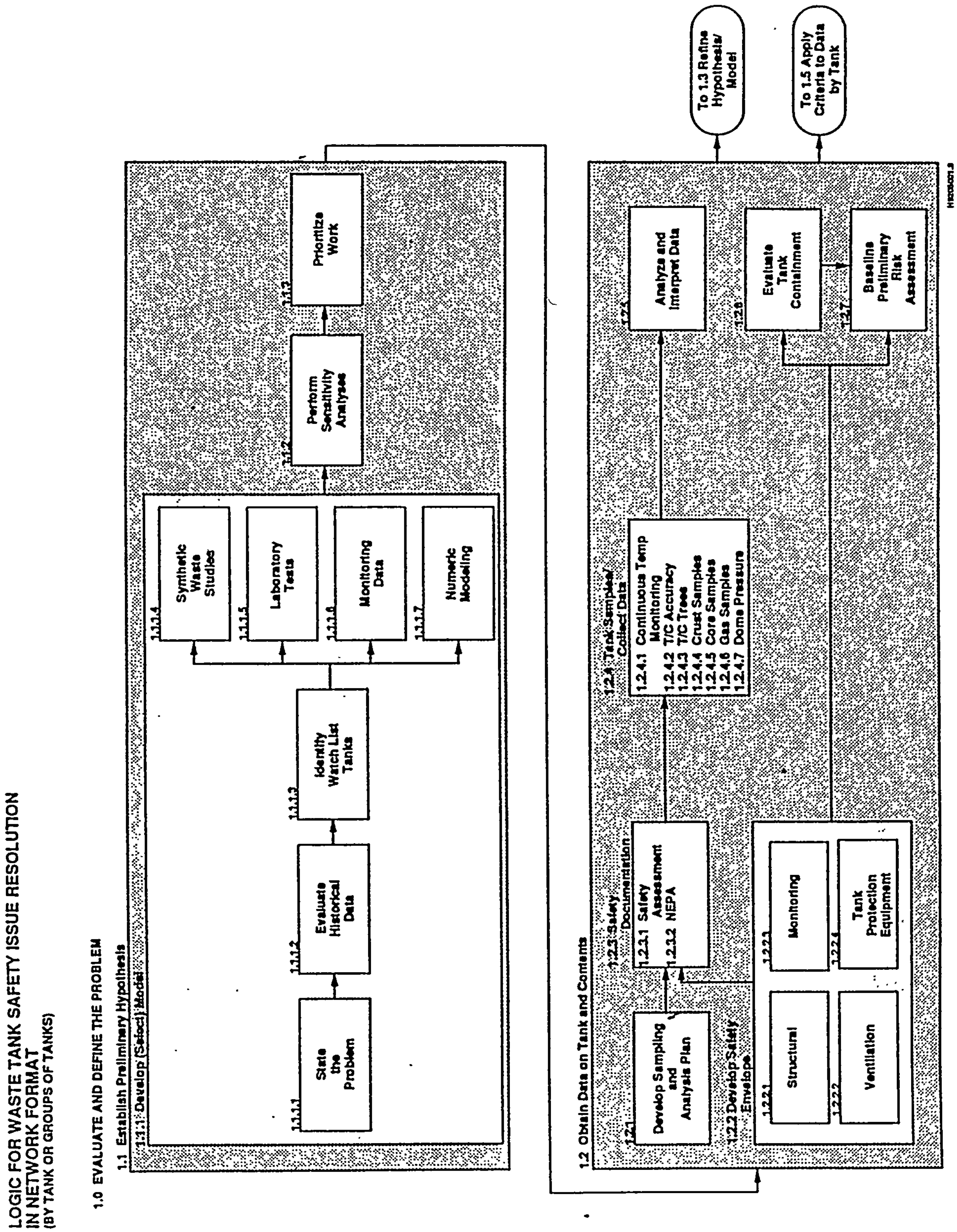


Figure A-6. Level 3/4 Logic Diagram for 1.0 Evaluation and Define the Problem (sheet 2 of 3).

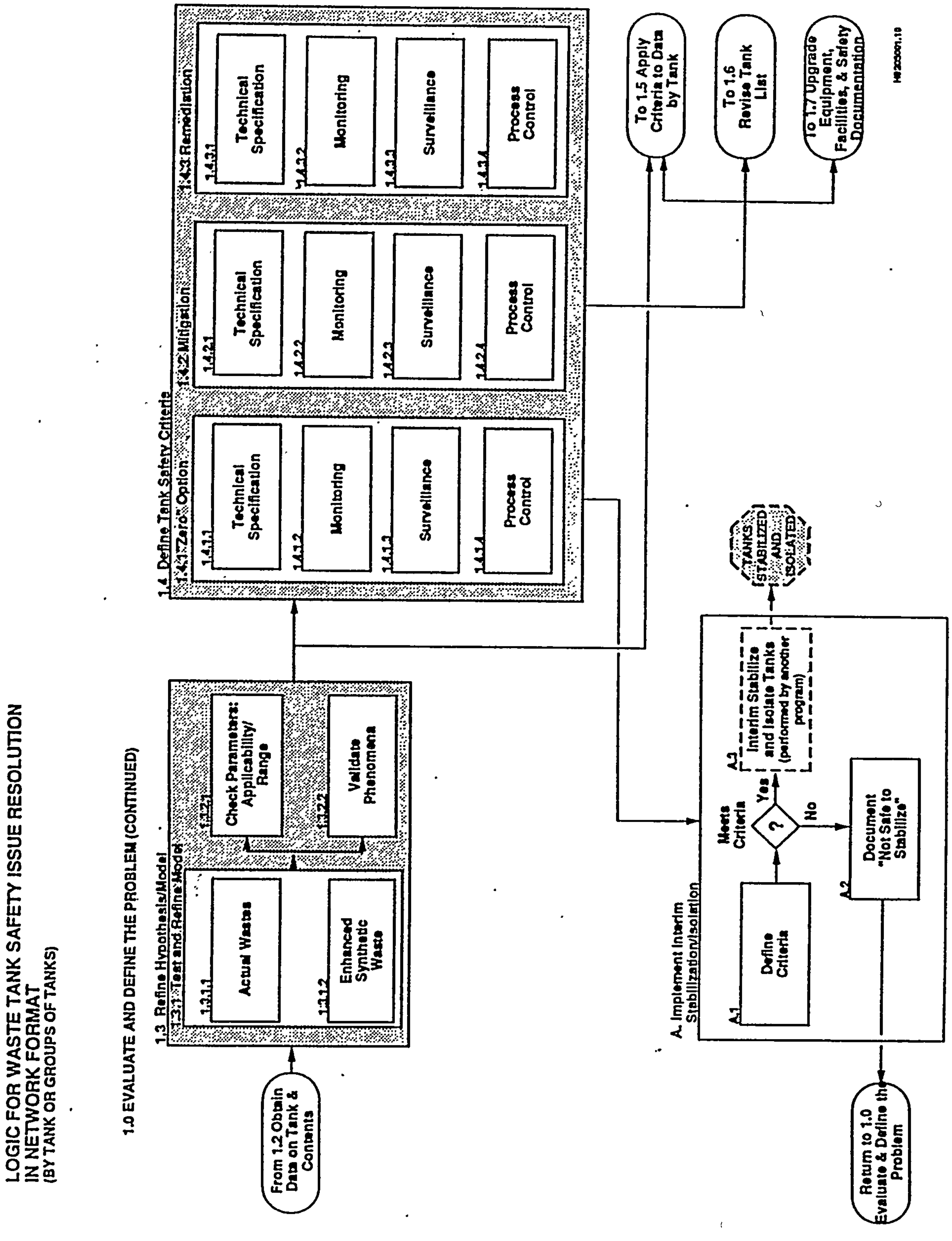


Figure A-7. Level 3/4 Logic Diagram for 1.0 Evaluation and Define the Problem (sheet 3 of 3).

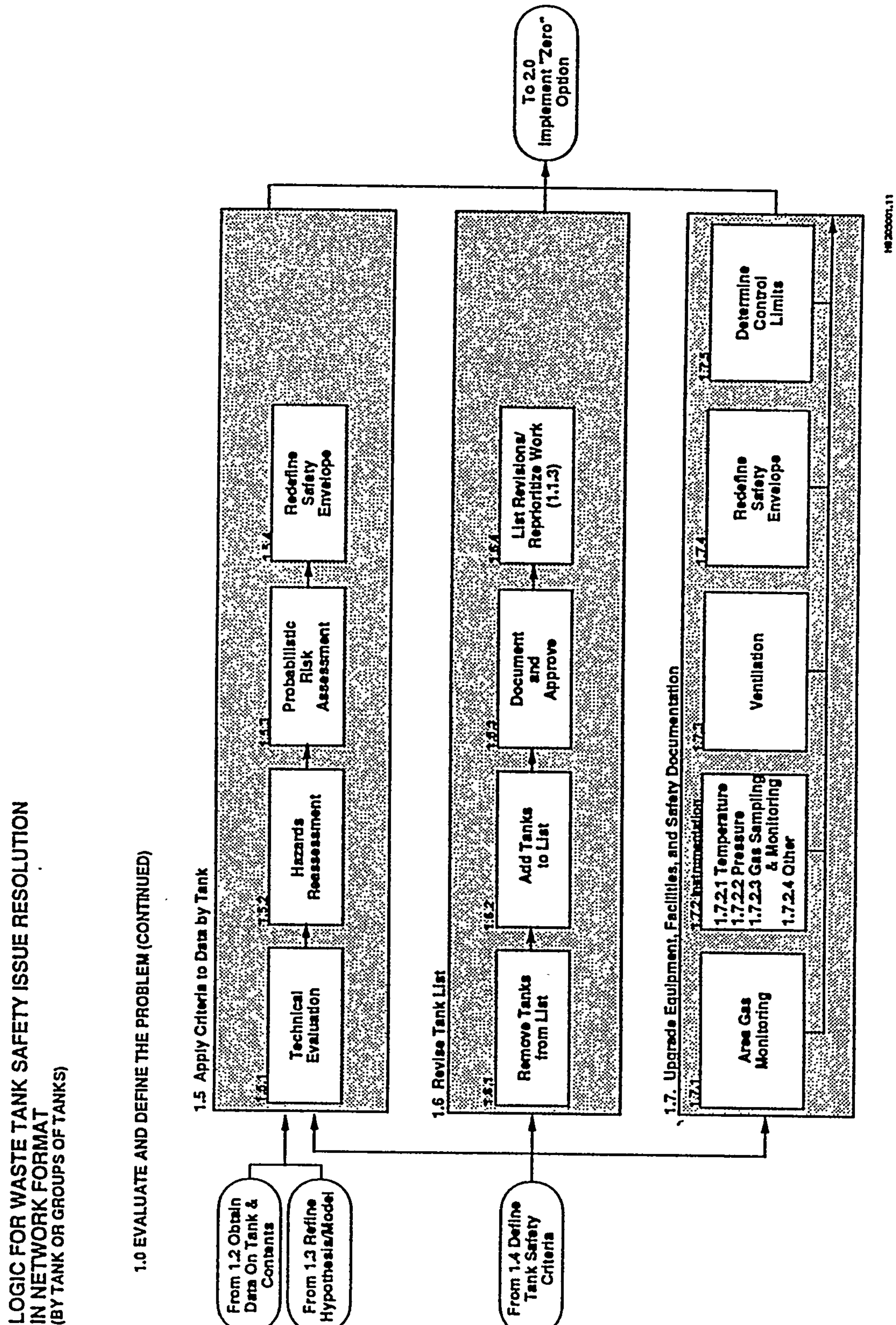


Figure A-8. Level 3/4 Logic Diagram for 3.0 Implement Mitigation.

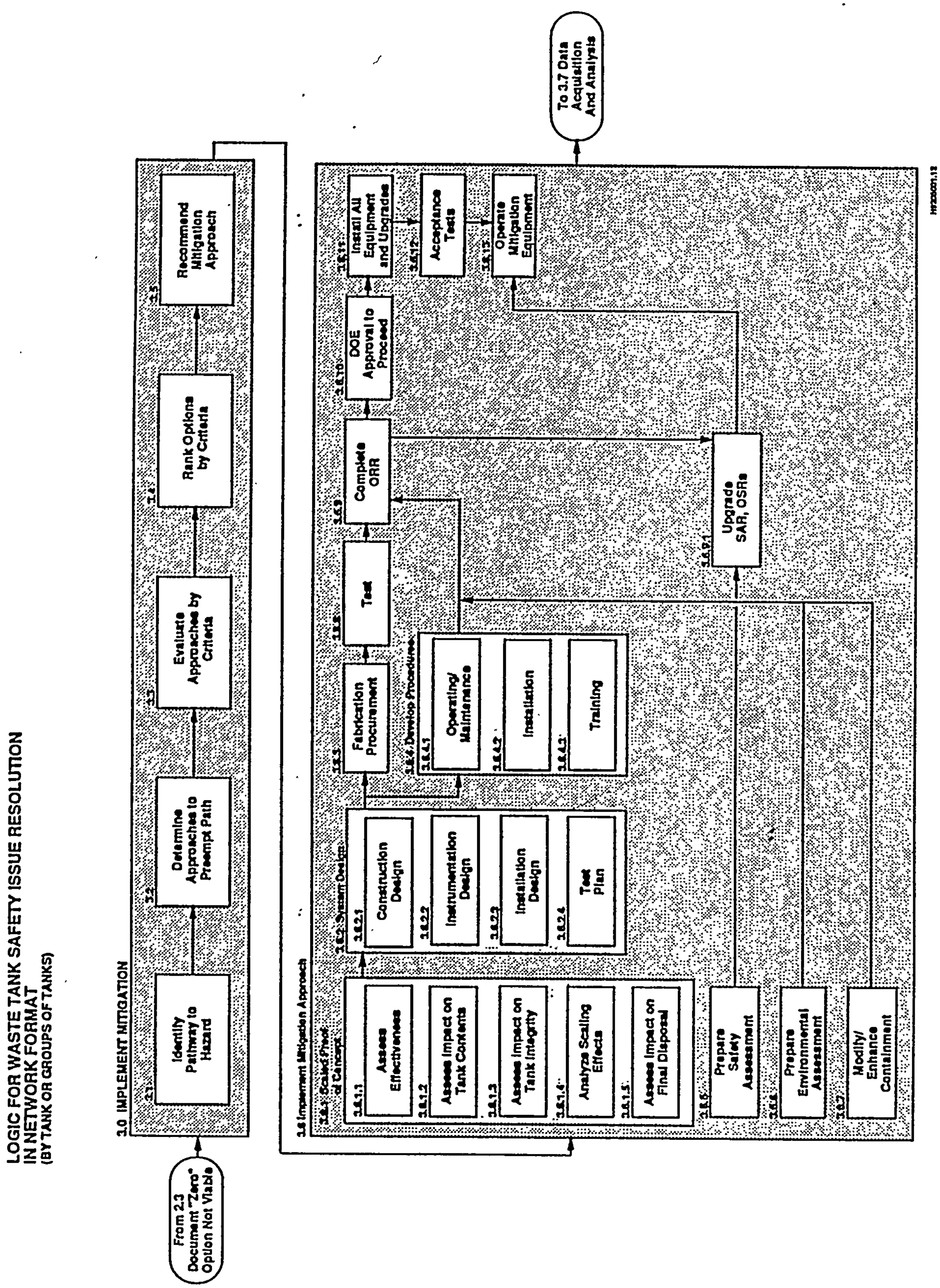
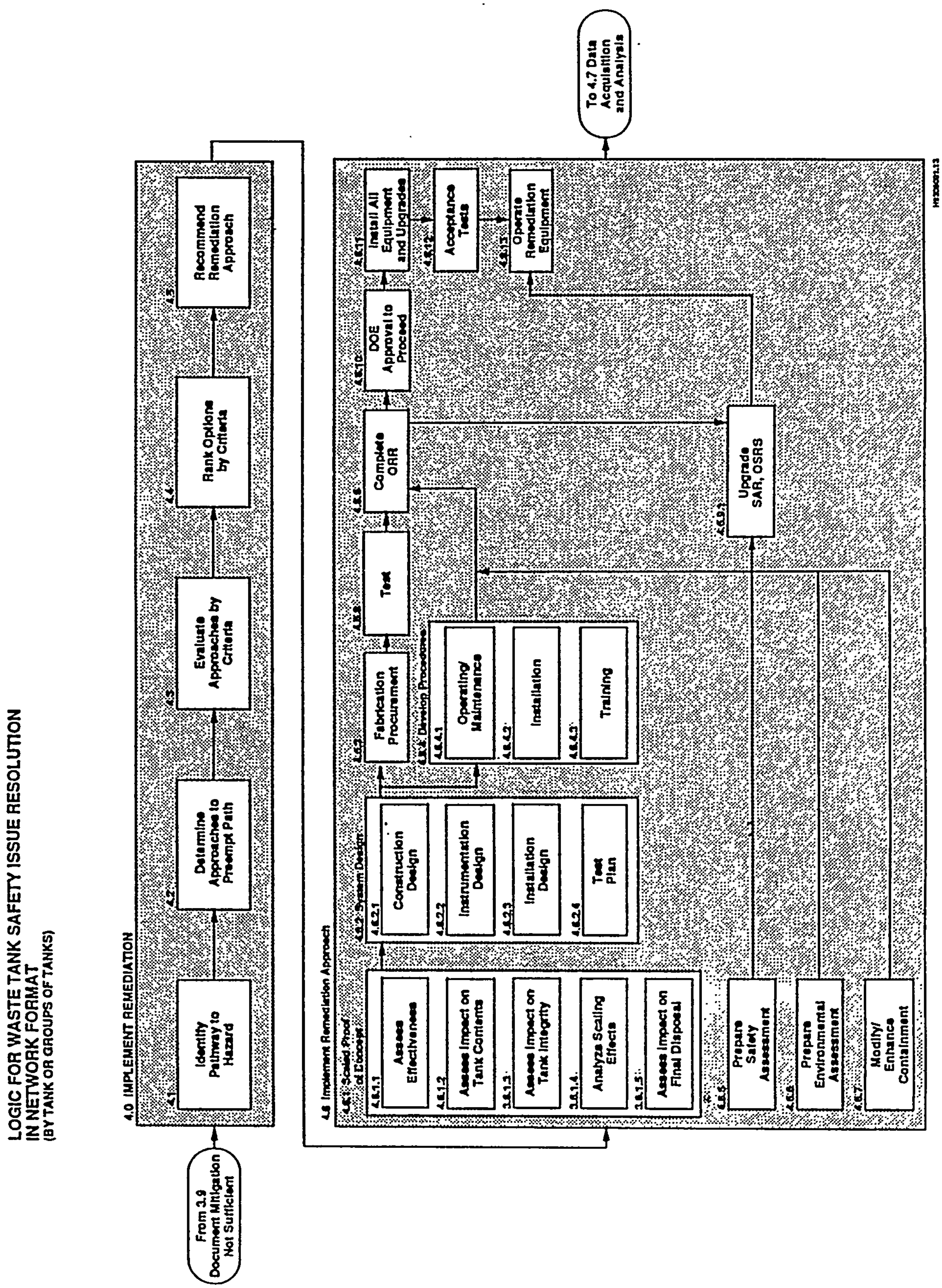


Figure A-9. Level 3/4 Logic Diagram for 4.0 Implement Remediation.



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