ENGINEERING STUDY

DEVELOPMENT AND DETERMINATION OF A SINGLE-SHELL TANK INTERIM STABILIZATION PUMPING STRATEGY

Prepared for

Westinghouse Hanford Company

April 1995

For the U.S. Department of Energy
Contract DE-AC06-93RL12359

Prepared by

ICF Kaiser Hanford Company
Richland, Washington

ER4919ES, Rev. 2

ICF Kaiser Hanford Company

DISCLAIMER

This report was prepared as an account of work sponsored by an agency of the United States Government. Neither the United States Government nor any agency thereof, nor any of their employees, make any warranty, express or implied, or assumes any legal liability or responsibility for the accuracy, completeness, or usefulness of any information, apparatus, product, or process disclosed, or represents that its use would not infringe privately owned rights. Reference herein to any specific commercial product, process, or service by trade name, trademark, manufacturer, or otherwise does not necessarily constitute or imply its endorsement, recommendation, or favoring by the United States Government or any agency thereof. The views and opinions of authors expressed herein do not necessarily state or reflect those of the United States Government or any agency thereof.

DISCLAIMER

Portions of this document may be illegible in electronic image products. Images are produced from the best available original document.

DISTRIBUTION SHEET

To	From	Page 1 of 1
Distribution	C. H. Brevick S3-10	Date June 12, 1995
Project Title/Work Order		EDT No. 611644
Development and Determination of a Single-Shell Tank Interim Stabilization Pumping Strategy		ECN No.

Name	MSIN	Text With All Attach.	Text Only	Attach./ Appendix Only	EDT/ECN Only
Westinghouse Hanford Company					
D. B. Engelman	R1-49	X			
A. K Dasqupta	S3-28	X			
C. E. Jenkins	R1-49	X			
D. C. Krahn	H4-68	X			
J. L. Lee	R2-50	X			
T. E. Rainey	R2-54	X			
R. E. Raymond	R2-54	X			
G. W. Ryan	H4-65	X			
R. R. Stickney	R1-49	X			
TFIC (Tank Farm Information Center)	R1-20	X			
Central Files	L8-04	X (2)			
OSTI	A3-36	X (2)			
ICF-Kaiser Hanford Company					
C. H. Brevick	S3-10	X			
L. J. Garvin	S3-10	X (5)			
S. L. Kujak	S3-10	X			
D. T. Vladimiroff	R2-80	X			
ICF KH Publications	E6-63	0			
ICF KH Doc Control	S3-10	X			
Pacific Northwest Laboratory					
J. B. Colson	K5-10	X			
J. W. Johnston	K3-59	X			
Department of Energy - Richland Operations					
G. E. Bishop	S7-54	X			
G. Z. Morgan	S7-54	X			

JUN 12 1995

ENGINEERING DATA TRANSMITTAL

1. EDT № 611644

2. To: (Receiving Organization) DISTRIBUTION	3. From: (Originating Organization) TWRS	4. Related EDT No.:
5. Proj./Prog./Dept./Div.: ER4919	6. Cog. Engr.: L. J. Garvin	7. Purchase Order No.:
8. Originator Remarks: This document describes development and determination of a single-shell tank interim stabilization pumping strategy.		9. Equip./Component No.: N/A
		10. System/Bldg./Facility: Tank Farms
11. Receiver Remarks:		12. Major Assm. Dwg. No.: N/A
		13. Permit/Permit Application No.: N/A
		14. Required Response Date: N/A

15. DATA TRANSMITTED

(A) Item No.	(B) Document/Drawing No.	(C) Sheet No.	(D) Rev. No.	(E) Title or Description of Data Transmitted	(F) Approval Designator	(G) Reason for Transmittal	(H) Originator Disposition	(I) Receiver Disposition
1	WHC-SD-WM-ES-345		0	Development and Determination of a Single-Shell Tank Interim Stabilization Pumping Strategy.	N/A	1	1	1

16. KEY

Approval Designator (F)	Reason for Transmittal (G)	Disposition (H) & (I)
E, S, Q, D or N/A (see WHC-CM-3-5, Sec.12.7)	1. Approval 2. Release 3. Information 4. Review 5. Post-Review 6. Dist. (Receipt Acknow. Required)	1. Approved 2. Approved w/comment 3. Disapproved w/comment 4. Reviewed no/comment 5. Reviewed w/comment 6. Receipt acknowledged

17. SIGNATURE/DISTRIBUTION (See Approval Designator for required signatures)

(G) Reason	(H) Disp.	(J) Name	(K) Signature	(L) Date	(M) MSIN	(J) Name	(K) Signature	(L) Date	(M) MSIN	(G) Reason	(H) Disp.
1	1	Cog.Eng. T. E. Rainey	T E Rainey	6/7/95	R2-54	L. J. Garvin	L J Garvin	6/8/95	S3-10	1	1
1	1	Cog. Mgr. D B. Engelman	D B Engelman	6/12/95	R1-49	S. K. Kujak	S K. Kujak	6/6/95	S3-10	1	1

18.	19.	20.	21. DOE APPROVAL (if required)
L. J. Garvin L J Garvin 6/8/95 Signature of EDT Originator Date	Authorized Representative for Receiving Organization Date	D. B. Engelman D B Engelman 6/12/95 Cognizant Manager Date	Ctrl. No. ☐ Approved ☐ Approved w/comments ☐ Disapproved w/comments

BD-7400-172-2 (04/94) GEF097

BD-7400-172-1

SUPPORTING DOCUMENT

1. Total Pages 57

2. Title

Development and Determination of a Single-Shell Tank Interim Stabilization Pumping Strategy

3. Number

WHC-SD-WM-ES-345

4. Rev No.

0

5. Key Words

Interim Stabilization, Pumping Strategy, Single-Shell tank pumping, prioritization

6. Author

Name: L. J. Garvin
S. K. Kujak

Signature S. K. Kujak 6/6/95

Organization/Charge Code 5A400/E40753
Facilities and Technical Support

7. Abstract

This Activity Plan addresses the interim stabilization prioritization of the 42 non-interim stabilized single-shell tanks (SST) to minimize future damage to the environment. The scope of this study includes recommendation of a pumping strategy and a pumping schedule. The pumping prioritization is designed to minimize the expected environmental consequences of future failures within resource constraints.

DISCLAIMER

This report was prepared as an account of work sponsored by an agency of the United States Government. Neither the United States Government nor any agency thereof, nor any of their employees, makes any warranty, express or implied, or assumes any legal liability or responsibility for the accuracy, completeness, or usefulness of any information, apparatus, product, or process disclosed, or represents that its use would not infringe privately owned rights. Reference herein to any specific commercial product, process, or service by trade name, trademark, manufacturer, or otherwise does not necessarily constitute or imply its endorsement, recommendation, or favoring by the United States Government or any agency thereof. The views and opinions of authors expressed herein do not necessarily state or reflect those of the United States Government or any agency thereof.

8. RELEASE STAMP

OFFICIAL RELEASE BY WHC (2)
DATE JUN 12 1995

RELEASE AUTHORIZATION

Document Number:	WHC-SD-WM-ES-345, REV 0
Document Title:	Development and Determination of a Single-Shell Tank Interim Stabilization Pumping Strategy
Release Date:	6/12/95

This document was reviewed following the procedures described in WHC-CM-3-4 and is:

APPROVED FOR PUBLIC RELEASE

WHC Information Release Administration Specialist:

Kara M. Broz — June 12, 1995

Kara M. Broz

TRADEMARK DISCLAIMER. Reference herein to any specific commercial product, process, or service by trade name, trademark, manufacturer, or otherwise, does not necessarily constitute or imply its endorsement, recommendation, or favoring by the United States Government or any agency thereof or its contractors or subcontractors.

This report has been reproduced from the best available copy. Available in paper copy and microfiche. Printed in the United States of America. Available to the U.S. Department of Energy and its contractors from:

U.S. Department of Energy
Office of Scientific and Technical Information (OSTI)
P.O. Box 62
Oak Ridge, TN 37831
Telephone: (615) 576-8401

Available to the public from: U.S. Department of Commerce
National Technical Information Service (NTIS)
5285 Port Royal Road
Springfield, VA 22161
Telephone: (703) 487-4650

ER4919ES, Rev. 2

ENGINEERING STUDY

FOR

DEVELOPMENT AND DETERMINATION OF A SINGLE-SHELL TANK INTERIM STABILIZATION PUMPING STRATEGY

Prepared by

ICF Kaiser Hanford Company
Richland, Washington

for

Westinghouse Hanford Company

Scott Kujak	5/4/95	Gina McBayless	4/27/95
Principal Lead Engineer	Date	Technical Documents	Date
[illegible]	4/27/95	S.D. Consort	5/1/95
Safety Engineering	Date	Environmental Engineering	Date
[illegible]	5-1-95	[illegible]	5/4/95
Quality Engineering	Date	Project Manager	Date

Westinghouse Hanford Company

[illegible]	5/16/95
Tank Stabilization and Engineering Support	Date

TABLE OF CONTENTS

1.0 OBJECTIVE 1
  1.1 BACKGROUND AND SCOPE 1
  1.2 PURPOSE AND NEED 3

2.0 SUMMARY 4

3.0 RECOMMENDATIONS AND CONCLUSIONS 5
  3.1 RECOMMENDATIONS 5
  3.2 CONCLUSIONS 6

4.0 UNCERTAINTIES 7

5.0 DESCRIPTION OF ALTERNATIVES AND APPROACHES 8

6.0 RECOMMENDED APPROACH 17

7.0 NO ACTION ALTERNATIVE 20

8.0 REFERENCES 21

APPENDICES

Appendix A. Recommended Pumping Sequence and Comparisons
Appendix B. Tables
Appendix C. Calculations and Backups for Recommended Pumping Sequence

ABBREVIATIONS

DCRT	double-contained receiving tank
DOE	U.S. Department of Energy
DSSF	double-shell slurry feed
DST	double-shell tank
HVAC	heating, ventilating, and air-conditioning
SNM	special nuclear material
SST	single-shell tank
TPA	Tri-Party Agreement
TRAC	track radioactive components
WAC	Washington Administrative Code
WHC	Westinghouse Hanford Company

ENGINEERING STUDY

DEVELOPMENT AND DETERMINATION OF A SINGLE-SHELL TANK INTERIM STABILIZATION PUMPING STRATEGY

WORK ORDER ER4919

1.0 OBJECTIVE

This study addresses interim stabilization prioritization of the remaining 42 noninterim stabilized single-shell tanks (SSTs) to minimize future damage to the environment. The scope of this study includes recommendation of a pumping strategy and pumping schedule. The pumping prioritization is designed to minimize the expected environmental consequences of future failures within resource constraints.

1.1 BACKGROUND AND SCOPE

The U.S. Department of Energy (DOE) owns several sites that manufacture, fabricate, or use special nuclear material (SNM). One DOE site is Hanford, located along the Columbia River in southeastern Washington State. The 560 square mile Hanford Site contains several SNM manufacturing and associated waste storage and treatment facilities. This report focuses on the waste storage tank facilities where liquid wastes from the plutonium/ uranium separation processes are stored.

The DOE has shifted its main objective from production of SNM to cleanup of facilities and restoration of its manufacturing sites. With approximately 50 years of SNM production at Hanford, large volumes of liquid waste byproducts that consist of radioactive and toxic chemical mixtures have accumulated. Liquid wastes are stored in large underground waste storage tanks that are clustered in rectangular arrays called tank farms. The tank farms are located in the 200-West and 200-East Areas of the Hanford Site. All tank farms are designated by the prefix 241. Farms are identified by a single or double letter depending

DISTRIBUTION OF THIS DOCUMENT IS UNLIMITED MASTER

upon their location. Individual tanks are designated by numbers, frequently starting with 101, within a given tank farm (e.g., 241-SX Tank Farm and Tank 241-SX-101).

Between 1943 and 1964, 149 SSTs were designed and constructed in the 200 Areas. Wastes were added to these tanks from 1943 until November 1980. Each of the 12 tank farms contains 4 to 18 SSTs. Twenty-eight double-shell tanks (DSTs) were fabricated and the first tank was put into service in 1971. The DSTs are arranged in six tank farms and each farm has between two and eight tanks. The DSTs were designed and constructed similar to the SSTs, but with an extra steel liner inside the tank, and were intended to store all the waste contained in the SSTs.

Most SSTs have exceeded their design life. Due to several factors, including the high number of failures (67 of 149 or 45% of the tanks are currently defined as "assumed" or "confirmed" leakers), the SSTs were taken out of service in November 1980. No new waste has been added to the tanks since that time. Tanks are called leakers if there is evidence of leaking that relates to a tank. Tanks are declared "confirmed leakers" if there is direct measurement evidence of leaking (i.e., a drop in liquid level). Tanks are declared "assumed leakers" only if there is indirect evidence of leaking (i.e., detected radioactivity in the surrounding soil) with no confirmation by measurement. The number of failures can be loosely associated with the age of the tanks.

Of the 149 SSTs, 106 have been interim stabilized which involves pumping as much liquid as possible to DSTs. Interim stabilization occurs when an SST contains less than 50,000 gal of interstitial liquid (i.e., liquid trapped in the crystal structure) and less than 5,000 gal of supernatant liquid. Pumping will usually continue until the flowrate decreases to 0.05 gal/min. This interim stabilization step was taken to reduce the amount of leakage resulting from a tank failure.

Each of the 42 SSTs awaiting interim stabilization contains between 46,000 and 953,000 gal of waste, much of which is pumpable liquid. Tank 241-BX-111 is in the process of being interim stabilized. The 42 tanks contain about 5 Mgal of pumpable liquid that must be moved into the DSTs.

The SST failures and the increasing age of the tanks are indications that the remaining sound SSTs could start leaking. Therefore, the 42 tanks (i.e., 8 past leaking and 34 sound tanks) will be interim stabilized as the first step in the cleanup process and as an integral part of the ongoing DOE cleanup objective. Interim stabilization will minimize the environmental impact of tank leaking.

Tanks 241-C-106 and 241-C-105 are high-heat tanks and will not be interim stabilized in the same manner as the other SSTs, thus leaving 40 SSTs to be interim stabilized. The tanks generate large amounts of heat that boil away existing liquids and require additional water to control tank temperatures. Tank 241-C-105 is monitored by a process test and will be interim stabilized through evaporation. Tank 241-C-106 will be addressed during the retrieval program. High-heat tanks have exhibited the highest failure rate (82%). Therefore, Tanks 241-C-105 and 241-C-106 appear to have a high potential for tank failure and the liquid waste should be transferred from them in the near future.

A statistical study of the failed SSTs was conducted to determine if correlations existed between the failures and tank content, tank usage, or tank fabrication characteristics that could be useful in prioritizing the pumping strategy. The correlation study and the consequential and random failure approaches were used as inputs and helped develop the recommended strategy, which results in a prioritized list of the remaining noninterim stabilized tanks and tank farms.

1.2 PURPOSE AND NEED

The noninterim stabilized tanks contain large volumes of radioactive and chemical wastes that are semi-liquid at best and very fluid at worst. Interim stabilization of the SSTs is a DOE objective and a critical step in the Hanford Federal Facility Agreement and Consent Order (Tri-Party Agreement [TPA]). Eventually, each SST will fail. The goal is to minimize the impact on the environment by sequentially stabilizing tanks according to the highest combination of risk and consequence. This study provides a technical basis for defining the stabilization priorities based on the age, fabrication characteristics, composition of contents, and volume of a tank along with the potential effects it may have on the environment.

2.0 SUMMARY

Four SST prioritization approaches were created and documented for this study: random failure, consequential, correlation, and recommended.

Random Failure Approach

The random failure approach assumed no correlation between tank failure and tank fabrication, use, or contents. Thus, each noninterim stabilized tank would have equal potential for failure. The resulting pumping order depends on the length of time required to pump the contents of the SST down to the interim stabilization criteria. Therefore, the tanks that can be pumped the fastest are pumped first. This approach quickly reduces the number of nonstabilized tanks and, therefore, the chance of a failure.

Consequential Approach

The consequential approach uses two mathematical models, a chemical model, and a radiological model to quantify the consequence of an environmental release based on a hazard rating of the tank contents. The models were applied to each tank and the resulting consequence numbers were summed to give a total consequence for the contents of each tank. The consequential score was divided by the tank volume and reported as a score per 1,000 gal (Kgal). The scores were ranked by descending values to give the consequential pumping priorities.

Correlation Approach

The correlation study compared 30 tank characteristics with tank integrity (i.e., leaking or sound). The resulting indicators were ranked as having a significant correlation, mild correlation, or no correlation. Characteristics such as watch list designation, content type, and tank farm showed a significant or mild correlation with the tank status.

Recommended Approach

The recommended approach was generated by combining the results of the other approaches to develop a list of SSTs by pumping priority. This approach used a mathematical computation to combine some features of the other approaches and focused on the risk associated with the contents of each tank and the propensity of a tank to fail/ leak. A value was calculated for each tank that combined the results from the consequence study (consequence value) and the correlation study (historical tank performance for similar tanks that have failed). The product of these values was used as an indicator of the risk associated with each tank.

The risk indicators were summed to give an indication of the total risk associated with SSTs that are not interim stabilized. Because of the time needed to prepare each tank farm for pumping and to resolve the various watch list tank safety questions, pumping priorities were chosen that would reduce the total risk associated with noninterim stabilized tanks.

The recommended prioritization listing based on a "normalized leak" (i.e., 5,000 gal) is shown in Table A-1 and as a curve of risk indicator versus time in Figure A-1 (see Appendix A). The DST availability, waste type compatibility, and transfer routings were investigated to provide guidance on the destination of the SST contents.

3.0 RECOMMENDATIONS AND CONCLUSIONS

3.1 RECOMMENDATIONS

The interim stabilization tank pumping sequence strategy and risk indicator versus time curves found in Table A-1 and Figure A-1 and the tank farm preparation and pumping schedule found in Figure A-6 should be followed (see Appendix A). The list was created by reviewing the three approaches and their results. From this review, a recommended prioritization pumping sequence that best satisfied the constraining factors was developed. The constraints can be defined as the time required to resolve the watch list issue, time to prepare the farms for pumping, pumping duration, possibility of transfer line failure and the renegotiated TPA schedule. Minimizing the risk of environmental impacts by pumping SSTs

with characteristics common to leaking tanks and a large consequential risk due to the hazardous nature of the contents was considered.

Further studies should be conducted to gain insight into tank failure probabilities based on variable conditions that exist in the SSTs. Tank failure probabilities would assist in the decision making process if the pumping prioritization list from this study becomes outdated due to unanticipated changes.

Careful operational/engineering reviews should be conducted to determine the feasibility of pumping multiple tank farms at the same time and consolidating the remaining liquid waste into fewer SSTs.

3.2 CONCLUSIONS

Environmental risks vary between SSTs. Table B-4 contains the calculation of the risk indicators for the 40 SSTs associated with this study. There are at least two factors associated with risk: the consequence from the release of tank contents following failure, and the likelihood of failure of the noninterim stabilized SSTs. (See Section 6.0 for further information.)

Risk factors decrease as the SST waste is pumped and interim stabilization status is reached. However, some risk is associated with the interim stabilized status of SSTs. Two larger and four smaller interim stabilized SSTs have leaked.

Using the recommended pumping strategy reduces the unpumped tank risk more quickly than the preliminary strategy outlined in the TPA. Table A-1, Figure A-1, Table A-2, and Figure A-2 display the tables and curves related to the recommended pumping strategy and the TPA strategy, and the curves in Figure A-3 compare the recommended pumping strategy risk with the TPA pumping schedule risk (see Appendix A). Figure A-6 shows the recommended schedule for tank farm preparation and pumping.

Tank 241-BX-106 should be moved to the top of the pumping priority list because it has the highest risk indicator (i.e., the highest consequence per unit volume and a high

likelihood of failure). The tank should be pumped as soon as the ferrocyanide issue is resolved and transfer lines can be installed; the existing transfer lines have failed.

Attention should be focused on manpower to expedite studies and resolution of the watch list tank concerns. As a result, tank farm preparation work would not need to be repeated when the watch list tanks in that farm are released for pumping. A more timely risk reduction can be attained by pumping entire tank farms without repeating labor efforts.

4.0 UNCERTAINTIES

Several uncertainties were found to exist during the course of this study. The uncertainties and the assumptions used in this study are listed below.

Engineering Assessments

1. The SST pumpable volumes indicated in the tank farm surveillance and the June 1993 waste status summary report were used (ref 3).

2. For the actual percent volume reduction of the 242-A Evaporator, 85% usually was used but 70% was assumed as a conservative estimate.

3. The DST and SST waste compatibility data in ref 3 and 7 were assumed. Additional sampling will be required to confirm compatibility.

4. The data in ref 7 were assumed for the DST waste type after volume reduction in the 242-A Evaporator.

5. An operable transfer system was assumed for failure time of the SST to DST liquid waste transfer system. Repair and replacement of systems known to have failed are included in the preparation time.

6. Unavailable DST space resulting from administrative constraints, such as the segregated space in Tank 241-AW-103, was assumed to become available for interim stabilization use.

7. A preliminary date of spring 1994 was assumed for startup of the 242-A Evaporator. The evaporator started on schedule.

Timing of Administrative Decisions

1. The resolution date of unresolved safety questions for the ferrocyanide watch list tanks was March 1994. The resolution dates for organic and hydrogen watch list tanks will be June 1995 and March 1996, respectively.

2. The data found in the November 22, 1993 interim stabilization schedule were used to determine the timing and duration of the tank farm upgrades (i.e., mechanical; instrumentation; heating, ventilating, and air-conditioning [HVAC], etc.)

3. Review and approval time to commence pumping. The dates to begin pumping each tank farm were based on the assumption that review and approval had been completed.

5.0 DESCRIPTION OF ALTERNATIVES AND APPROACHES

Random Failure Approach

The goal of the random failure approach is to prioritize interim stabilization of the remaining 40 SSTs by maximizing the number of tanks stabilized per year (ref 9).

Due to the focus and timing of this approach to the study, no correlations between tank failures and tank characteristics or contents were assumed to exist. Assuming that the same failure likelihood applies to all tanks, the only factor that affects the yearly chance of

tank failure is the number of tanks that have potential to fail because they are not interim stabilized. Although the exact likelihood of a tank failure in any given year was not determined, the risk can be decreased by reducing the number of tanks with failure potential. As a result, the overall yearly likelihood of tank failure becomes lower as each tank is stabilized.

The random failure approach primarily focuses on one factor that affects likelihood: the relative magnitude of time required to interim stabilize each SST including administrative review/approval, facility upgrades and preparation, and actual pumping time. The pumping time is dependent on the required tank farm upgrades, administrative review and approval, the content volume, the amount of saltcake with trapped interstitial liquid, and the amounts of supernatant liquid and semi-fluid sludge. The resulting ranking relies on the concept that by emptying the tanks that can be rapidly interim stabilized first, the number of tanks stabilized will accrue faster and, therefore, the overall yearly failure rate will be reduced more quickly. The ranking for this approach is listed in Table B-2 (see Appendix B). Because correlations between tank failures and tank characteristics were found after completion of this approach to the study, the rankings were not used directly in the final recommended pumping sequence.

The priorities identified by this approach account for or make assumptions for many factors (listed as Uncertainties in Section 4.0) that can impact the relative speed with which a particular tank can be interim stabilized. The factors include administrative approval time (especially for watch list tanks), preparation time to ensure that all needed lines are in the condition necessary to safely transfer the tank contents, and time for necessary tank farm upgrades to allow transfers to be conducted.

<u>Consequential Approach</u>

The consequential approach involves development of a prioritization scheme to interim stabilize the remaining 40 SSTs (ref 10). This approach focuses primarily on identifying the magnitude of hazards posed by the radiological and chemical contents of each tank. Radioactive and chemical composition data were obtained from track radioactive components (TRAC) which is a system of numerous computer models that work together

to estimate the quantity of selected stable chemicals and radionuclides in each underground storage tank (ref 5).

Mathematical models were used to rank the total radioactive and chemical hazards associated with each SST being studied (ref 10 and 14). Separate models were used to assess the radiological and chemical damages caused by waste leakages from tanks independently. The radiological score and the chemical score of each tank were assigned a rank between 1 and 5, based on the range that each score was in. The ranks were added and multiplied by 100 to obtain a total score for each tank. The total score of each SST was divided by its total pumpable volume of waste in kilogallons to reflect the concentration of radiological and chemical hazard. This score provides a basis for comparing the relative impact of a leak from each tank. The tanks were ranked in order of decreasing consequential scores to generate a sequence for interim stabilization of the remaining SSTs. The ranking for this study is shown in Table B-2 and the actual scores for each tank are listed in Table B-5 (see Appendix B). Sample calculations, based on the models for the chemical and radiological hazards associated with Tank 241-S-101, are shown in Appendix C.

Correlation Approach

The objective of the Pacific Northwest Laboratory correlation study was to identify relationships between the tanks that have leaked, the quantity of the liquid losses, and other characteristics of the 149 SSTs in the 200 Area on the Hanford Site (ref 11). The current tank data included in this study were age, the last year waste was added, the year the tank was declared an assumed leaker, design and construction specifications, and categories of contained waste.

The analyses provide a basis for developing a comprehensive strategy to complete the interim stabilization of SSTs that best minimizes the overall impact of actual and potential leaks.

Primary Findings

The relationships between tank integrity status (i.e., assumed leaking or sound) and 16 other tank characteristics included in the study were investigated. Several characteristics were found to have statistically significant or mild relationships with tank integrity. The characteristics are summarized below. Currently, 67 SSTs (45% of the 149 SSTs) are classified as leaking and 82 SSTs (55%) are classified as sound. This 45/55 percentage split is used to interpret the results.

- Waste Group - The waste group characteristic (30 groups defined in ref 8 and 11) provided some significant insights. The 30 groups were defined by the four most prominent waste types from a list of 49 types. Group 1 had 22 tanks with REDOX high-level waste as the primary waste and evaporator bottoms as the secondary waste. Only 14% of the Group 1 SSTs leaked (perhaps because evaporator bottoms precipitate into a solid saltcake that could seal the liquid into the tank). Only five tanks in the group have been interim stabilized, but the low number of failures should lower the priority of the remaining 17 tanks to be interim stabilized.

- Watch List Classification - Classification of tanks by their watch list categories showed that the 15 flammable gas (hydrogen) watch list tanks had one leaking tank and 14 sound tanks. This 7% leaking/93% sound split is removed from the expected 45/55 percentage split on tank integrity; however, 9 of the 11 high-heat tanks (82%) had leaked. Therefore, high-heat tanks should have a high pumping priority if leaking potential is the primary criterion for interim stabilization.

- Waste Type - Only 2 of the 11 double-shell slurry feed (DSSF) waste tanks (18%) leaked. The other nine tanks are awaiting interim stabilization and should be placed low on the pumping priority list if leaking potential is the only consideration.

The following characteristics showed some degree of correlation:

- Years Since Last Waste Added - Of the 20 tanks that last received waste between 1968 and 1972, 80% were leaking which may relate to the waste type being added during that time period.

- Tank Farm - The percentage of leaking tanks in a farm ranged from 83% for the TY Tank Farm and 67% for the SX Tank Farm, to 25% for the U Tank Farm and 8% for the S Tank Farm. These statistics appear to be related to the type of waste being stored in the tanks and not related to the farm, the year the tank was built, or the contractor that built the tanks.

The findings from the correlation study are summarized in Table B-5 (see Appendix B). The statistic reported in the table as the contingency coefficient is a type of correlation coefficient that lies between 0 and 1.00. Characteristics tabulated against tank integrity are more likely to have occurred by chance. Therefore, a correlation between a characteristic and tank integrity is more likely as the value nears 1.00 if the coefficient value is large. For the purpose of this study, three broad categories of correlation coefficient with respect to tank integrity were used: "significantly related" (greater than 0.33), "may be related" (0.2 to 0.33), and "little or no relationship" (less than 0.2).

Time series data on liquid and solid waste levels of the SSTs from 1944 to 1993 and temperature profiles from the times when tanks had operational thermocouples were investigated but not analyzed in detail. The tank level data, available on a quarterly basis for most tanks, were difficult to interpret and were not available for most of the tanks that were taken out of service in 1980. The data were supposed to be used to develop indicators of tank stress due to loading and unloading volume fluctuations and temperature fluctuations. Data, time, and funding limitations did not allow full investigation of the potential to use the data as indicators of leak propensity. Therefore, the other tank characteristic data were more valuable than the time series data.

The findings relating to the random failure study, the consequential study, and the correlation study are shown in Table B-1 (see Appendix B).

Space Availability

As part of the interim stabilization process, 5,048 Kgal of SST waste must be transferred to existing DSTs. There are 28 DSTs that may be available for interim stabilization of the SSTs. Some of the tank space is unavailable due to administrative or other constraints; therefore, the affected tanks are considered unavailable for this study. Some of the DST space has been allocated for other projects, but is assumed to be available (if needed) to support the interim stabilization process. This assumption may not be valid because of other site priorities. However, studies indicate that sufficient DST space should be available without the assumptions. Within the 28 DSTs, 2,775 Kgal of space are available to receive SST waste: 411 Kgal are available in the 200-West Area and 2,364 Kgal are available in the 200-East Area.

The 242-A Evaporator is expected to restart in the spring of 1994. The first evaporator campaign is scheduled to be completed at the start of 1995. Projections indicate that the DST waste involved will be reduced by 70%, creating 2,015 Kgal of additional space (ref 6 and 7). The newly created space from the evaporator is assumed to be available for SST interim stabilization efforts. The second campaign is scheduled to be completed by the start of 1996, creating an additional 2,154 Kgal of space for SST interim stabilization (ref 7).

New DSTs are being proposed for the 200-East and the 200-West Areas. Two new DSTs are planned for construction in the 200-West Area and may be available as early as 1996 to 1998. Four new DSTs in the 200-East Area are scheduled to be completed before the year 2000. Each new DST will have a 1.16-Mgal capacity (ref 11).

Chart 1 illustrates current and projected available space within DST farms to receive SST waste as part of the interim stabilization process. Though compatibility between SST waste and DST waste may affect SST interim stabilization efforts, the chart demonstrates that sufficient space will be available to support the efforts throughout the course of the project. The total volume of SST pumpable waste to be transferred is approximately 5,048 Kgal and more than 13,000 Kgal of space will be made available by the end of 1997

as shown on the chart (ref 3). The proposed new DSTs will add an additional 2 Mgal of space by 1998.

CHART 1		
Condition/Event	Available DST Space	
	By Project	Accumulated
Current Available Space	2,775 Kgal West: 441 Kgal East: 2,364 Kgal	
1995: First evaporator campaign completed	2,015 Kgal	4,790 Kgal
1996: Second evaporator campaign completed	2,154 Kgal	6,944 Kgal
1996-1997: Evaporator continues to reduce waste volumes, making 255 Kgal/month available (ref 2)	6,120 Kgal	13,064 Kgal
1998: Completion of two additional DSTs in 200-West Area	2,320 Kgal	15,384 Kgal

SST to DST Compatibility

Besides DST space availability, the compatibility of SST and DST waste types is another criterion for SST pumping. When an SST is ready to be pumped, a process grab or dip sample is obtained from the SST and the designated receiver DST. The samples are analyzed to confirm waste type and thus compatibility according to the Westinghouse Hanford Company (WHC) tank waste capability program (ref 12). For samples that are incompatible with the designated receiver DST, a different receiver DST is established. If the corrosion specification criteria is violated, the SST liquid effluent can be chemically adjusted to DST specifications when the waste reaches the double-contained receiving tank (DCRT) (this method was used during the pumping of Tank 241-T-101) or a new DST can be designated (ref 13). The investigations and Chart 1 indicate that tank space is or will be available in the 200 Area for all SST contents. The 200-West Area space is limited and failure of the cross-site transfer lines will make completion of any schedule difficult. There are more than 3,500 Kgal of pumpable SST liquid for the 411 Kgal of available DST space

in the 200-West Area. Table B-3 summarizes the DST and SST compatibilities and DST volume availabilities (see Appendix B).

Sensitivity Analysis

Various assumptions were made to develop the recommended pumping approach. An evaluation was conducted to determine which assumptions were the most sensitive and, therefore, the most constraining to the recommended pumping approach. Sensitivity is delaying or halting the interim stabilization process. Assumptions that fall within the sensitivity category are the waste transfer system, DST space availability, and SST to DST waste compatibility.

The pumping strategy is very sensitive to the condition of the cross-site transfer system. The most critical concern is the transfer system between the 200-East and 200-West Areas. The current transfer system has six lines, four of which are plugged or have failed the hydrostatic test. This condition will abate when the new east-west transfer line from project W-058 is completed on or about January 1998. If the present east-west transfer line fails, routing through the terminus would have to be halted. The greatest effect would be on the 200-West Area because it contains only three DSTs (i.e., one available DST and two watch list DSTs) with limited space availability and the largest SST volumes to be transferred. The only alternatives to this condition would be to use aboveground transfer lines, truck, or rail tank car transfer methods to accomplish east-west movement around the failed pipe sections, or the entire east-west transfer line; accelerate the DST completion schedule; or accelerate the east-west transfer line completion schedule.

The recommended SST pumping prioritization is very sensitive to DST space availability and somewhat sensitive to DST waste compatibility. If the 242-A Evaporator does not start up in 1994 or 1995 and continue to run, then the necessary space will not be created which could force a complete halt in the ongoing SST interim stabilization. If for some reason the evaporator startup is rescheduled to 1996 or later or the evaporator is not reliable, management should consider combining the contents of compatible SSTs to lower the number of tanks subject to failure, thereby lowering the chance of tank failures occurring per year (i.e., the random failure approach). Accelerating the DST construction project for

earlier tank completion and usage should be considered also. Failure to construct the DSTs now planned would greatly impact the ability to interim stabilize the remaining noninterim stabilized SSTs.

The liquid waste compatibility concerns can be resolved in various manners. The SST liquid waste may be chemically adjusted as it is accumulated in a DCRT awaiting further transfer to a designated DST. If the adjustment is not possible, the 242-A Evaporator can be scheduled to create DST space for that specific waste type. If the 242-A Evaporator is not online, consolidation of equivalent DST waste types into fewer DSTs can create DST space for the SST waste type under consideration. Although the consolidation does not create space, the new arrangement of existing space may provide some operational flexibility and benefits.

There is not enough DST space for complexed waste now stored in the SSTs. Using the recommended pumping sequence, the available DST space for complex waste would be used by mid-1996 following the pumping of Tanks 241-C-102, 241-C-107, 241-C-110, and 241-U-107. One of the following actions must be taken before available DST space runs out:

- Redesignate a noncomplexed DST as a complexed tank.

- Include a complexed waste DST when scheduling further evaporator campaigns.

- Reschedule the current defined evaporator campaigns to include a complexed DST.

All available DST complexed space is located in the 200-East Area which is another indication of the impact of an east-west transfer system failure.

6.0 RECOMMENDED APPROACH

Data and results compiled from the consequential and correlation approaches were used to develop the recommended approach. The consequence of a tank failure was combined with the likelihood of tank failure to indicate the environmental risk of each tank.

In order to develop an indicator of the risk related to each noninterim stabilized SST, the calculated consequence rating for each tank was selected from the consequence approach and the historical tank failure performance for similar tanks/contents was selected from the correlation portion of this study. For failed tanks that exhibited correlations with more than one tank characterization, the higher likelihood of failure was used to provide a more conservative indication. For tanks that had no characteristics exhibiting correlations with the failed tanks, the average tank failure history (i.e., 45%) was used to indicate an average likelihood of failure. For each tank, the consequence rating was multiplied by the likelihood of tank failure to indicate the risk associated with the tank. The risk indicator was calculated using the entire contents of the tank and separately on a normalized leak (i.e., 5,000 gal) basis to compare results.

The normalized leak basis was investigated because of indications that tank leakage over the last 10 to 15 years has ranged between 2,000 and 5,000 gal rather than the entire tank capacity. A loss of 5,000 gal was chosen as the normalized most likely detectable leak. The risk indicator calculations are on Table B-4 for the entire tank contents and Table B-4a for the normalized leak (see Appendix B). For the purpose of this study, a normalized leak was used to develop the pumping strategy. However, the final recommended pumping sequence was checked using the entire tank content risk indicators to see if there may be a different pumping sequence. The recommended pumping priorities are the same under both assumptions.

The risk associated with the failure of interim stabilized tanks was investigated for this study. There are 94 SSTs sized from 530,000 gal to 1.1 Mgal and sixteen 55,000 gal tanks that have been interim stabilized. Two larger tanks and four smaller tanks have leaked since interim stabilization. The volume that leaked from the two larger tanks averaged approximately 6,000 gal. Previous criteria for interim stabilization allowed more

liquids to be present in the early tanks that were pumped; therefore, more content could leak after failure. The risk associated with interim stabilized tanks, while lower than noninterim stabilized tanks, does not appear to have decreased to zero.

To calculate the risk indicators associated with interim stabilization status of the 40 tanks involved with this study, a 5% likelihood of tank failure (i.e., 6 out of 110 tanks have leaked) with 3,000 gal of leakage was assumed. These values were chosen to give a degree of conservatism and the decrease in risk that could be accomplished by interim stabilization. The calculations are shown in Tables B-4 and B-4a (see Appendix B).

Summing the risk indicators associated with a normalized leak from each noninterim stabilized tank gives an indication of the total risk related to the 40 SSTs. Plots outlining total risk versus time of several pumping strategies were used for a strategy comparison. Total risk decreases as SSTs are pumped. The pumping sequence that most quickly reduced risk and stayed within real or assumed constraints was recommended. The strategy is given in Figure A-1 and Table A-1 (see Appendix A). The time to prepare a tank farm for pumping (including testing time) and the time to pump the liquid from tanks within the farm were considered in the development of the recommended pumping sequence. The times plotted against the total content risk of the tank farm are shown in Figure A-5 (see Appendix A). The schedule for tank farm preparation and pumping is shown in Figure A-6 (Appendix A). Preparing and pumping a few tanks and then moving to another farm or farms before returning requires that labor and testing be redone to prepare for the next pumping cycle. The recommended pumping strategy is arranged on an entire tank farm basis, except for Tanks 241-C-103, 241-T-111, the 241-BY Farm tanks, and the watch list tanks in the S Tank Farm to reduce wasted labor. The following assumptions were considered to prepare the WHC Tank Waste Remediation Systems interim stabilization schedule:

- Work force limitations: Three tank farms can be prepared for pumping at the same time except that Tank 241-T-111 was prepared on an emergency basis along with three other tank farms.

- Dates for watch list concern resolution.

- Dates for completion of the aboveground transfer line for Tank 241-BX-106 waste transfer.

- Tank pumping constraint: Two tanks per farm are pumped at full flow, or several are pumped at the lower flowrates as interstitial liquid is removed.

The logic used to produce the recommended pumping sequence. (See the schedule in Figure A-6 and Table A-1 and Figure A-1 in Appendix A for the risk indicator versus time calculations and curves).

Currently, the BY, C, and S Tank Farms are being prepared for pumping and Tank 241-BX-111 is being pumped. Tank 241-BX-106 was preferred to be pumped first but it is a watch list tank with only 15 Kgal of pumpable liquid and has nonfunctional transfer lines. (Over the surface transfer lines will be needed.) Taking the preparation momentum into account, parts of the BY Tank Farm and most of the C Tank Farm were chosen to be pumped first. The time needed to prepare the nonwatch list tanks in the S Tank Farm delays the start of pumping in this farm until early 1996. The preparation times used for these two farms include the time needed to prepare the extra (more than in the current TPA schedule) tanks. The need to move quickly in order to gain waivers for pumping Tank 241-C-103 (a watch list tank) should be considered to avoid wasted labor (shown in this strategy) by preparing the farm again for later pumping.

Tank 241-BX-106 was chosen to be next in the sequence because of the time needed to prepare over the surface transfer lines. The T Tank Farm was chosen to be pumped with the recommendation that waivers be obtained to pump Tank 241-T-110 (a hydrogen watch list tank) without the wasted labor (shown in this pumping strategy) to prepare the T Tank Farm for repumping a few months later when full approval to pump watch list tanks is anticipated. Then the nonwatch list tanks in the S Tank Farm can start pumping. The U, SX, S (watch list tanks), AX, and A Tank Farms will be pumped respectively.

The constraints on the transfer of Tank 241-BX-106 should be addressed as soon as possible because the contents should be pumped quickly. Tank 241-BX-106 has the largest risk indicator which means that the consequence and likelihood of failure are high. Further

studies and the resolution of the associated concerns related to the watch list tanks should be expedited to optimize the labor used to prepare a tank farm for pumping.

Table A-2 and Figure A-2 show the TPA pumping sequence and its related curve of risk indicator for a normal leak versus time comparison. Figure A-3 shows the plots of the TPA and the recommended pumping strategies on a normalized leak basis on the same graph to indicate the degree of risk associated with each pumping sequence.

Figure A-4 shows the effect of pumping Tank 241-BX-106 earlier than the present TPA scheduled time. These figures show the drop in risk indicator only when a milestone or tank farm pumping has been completed; therefore, the actual reduction of risk indicator may be quicker than what is shown on Figure A-4. The figure supports the recommendation to pump Tank 241-BX-106 quickly.

Table C-3 and Figure C-3 relate to the recommended pumping strategy but are based on the assumption that the entire contents of each tank leak, Table C-4 and Figure C-4 indicate the TPA schedule based on the same assumption, and Figure C-5 is a comparison of the recommended pumping strategy and the TPA pumping sequence based on the entire contents of each tank (see Appendix C). There is no difference in the pumping order used in either the normalized leak approach or the entire tank content approach.

7.0 NO ACTION ALTERNATIVE

The section for this alternative is included in the study for format purposes. No action is not believed to be a viable option for the SST contents. The TPA includes specific milestones for stabilization of the SSTs.

The consequences of doing nothing can be costly and far reaching. Leaving the noninterim stabilized SST tanks as is will increase the amount of leaking SSTs and the chance for a large long-term environmental impact. The impact would cause a significant increase in costs, cleanup efforts, and a large impact on public relations that could turn into a political issue. As the SSTs and the transfer system age, they will exceed their design life if they

haven't already which will make later transfers more hazardous with increased likelihood of leaks. Interim stabilization of the remaining SSTs is more beneficial to limit costs, cleanup effort, and further damage to the environment as much as possible.

8.0 REFERENCES

1. Washington State Department of Ecology, "Dangerous Wastes Regulations, Tank Systems, Chapter 173-303-640-WAC," 1992.

2. Report, "Managing The Assumed Leak From Single-Shell Tank 241-T-101," Document No. ER3415ER, Rev. 1, prepared by Kaiser Engineers Hanford Company, March 1993.

3. Report, "Tank Farm Surveillance and Waste Status Summary Report for June 1993," prepared by Westinghouse Hanford Company, Document No. WHC-EP-0182-63, October 1993.

4. Internal Memorandum, Kaiser Engineers Hanford Company, "Requested Information for the Determination of a Probabilistic or Consequential SST Pumping Approach," prepared by S.K. Kujak, September 7, 1993.

5. Report, "Preliminary Estimation of the Waste Inventories in Hanford Tanks through 1980," prepared by Rockwell Hanford Operations, Document No. RHO-SD-WM-TI-057, March 1984.

6. Internal Memorandum, Kaiser Engineers Hanford Company, "Questions Raised at ER4010 Meeting," prepared by S.K. Kujak, September 21, 1993.

7. Internal Memorandum, Kaiser Engineers Hanford Company, "Present and Future Available Double-Shell Tank Space for the Pumping of Single-Shell Liquid Waste (ER4919) and a Tank-by-Tank Compatibility Comparison," prepared by S.K. Kujak, October 7, 1993.

8. Report, "The Sort on Radioactive Waste Type Model: A Method to Sort Single-Shell Tanks into Characteristic Groups," prepared by Westinghouse Hanford Company, Document No. WHC-EP-0449, August 1991 (draft).

9. Letter Report, "Probabilistic Prioritization for the Interim Stabilization of the Single-Shell Tanks," prepared by Kaiser Engineers Hanford Company, Document No. ER4919LR, December 1993.

10. Letter Report, "Consequential Prioritization for the Interim Stabilization of the Single-Shell Tanks," prepared by Kaiser Engineers Hanford Company, Document No. ER4919LR2, December 1993.

11. Letter Report, "Prioritization of Interim Stabilization of SSTs (Correlation Study)," prepared by Pacific Northwest Laboratory, November 1993.

12. Report, "Tank Farm Waste Compatibility Program," prepared by Westinghouse Hanford Company, Document No. WHC-SD-WM-OCD-0115, November 1, 1991.

13. Letter, C.H. Brevick (Kaiser Engineers Hanford Company) to R.R. Stickney (Westinghouse Hanford Company), "Single-Shell Tank Noninterim Stabilized Liquid Sample Data Table - ER3784-03," August 9, 1993.

14. Report, "Preliminary Estimation of the Waste Inventories in Hanford Tanks through 1980," prepared by Rockwell Hanford Operations, Document No. RHO-SD-WM-TI-057, March 1984.

APPENDIX A

Recommended Pumping Sequence and Comparisons

The data points shown on the figures in this appendix display the value of the risk indicator at a point in time. The lines connecting these indicator points should not be used to judge risk associated with any other given time. The end points are known but the exact shape of the lines connecting these points may not be as depicted.

Table A-1	Recommended Pumping Sequence Using a 'Normalized' Leak
Figure A-1	Risk Evaluation Recommended Pumping Approach Sequence Using a 'Normalized' Leak
Table A-2	TPA Milestone Pumping Sequence Using a 'Normalized' Leak
Figure A-2	Risk Evaluation TPA Milestone Schedule Using a 'Normalized' Leak
Figure A-3	Risk Comparison of the TPA Schedule to the Recommended Approach Using a 'Normalized' Leak
Figure A-4	Risk Comparison of the TPA Schedule, TPA Schedule with BX-106 Shifted to Milestone M-41-08 and the Recommended Approach
Figure A-5	Tank Farm Normalized Risk vs Preparation Time and Interim Stabilization Time
Figure A-6	Recommended Interim Stabilization Schedule

TABLE A-1

RECOMMENDED PUMPING SEQUENCE USING A 'NORMALIZED' LEAK

FARM	SST (IN ORDER OF PUMPING PRIORITY)	RISK DECREASE PER FARM	ESTIMATED INTERIM STABILIZATION TIME (DAYS)	INTERIM STABILIZATION START DATE	INTERIM STABILIZATION COMPLETION DATE
		776.38 (TOTAL from TABLE B-6a)		10/1/93	
T	T-111	9.32	317	5/17/94	3/30/95
BY	BY-109, BY-102	92.59	215	5/30/94	12/31/94
C	C-107, C-102, C-110	233.77	92	9/30/94	12/31/94
BY	BY-106, BY-105, BY-103	40.60	546	6/1/95	11/28/96
BX	BX-106	193.34	15	6/1/95	6/16/95
S (non-WATCH LIST TANKS)	S-107, S-103, S-109, S-101, S-108, S-110, S-106	30.61	414	1/2/96	2/19/97
T	T-104, T-110, T-107	56.45	143	5/22/96	10/12/96
C	C-103	6.62	133	6/30/96	11/10/96
U	U-102, U-111, U-106, U-107, U-108, U-109, U-103, U-105	24.23	406	7/26/96	9/5/97
S (WATCH LIST TANKS)	S-102, S-112, S-111	10.02	531	10/24/96	4/8/98
A	A-101	1.34	996	12/27/96	9/19/99
AX	AX-101	1.76	761	4/22/97	5/23/99
SX	SX106,SX102, SX101,SX103, SX104,SX105	16.43	609	8/8/97	4/9/99

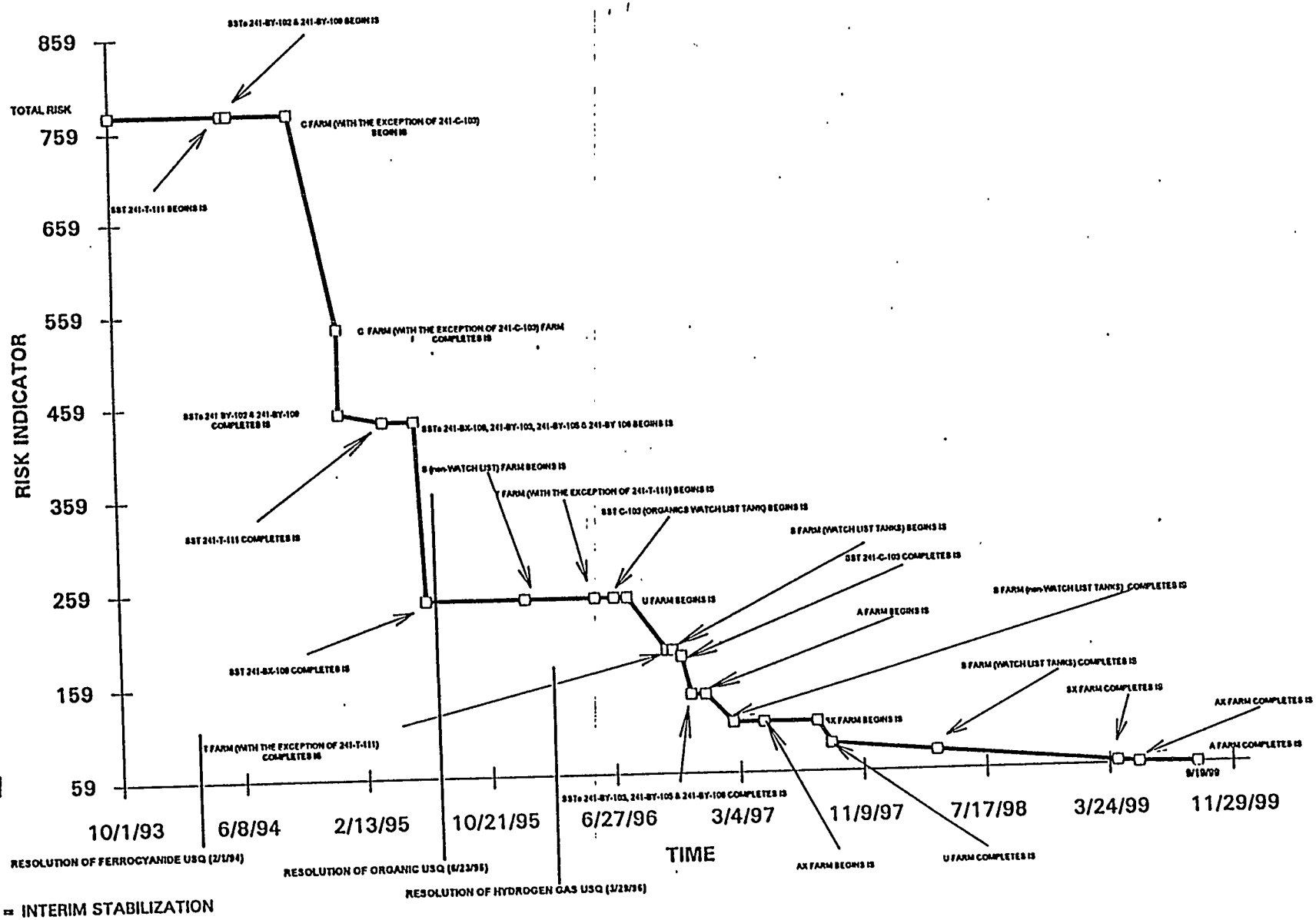
To create the Recommended Approach Schedule certain assumptions were made:

i) SSTs 241-BY-102 & 241-BY-109 preparation for pumping will be completed by 5/30/94

ii) only 3 farms are to be prepared for pumping at the same time (with the exception of 241-T-111).

RISK EVALUATION

RECOMMENDED PUMPING APPROACH SEQUENCE USING A 'NORMALIZED' LEAK



IS = INTERIM STABILIZATION

Figure A-1

TABLE A-2

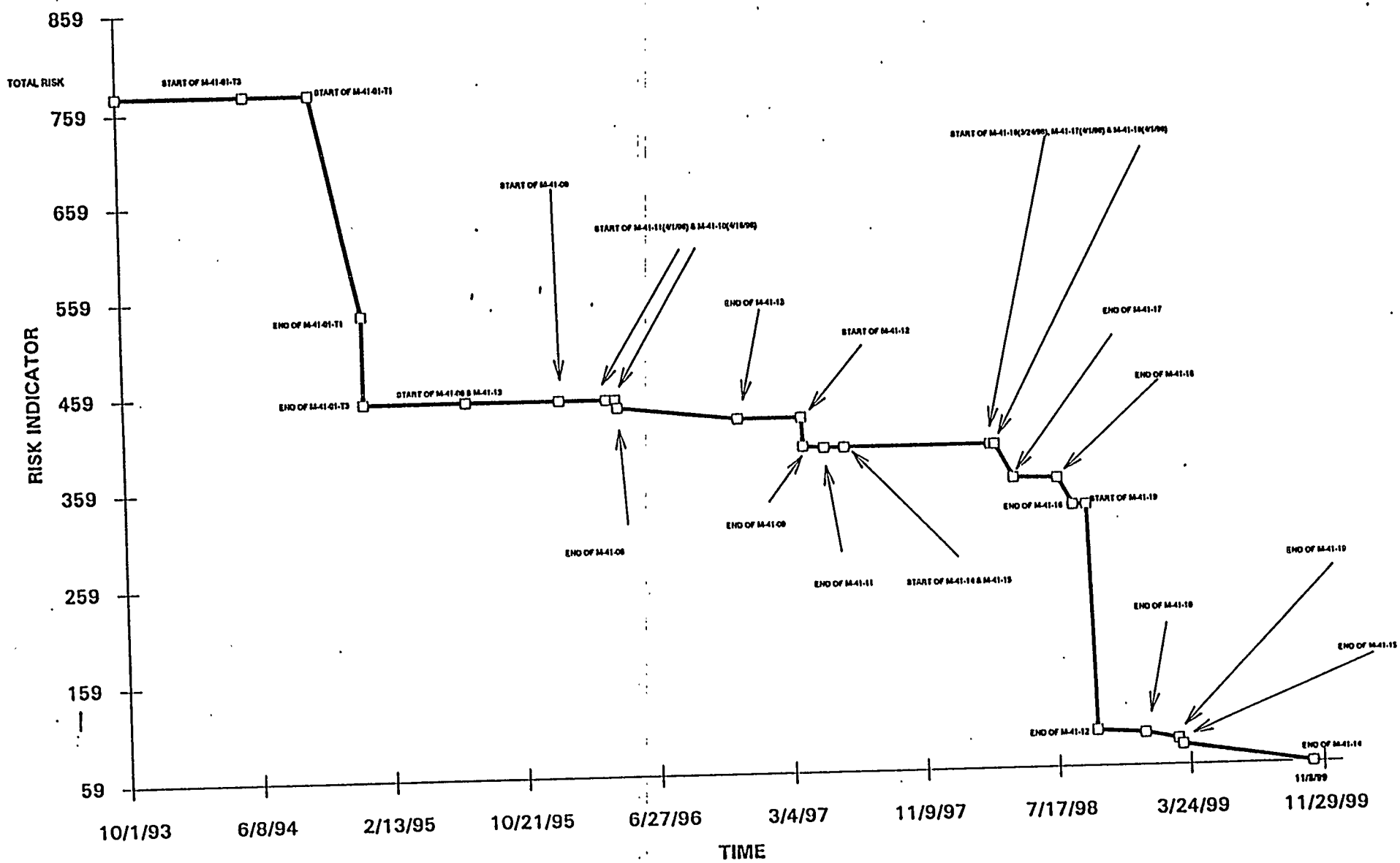
TPA MILESTONE PUMPING SEQUENCE USING A 'NORMALIZED' LEAK

TPA MILESTONE	SST	RISK DECREASE PER MILESTONE	INTERIM STABILIZATION TIME (DAYS)	INTERIM STABILIZATION START DATE	INTERIM STABILIZATION COMPLETION DATE
		776.38 (TOTAL from TABLE B-6a)		10/1/93	
M-41-01-T3	BY102, BY109	92.59	215	5/30/94	12/31/94
M-41-01-T1	C102, C107, C110	233.77	92	9/30/94	12/31/94
M-41-08	U102	8.61	285	7/12/95	4/22/96
M-41-13	U106, U107, U111	13.81	509	7/12/95	12/2/96
M-41-09	S101, S103, S106, S107, S108, S109, S110	30.61	456	1/3/96	4/3/97
M-41-11	U103, U105, U108, U109	1.81	407	4/1/96	5/13/97
M-41-10	A101, AX101	3.11	984	4/18/96	12/28/98
M-41-12	BX106, BY103, BY105, BY106	233.94	545	4/1/97	9/28/98
M-41-14	S111, S112, SX101, SX102, SX103, SX104, SX105	20.50	871	6/20/97	11/8/99
M-41-15	S102, SX106	5.94	627	6/20/97	3/9/99
M-41-16	T104, T111	28.41	153	3/24/98	8/24/98
M-41-17	T107	36.25	34	4/1/98	5/5/98
M-41-18	T110	1.11	117	4/1/98	7/27/98
M-41-19	C103	6.62	164	9/18/98	3/1/99

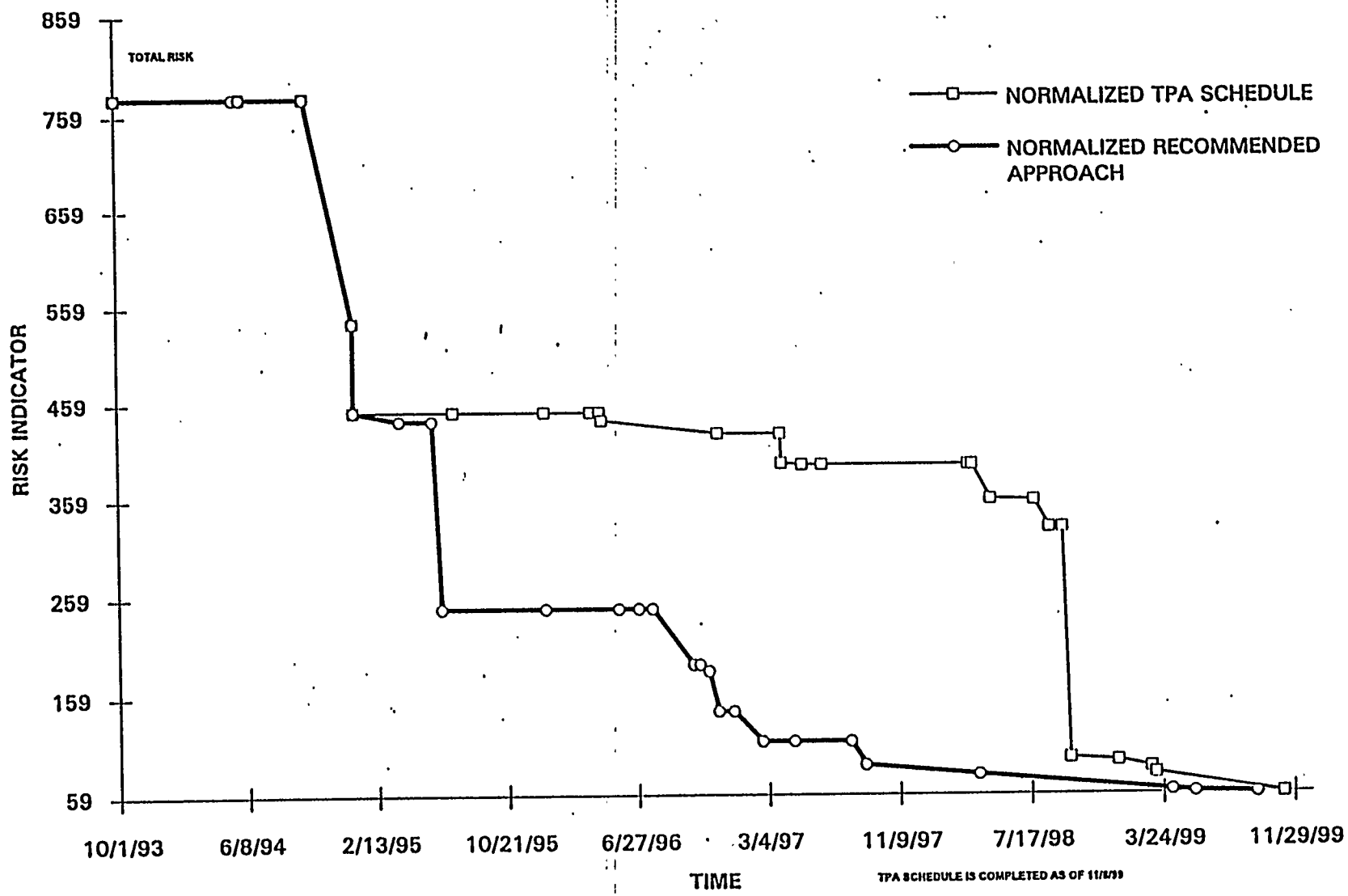
FIGURE A-2

RISK EVALUATION

TPA MILESTONE SCHEDULE USING A 'NORMALIZED' LEAK



RISK COMPARISON OF THE TPA SCHEDULE TO THE RECOMMENDED APPROACH USING A 'NORMALIZED' LEAK

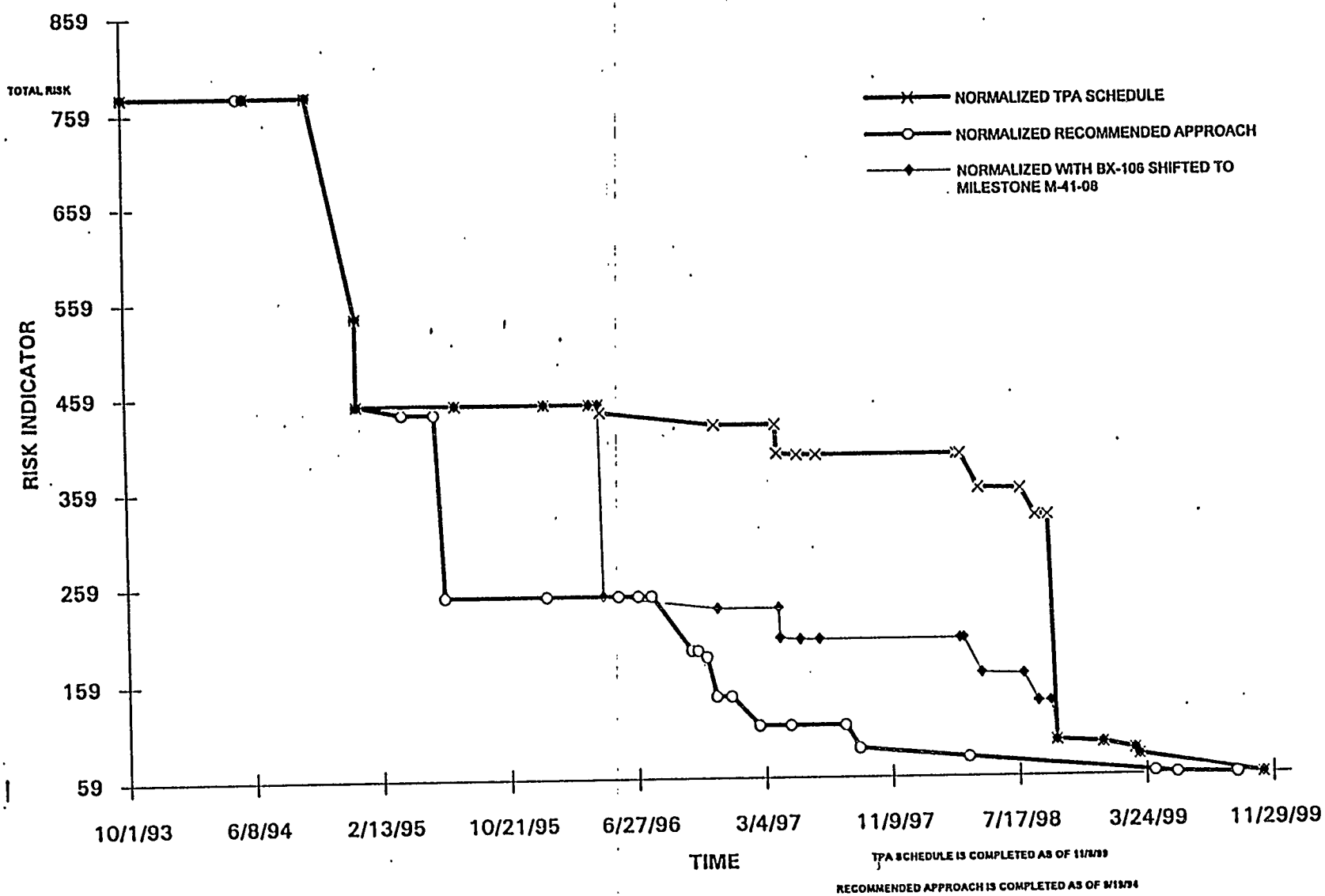


IS = INTERIM STABILIZATION

Figure A-3

RISK COMPARISON OF THE TPA SCHEDULE, TPA SCHEDULE WITH BX-106 SHIFTED TO MILESTONE M-41-08

AND THE RECOMMENDED APPROACH

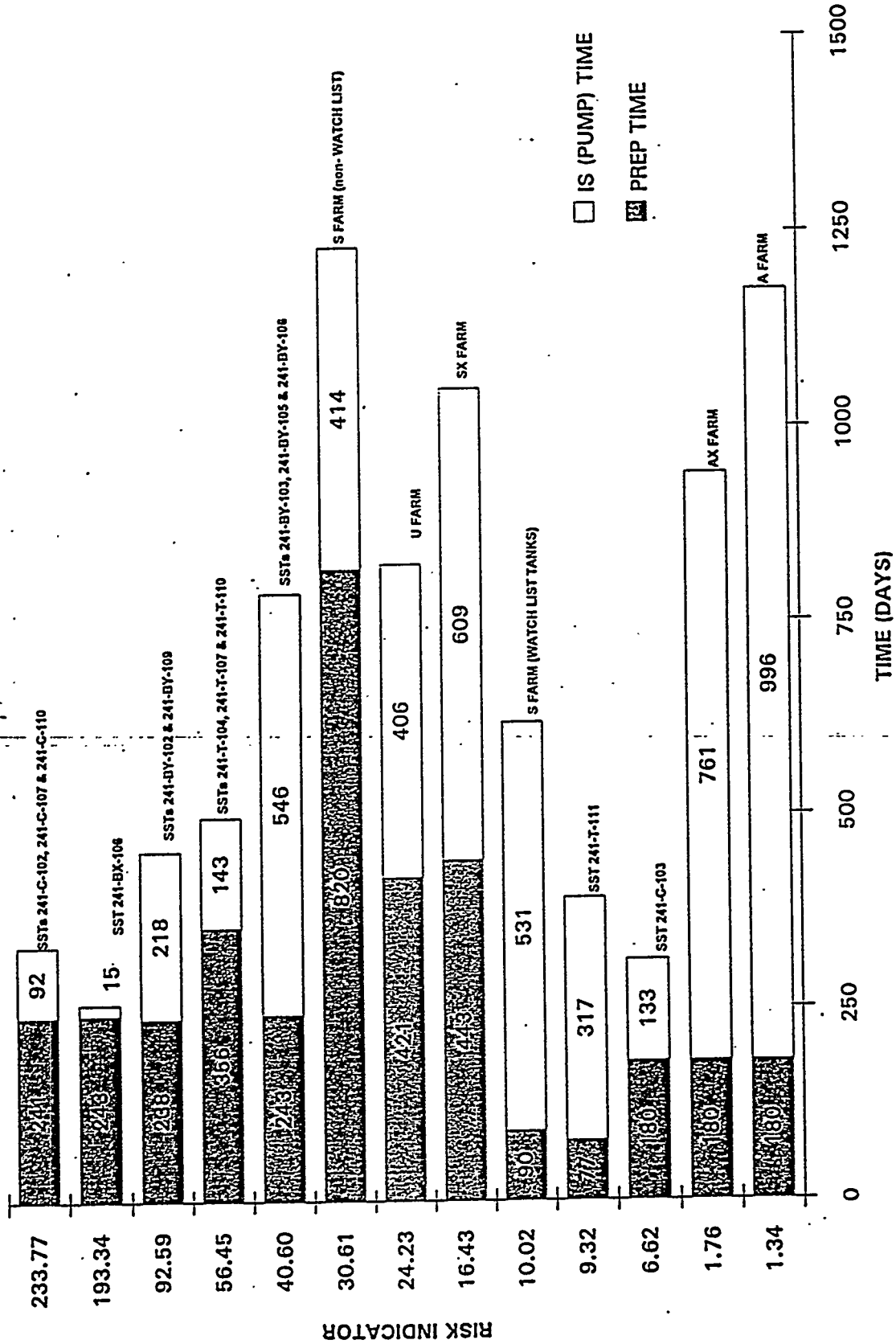


IS = INTERIM STABILIZATION

Figure A-4

FIGURE A-5

TANK FARM NORMALIZED RISK vs PREPARATION TIME AND INTERIM STABILIZATION TIME



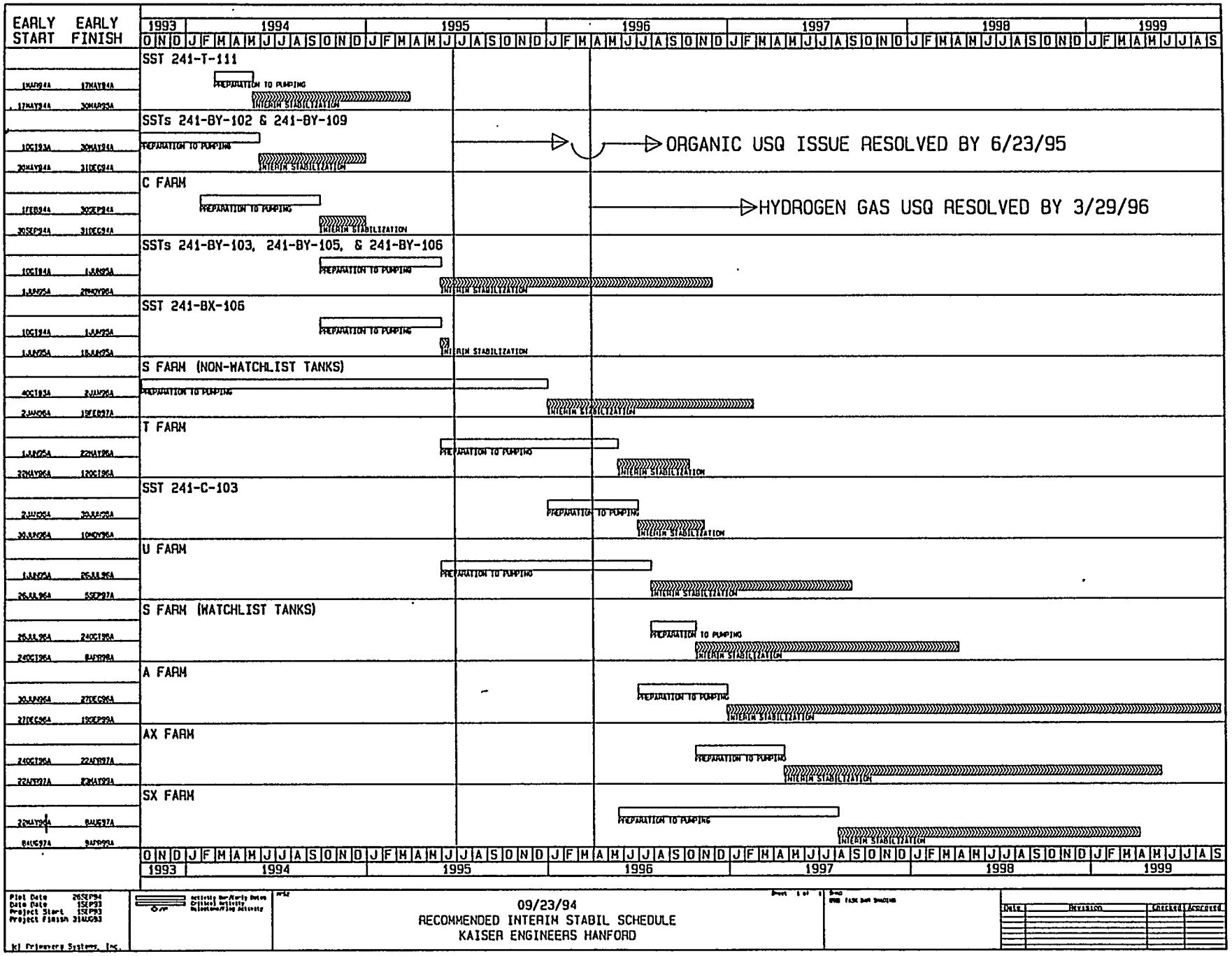

EARLY START
EARLY FINISH
1993
1994
1995
1996
1997
1998
1999
SST 241-T-111
PREPARATION TO PUMPING
INTERIM STABILIZATION
SSTs 241-BY-102 & 241-BY-109
ORGANIC USQ ISSUE RESOLVED BY 6/23/95
C FARM
HYDROGEN GAS USQ RESOLVED BY 3/29/96
SSTs 241-BY-103, 241-BY-105, & 241-BY-106
SST 241-BX-106
S FARM (NON-WATCHLIST TANKS)
T FARM
SST 241-C-103
U FARM
S FARM (WATCHLIST TANKS)
A FARM
AX FARM
SX FARM
09/23/94
RECOMMENDED INTERIM STABIL SCHEDULE
KAISER ENGINEERS HANFORD

Figure A-6

APPENDIX B

Tables

Table B-1 Correlation Study Results - % Leak

Table B-2 Single-Shell Tanks Ranking in Order of Pumping Priority

Table B-3 Waste Type and Double-Shell Tank Compatibility for the 40 Single-Shell Tanks

Table B-4 SST Risk Indicator Calculations Table

Table B-4a SST Risk Indicator Calculations Table Using a 'Normalized' Leak

Table B-5 Summary of Comparisons Between Assumed Leaker and Sound Tanks

TABLE B-1

CORRELATION STUDY RESULTS - % LEAK										
Tank Farm	Waste Type	Category: Tank Farm	DSSF[1]	ORG[2]	FeCN[3]	Gas[4]	Group[5]	Year[6]	Consequence Study Ranking	Random Failure Study Ranking
				--	Watch List	--				
BX 106	NCPLX	42			61				1	17
C* 110	DC	44							2	1
102	DC	44							4	3
107	DC	44							5	2
103	NCPLX	44		25					17	13
T 107	NCPLX	44			61				7	5
111	NCPLX	44							24	9
104	NCPLX	44							9	8
110	NCPLX	44				7			19	14
BY 103	NCPLX	42			61				15	16
102	NCPLX	42							3	6
109	NCPLX	42							8	7
105	NCPLX	42			61				25	18
106	NCPLX	42			61				29	23
U 106	NCPLX	25		25					30	33
102	NCPLX	25							26	35
111	DC	25	18	25					16	34
103	NCPLX	25				7			36	39
105	NCPLX	25				7	0		39	36
107	DC	25	18	25			0		31	37
108	NCPLX	25				7	0		34	40
109	NCPLX	25				7	0		35	38
SX 104	DC	67**	18			7	14	67**	28	21
102***	DC	67**	18			7	14	67**	27	19
101	DC	67**				7	14	67**	21	15
106	NCPLX	67**		25		7	14	67**	32	22
105	DC	67**	18			7	14	67**	33	26
103	NCPLX	67**				7	14	67**	22	24

TABLE B-1 (Continued)

CORRELATION STUDY RESULTS - % LEAK										
Tank Farm	Waste Type	Tank Farm	DSSF 1	ORG[2]	FeCN[3]	Gas[4]	Group[5]	Year[6]	Consequence Study Ranking	Random Failure Study Ranking
				Category -- Watch List --						
S 107	NCPLX	8					14	8	6	4
103	NCPLX	8	18				14	8	11	25
101	NCPLX	8					14	8	13	27
109	NCPLX	8					14	8	12	12
108	NCPLX	8					14	8	14	11
110	NCPLX	8					14	8	18	10
106	NCPLX	8					14	8	20	30
102	NCPLX	8	18	25		7	14	8	37	31
112	NCPLX	8				7	14	8	10	28
111	NCPLX	8				7	14	8	23	20
AX 101	DC	50	18			7			40	29
A 101	NCPLX	50	18			7			38	32

* Does not include C105 82%; C106 82%
** Most of Leakers were high heat.
*** May be Leaking - results differ
Shaded Assumed Leakers

1 = DSSF = Double-Shell Slurry Feed
2 = ORG = Organics Tank
3 = FeCN = Ferrocyanide Tank
4 = GAS = Hydrogen Forming Tank
5 = GROUP = Waste Group
6 = YR = Year Built
DC = Dilute Complexant Waste
NCPLX = Noncomplexant Waste

TABLE B-2

SINGLE-SHELL TANKS RANKING IN ORDER OF PUMPING PRIORITY			
Tank Number	Pumping Time (days)	Random Failure Study Rank	Consequence Study Rank
BX-106*	15	17	1
C-110	39	1	2
BY-102	292	6	3
C-102	93	3	4
C-107	95	2	5
S-107	123	4	6
T-107*	33	5	7
BY-109	341	7	8
T-104	143	8	9
S-112*	285	28	10
S-103	176	25	11
S-109	303	12	12
S-101	225	27	13
S-108	268	11	14
BY-103	350	16	15
U-111	253	34	16
C-103*	133	13	17
S-110	265	10	18
T-110*	115	14	19
S-106	414	30	20
SX-101*	320	15	21
SX-103*	557	24	22
S-111	20	20	23
T-111	148	9	24
BY-105*	432	18	25
U-102	283	35	26
SX-102*	452	19	27

TABLE B-2 (Continued)

SINGLE-SHELL TANKS RANKING IN ORDER OF PUMPING PRIORITY			
Tank Number	Pumping Time (days)	Random Failure Study Rank	Consequence Study Rank
SX-104*	500	21	28
BY-106*	546	23	29
U-106*	133	33	30
U-107*	349	37	31
SX-106*	500	22	32
SX-105*	609	26	33
U-108*	406	40	34
U-109*	379	38	35
U-103*	404	39	36
S-102*	531	31	37
A-101*	996	32	38
U-105*	343	36	39
AX-101*	761	29	40
* Denotes watch list tank			

TABLE B-3

WASTE TYPE AND DOUBLE-SHELL TANK COMPATIBILITY FOR THE 40 SINGLE-SHELL TANKS			
Single-Shell Tank	Waste Type	Possibly Compatible Double-Shell Tanks (Volume in Kilogallons)	Estimated Liquid Volume to be Pumped (Kilogallons)
A-101* (Hydrogen)	NCPLX	AN-101 (500) AP-101 (79) AP-102 (33) AP-103 (7) AP-104 (1121) AP-105 (319) AP-106 (11) AP-107 (25) AP-108 (238) AW-102 (254) AW-103 (495) AW-104 (16) AW-105 (138) AW-106 (66) SY-102 (411)	390
	Total	(3394)	
AX-101* (Hydrogen)	DC	AN-102 (39) AN-107 (72) AY-102 (131)	298
	Total	(242)	
BX-106* (Ferrocyanide)	NCPLX	Same as A-101	15
BY-102	NCPLX	Same as BX-106	22
BY-103* (Ferrocyanide)	NCPLX	Same as BX-106	137
BY-105* (Ferrocyanide)	NCPLX	Same as BX-106	169
BY-106* (Ferrocyanide)	NCPLX	Same as BX-106	213
BY-109	NCPLX	Same as BX-106	57
C-102	DC	Same as AX-101	19
C-103* (Organic Salts)	NCPLX	Same as BX-106	133
C-107	DC	Same as AX-101	20

TABLE B-3 (Continued)

WASTE TYPE AND DOUBLE-SHELL TANK COMPATIBILITY FOR THE 40 SINGLE-SHELL TANKS			
Single-Shell Tank	Waste Type	Possibly Compatible Double-Shell Tanks (Volume in Kilogallons)	Estimated Liquid Volume to be Pumped (Kilogallons)
C-110	DC	Same as AX-101	5
S-101	NCPLX	Same as BX-106	90
S-102* (Hydrogen, Organic Salts)	NCPLX	Same as A-101	208
S-103	NCPLX	Same as A-101	79
S-106	NCPLX	Same as BX-106	162
S-107	NCPLX	Same as BX-106	44
S-108	NCPLX	Same as BX-106	105
S-109	NCPLX	Same as BX-106	119
S-110	NCPLX	Same as BX-106	103
S-111* (Hydrogen)	NCPLX	Same as BX-106	134
S-112* (Hydrogen)	NCPLX	Same as BX-106	112
SX-101* (Hydrogen)	DC	Same as AX-101	124
SX-102* (Hydrogen)	DC	Same as A-101	177
SX-103* (Hydrogen)	NCPLX	Same as BX-106	211
SX-104* (Hydrogen)	DC	Same as A-101	195
SX-105* (Hydrogen)	DC	Same as A-101	238
SX-106* (Hydrogen, Organic Salts)	NCPLX	Same as BX-106	233
T-104	NCPLX	Same as BX-106	44
T-107* (Ferrocyanide)	NCPLX	Same as BX-106	16
T-110* (Hydrogen)	NCPLX	Same as BX-106	36

TABLE B-3 (Continued)

WASTE TYPE AND DOUBLE-SHELL TANK COMPATIBILITY FOR THE 40 SINGLE-SHELL TANKS			
Single-Shell Tank	Waste Type	Possibly Compatible Double-Shell Tanks (Volume in Kilogallons)	Estimated Liquid Volume to be Pumped (Kilogallons)
T-111	NCPLX	Same as BX-106	45
U-102	NCPLX	Same as BX-106	122
U-103* (Hydrogen)	NCPLX	Same as BX-106	166
U-105* (Hydrogen)	NCPLX	Same as BX-106	157
U-106* (Organic Salts)	NCPLX	Same as BX-106	61
U-107* (Organic Salts)	DC	Same as A-101	156
U-108* (Hydrogen)	NCPLX	Same as BX-106	174
U-109* (Hydrogen)	NCPLX	Same as BX-106	160
U-111	DC	Same as A-101	99
		Totals	5,050

* Denotes watch list tank
SST single-shell tank
DST double-shell tank

TABLE B-4

SST RISK INDICATOR CALCULATIONS TABLE

SST	TANK CONSEQUENCE PER KGAL (CI)	TANK CONSEQUENCE PER TANK VOLUME (CI)	FAILURE PROPENSITY (PI)	FAILURE PROPENSITY - LEAK AFTER IS (PI')	TANK RISK PER KGAL (CI*PI)	TANK RISK PER TANK VOLUME (CI*PI)	TANK RISK AFTER IS PER TANK VOLUME (CI*PI')*3	TOTAL PUMPABLE VOLUME (KGAL)	SST
BX-106	66.67	1000	0.61	0.05	40.07	610	10.00	15	BX-106
BY-103*	6.57	900	0.61	0.05	4.01	549	0.99	137	BY-103*
BY-105*	4.14	700	0.61	0.05	2.53	427	0.62	169	BY-105*
BY-106*	3.29	700	0.61	0.05	2.01	427	0.49	213	BY-106*
BY-102	31.61	700	0.45	0.05	14.31	315	4.77	22	BY-102
BY-109	12.28	700	0.45	0.05	5.53	315	1.84	57	BY-109
C-102	26.32	500	0.45	0.05	11.84	225	3.95	19	C-102
C-107	25	500	0.45	0.05	11.25	225	3.75	20	C-107
U-102	4.1	500	0.45	0.05	1.85	225	0.62	122	U-102
C-103	6.02	800	0.25	0.05	1.51	200	0.80	133	C-103
T-104	9.09	400	0.45	0.05	4.09	180	1.36	44	T-104
SX-106	3	700	0.25	0.05	0.75	175	0.45	233	SX-106
U-111	6.06	600	0.25	0.05	1.52	150	0.91	99	U-111
SX-103	4.74	1000	0.14	0.05	0.66	140	0.71	211	SX-103
S-112	8.93	1000	0.14	0.05	1.25	140	1.34	112	S-112
C-110*	60	300	0.45	0.05	27.00	135	9.00	5	C-110*
SX-104*	3.59	700	0.18	0.05	0.65	126	0.54	195	SX-104*
SX-102**	3.95	700	0.18	0.05	0.71	126	0.59	177	SX-102**
SX-105	2.94	700	0.18	0.05	0.53	126	0.44	238	SX-105
S-109	7.56	800	0.14	0.05	1.06	126	1.13	119	S-109
AX-101	2.35	700	0.18	0.05	0.42	126	0.35	298	AX-101
A-101	1.79	700	0.18	0.05	0.32	126	0.27	390	A-101
U-107	3.21	500	0.25	0.05	0.80	125	0.48	156	U-107
S-102	2.4	500	0.25	0.05	0.60	125	0.36	208	S-102
T-107*	12.5	200	0.61	0.05	7.63	122	1.88	16	T-107*
S-106	4.94	800	0.14	0.05	0.69	112	0.74	162	S-106
S-103	7.59	600	0.18	0.05	1.37	108	1.14	79	S-103
S-108	6.67	700	0.14	0.05	0.93	98	1.00	105	S-108
T-111*	4.44	200	0.45	0.05	2.00	90	0.67	45	T-111*
SX-101	4.84	600	0.14	0.05	0.68	84	0.73	124	SX-101
S-107	13.64	600	0.14	0.05	1.91	84	2.05	44	S-107
S-101	6.67	600	0.14	0.05	0.93	84	1.00	90	S-101
S-110	5.83	600	0.14	0.05	0.82	84	0.87	103	S-110
S-111.	4.48	600	0.14	0.05	0.63	84	0.67	134	S-111
U-106	3.28	200	0.25	0.05	0.82	50	0.49	61	U-106
U-108	2.87	500	0.07	0.05	0.20	35	0.43	174	U-108
U-103	2.41	400	0.07	0.05	0.17	28	0.36	166	U-103
U-109	2.5	400	0.07	0.05	0.18	28	0.38	160	U-109
T-110	5.56	200	0.07	0.05	0.39	14	0.83	36	T-110
U-105	1.27	200	0.07	0.05	0.09	14	0.19	157	U-105

IS = INTERIM STABILIZATION

TOTAL RISK PER KGAL = 155.28

TOTAL RISK PER TANK VOLUME = 6563

* DESIGNATES ASSUMED LEAKERS

TABLE B-4

SST RISK INDICATOR CALCULATIONS TABLE USING A 'NORMALIZED' LEAK

SST	TANK CONSEQUENCE PER KGAL (CI)	NORMALIZING FACTOR (KGAL)	FAILURE PROPENSITY (PI)	FAILURE PROPENSITY - LEAK AFTER IS (PI')	TANK RISK PER KGAL (CI*PI)	'NORMALIZED' TANK RISK PER TANK VOLUME (CI*PI)*5	TANK RISK AFTER IS PER TANK VOLUME (CI*PI')*3	TOTAL PUMPABLE VOLUME (KGAL)	SST
BX-100	80.07	5	0.01	0.05	40.07	203.34	10.00	15	BX-100
C-110*	60	5	0.45	0.05	27.00	135.00	9.00	5	C-110*
BY-102	31.81	5	0.45	0.05	14.31	71.57	4.77	22	BY-102
C-102	20.32	5	0.45	0.05	11.04	55.22	3.65	10	C-102
C-107	25	5	0.45	0.05	11.25	56.25	3.75	20	C-107
T-107*	12.5	5	0.01	0.05	7.03	35.13	1.88	10	T-107*
BY-109	12.28	5	0.45	0.05	5.53	27.03	1.84	57	BY-109
T-104	9.09	5	0.45	0.05	4.09	20.45	1.36	44	T-104
BY-103*	8.57	5	0.01	0.05	4.01	20.04	0.99	137	BY-103*
BY-105*	4.14	5	0.01	0.05	2.53	12.03	0.62	100	BY-105*
BY-108*	3.28	5	0.01	0.05	2.01	10.03	0.49	213	BY-108*
T-111*	4.44	5	0.45	0.05	2.00	9.99	0.67	45	T-111*
S-107	13.04	5	0.14	0.05	1.91	9.55	2.05	44	S-107
U-102	4.1	5	0.45	0.05	1.85	9.23	0.62	122	U-102
U-111	6.08	5	0.25	0.05	1.52	7.58	0.91	90	U-111
C-103	6.02	5	0.25	0.05	1.51	7.53	0.90	133	C-103
S-103	7.59	5	0.18	0.05	1.37	6.83	1.14	79	S-103
S-112	8.93	5	0.14	0.05	1.25	6.25	1.34	112	S-112
S-109	7.56	5	0.14	0.05	1.06	5.29	1.13	119	S-109
S-108	6.67	5	0.14	0.05	0.93	4.67	1.00	105	S-108
S-101	6.67	5	0.14	0.05	0.93	4.67	1.00	90	S-101
U-106	3.28	5	0.25	0.05	0.82	4.10	0.49	61	U-106
S-110	5.83	5	0.14	0.05	0.82	4.08	0.87	103	S-110
U-107	3.21	5	0.25	0.05	0.80	4.01	0.48	150	U-107
SX-100	3	5	0.25	0.05	0.75	3.75	0.45	233	SX-100
SX-102**	3.95	5	0.18	0.05	0.71	3.56	0.59	177	SX-102**
S-106	4.94	5	0.14	0.05	0.69	3.46	0.74	162	S-106
SX-101	4.84	5	0.14	0.05	0.68	3.39	0.73	124	SX-101
SX-103	4.74	5	0.14	0.05	0.66	3.32	0.71	211	SX-103
SX-104*	3.59	5	0.18	0.05	0.65	3.23	0.54	195	SX-104*
S-111	4.48	5	0.14	0.05	0.63	3.14	0.67	134	S-111
S-102	2.4	5	0.25	0.05	0.60	3.00	0.36	208	S-102
SX-105	2.94	5	0.18	0.05	0.53	2.65	0.44	230	SX-105
AX-101	2.35	5	0.18	0.05	0.42	2.12	0.35	298	AX-101
T-110	5.56	5	0.07	0.05	0.39	1.95	0.83	36	T-110
A-101	1.79	5	0.18	0.05	0.32	1.61	0.27	390	A-101
U-108	2.87	5	0.07	0.05	0.20	1.00	0.43	174	U-108
U-109	2.5	5	0.07	0.05	0.18	0.88	0.38	160	U-109
U-103	2.41	5	0.07	0.05	0.17	0.84	0.36	160	U-103
U-105	1.27	5	0.07	0.05	0.09	0.44	0.19	157	U-105

IS = INTERIM STABILIZATION

* DESIGNATES ASSUMED LEAKERS

** LEAKING STATUS IS INDETERMINATE

TOTAL RISK PER KGAL = 155.28

NORMALIZED' TOTAL RISK PER TANK VOLUME = 776.38

TOTAL RISK REMAINING AT THE COMPLETION OF IS = 50.30

TABLE B-5

SUMMARY OF COMPARISONS BETWEEN ASSUMED LEAKER AND SOUND TANKS		
Integrity by Characteristic	**Correlation**	**Comment**
Group (1-30) * - SORWT Study	0.523	Gp 1 22 tanks 14% leaked Gp 6 7 tanks 100% leaked Gp 10 4 tanks 0% leaked Gp 13 4 tanks 100% leaked
Last Waste Added, * Years Ago	0.397	20 tanks with last waste added 21 to 25 years ago 80% leaked
Watch List (WL) *	0.333	15 gas tank 7% leaked 11 Hi-Heat tanks 82% leaked
Farm (A-U, 12) ~	0.326	Farm[1] TY SX B A&AX TX,C,&T BX BY U S % Lk. 83 67 62 50 44 42 42 25 8
Built 1944-1964 ~	0.30	1951 72 tanks 8% leaked 1952[1] 6 tanks (TY farm built by SCO) 83% leaked 1954 15 tanks 67% leaked
Waste Type ~	0.200	DSSF 11 tanks 18% leaked other 8 tanks 25% leaked
Subcontractor: # MK, Other, SCO	0.156	SCO[1] built 6 tanks in 1952 83% leaked
Knuckle Size # 0, 6, 36, 48"	0.140	21 tanks with no knuckle 62% leaked
Tank Capacity: Kgal # 55, 535, 758, 1000	0.139	48 tanks with 758 Kgal capacity 39.6% leaked
Knuckle Fab # (GB, Other)	0.057	
Steel Type: # B, F, P, S	0.05	
Tank Bottom Dish # (0, 6, 12")	0.028	
Main Contractor: # DuPont GE	0.021	

* Characteristic is significantly related to integrity.
~ Characteristic may be related to integrity.
\# Characteristic shows little or no relationship to integrity.
1 These tanks are in the TY farm and were built in 1952 by SCO.
They also, contained high heat waste.

APPENDIX C

Calculations and Backups for Recommended Pumping Sequence

Table C-1 Tank 241-S-101 — Chemical Hazard Sample Calculation

Table C-2 Tank 241-S-101 — Radiological Hazard Sample Calculation

Table C-3 Recommended Pumping Sequence - Based on Entire Tank Content

Figure C-3 Risk Evaluation
Recommended Pumping Approach Sequence Based on Entire Tank Content

Table C-4 TPA Milestone Pumping Sequence Based on Entire Tank Content

Figure C-4 Risk Evaluation
TPA Milestone Schedule Based on Entire Tank Content

Figure C-5 Risk Comparison of the TPA Schedule to the Recommended Approach Based on Entire Tank Content

TABLE C-1

TANK 241-S-101 — CHEMICAL HAZARD SAMPLE CALCULATION					
Element Symbol	Element Name	CF	WF	Amount	Total
Ag	Silver	C	0.001	0	0
Al(OH)4	Aluminum Hydroxide	D	0.0002	0	0
As	Arsenic	X	1.0	0	0
B	Boron	D	0.0002	0	0
Be	Beryllium	A	0.1	0	0
C2H3O2	Acetate	C	0.001	1.5E4	1.5E1
C6H5O7	Citerate	C	0.001	1.7E7	1.7E4
CN	Cyanide	A	0.1	0	0
CO3	Carbonate	B	0.01	1.2E7	1.2E5
C204	Oxalate	A	0.1	0	0
Ca	Calcium	A	0.1	0	0
Cd	Cadmium	A	0.1	0	0
Cl	Chlorine	A	0.1	0	0
Cr	Chromium	D	0.0002	4.2E7	8.4E3
Cu	Copper	D	0.0002	0	0
EDTA	Organic Complexant	X	1.0	8.8E4	8.8E4
F	Fluorine	A	0.1	1.9E5	1.9E4
Fe	Iron	C	0.001	3.4E6	3.4E3
Fe(CN)6	Ferrocyanide	X	1.0	2.1E3	2.1E3
HEDTA	Organic Complexant	X	1.0	1.7E5	1.7E5
Hg	Mercury	X	1.0	0	0
K	Potassium	A	0.1	1.2E6	1.2E5
La	Lanthanum	C	0.001	0	0
Mg	Magnesium	C	0.001	0	0
Mn	Manganese	C	0.001	3.3E4	3.3E1
Mo	Molybdenum	C	0.001	0	0
NH3	Ammonia	B	0.01	0	0
NO2	Nitrite	B	0.01	9.2E6	9.2E4
NO3	Nitrate	B	0.01	7.4E8	7.4E6
Na	Sodium	A	0.1	2.8E8	2.8E7
NaAlO2	Sodium Aluminate	B	0.01	0	0
Na2CO3	Sodium Carbonate	B	0.01	0	0
NaNO2	Sodium Nitrite	B	0.01	0	0
NaNO3	Sodium Nitrate	B	0.01	0	0

TABLE C-1 (Continued)

TANK 241-S-101 — CHEMICAL HAZARD SAMPLE CALCULATION					
Element Symbol	Element Name	CF	WF	Amount	Total
NaOH	Sodium Hydroxide	C	0.001	0	0
Na3PO4	Sodium Phosphate	D	0.0002	0	0
Na2SO4	Sodium Tetra-Sulfate	D	0.0002	0	0
Ni	Nickel	B	0.01	4.1E4	4.1E2
OH	Hydroxide	C	0.001	1.7E8	1.7E5
P	Phosphorus	D	0.0002	0	0
PO4	Phosphate	D	0.0002	1.9E6	3.8E2
Pb	Lead	X	1.0	4.2E2	4.2E2
Pd	Palladium	C	0.001	0	0
Re	Rhenium	C	0.001	0	0
S	Sulfur	C	0.001	0	0
SO4	Sulfate	B	0.01	4.8E6	4.8E4
Sb	Antimony	D	0.0002	0	0
Se	Selenium	B	0.01	0	0
SeO4	Selerate	B	0.01	0	0
Si	Silicon	C	0.001	0	0
SiO3	Silicate	D	0.0002	7.6E5	1.5E2
Sn	Tin	A	0.1	0	0
TOC	Total Organic Content	X	1.0	0	0
Th	Thorium	D	0.0002	0	0
				TOTAL x 10	3.6E8

This table shows the elements/compounds that were found in some or all of the tanks on the Hanford Site. A table like this was completed for each tank that is to be interim stabilized. This is the calculation that was performed for tank S-101. In this calculation all of the weights of the elements/compounds are input into this table. Each chemical is assigned a chemical hazard factor (CF) with X being the most hazardous and D being the least hazardous. The weighing factor (WF) associated with the hazard factor is then multiplied by the amount of each element/compound present. Then the amounts of all the elements/ compounds is added together to come up with a total. This total is then multiplied by a factor of 10 to make up for data inconsistencies, etc. The grand total is then assigned to the tank and will be ranked accordingly when all of the data is complete for each tank.

TABLE C-2

TANK 241-S-101 — RADIOLOGICAL HAZARD SAMPLE CALCULATION					
Radionuclide	Content (Bq)	Content (Ci)	Half-Life (y=year, d=day, h=hour)	Applicable Multiplying Factor	Score
C14	1.9E+12	51.3	5730y	1000	2000
Co60	0	0	5.263y	0	0
Se79	2.2E+11	5.94	65000y	1000	2000
Sr89/90	2.0E+16	540000	27.7y	10000	20000
Y90	2.0E+16	540000	64h	1000	2000
Zr95	0	0	65.5d	0	0
Tc99	7.4E+12	199.8	212000y	1000	2000
Ru/Rh106	4.1E+06	.000111	368d	10	20
Sb125	0	0	2.71y	0	0
I129	1.1E+10	.297	1.7E+07y	100	200
Cs134	0	0	2.046y	0	0
Cs137	3.3E+15	89100	30y	1000	2000
Ce144	0	0	284d	0	0
Pm147	0	0	2.62y	0	0
Eu154/155	0	0	16y	0	0
U-Nat	7.4E+10	1.998	4.51E+09y	1000	2000
Np237	3.7E+09	0.0999	2.14E+06y	100	200
Pu238	3.7E+11	9.99	86.4y	100	200
Pu239/240	8.9E+12	240.3	24390y	1000	2000
Pu241	7.4E+12	199.8	13.2y	100	200
Am241	1.5E+13	405	433y	1000	2000
Am242m	2.2E+10	0.594	152y	100	200
Am243	8.1E+09	0.2187	7950y	100	200
Cm242	1.7E+10	0.459	162.5d	1	2
Cm244	3.7E+10	0.999	18.1y	10	20
				TOTAL	37242

The matrix shown on page 5 and the discussion of column 7 starts on page 6 (ref 10) were consulted to determine the 'Applicable Multiplying Factor' for each radionuclide in Tank S-101, based on the half-lives (column 4) and Curie contents (column 3) of the radionuclides. The multiplying factor was then multiplied by 2 (shown in column 6) to assign a score to each radionuclide. The last entry in column 6 (the bottom right corner of the table) demonstrates the total score assigned to Tank S-101 by the addition each individual radionuclide scores for that tank. The calculations were performed using an EXCEL spreadsheet.

TABLE C-2 (Continued)

TANK 241-S-101 — CONSEQUENCE SCORE

Chemical Hazard Scope	3.6E8
Chemical Hazard Rating	3
Radiological Hazard Score	37242
Radiological Hazard Rating	3
Ranking Factors Total	(3+3) X 100 = 600
Ranking Factor Divided by Liquid (Kgal)	600 ÷ 90 = 6.67

TABLE C-3

RECOMMENDED PUMPING SEQUENCE - BASED ON ENTIRE TANK CONTENT

FARM	SST (IN ORDER OF PUMPING PRIORITY)	RISK DECREASE PER FARM	ESTIMATED INTERIM STABILIZATION TIME (DAYS)	INTERIM STABILIZATION START DATE	INTERIM STABILIZATION COMPLETION DATE
		6563 (TOTAL from TABLE B-6)		10/1/93	
T	T-111	89.33	317	5/17/94	3/30/95
BY	BY-109, BY-102	623.39	215	5/30/94	12/31/94
C	C-107, C-102, C-110	568.30	92	9/30/94	12/31/94
BY	BY-106, BY-105, BY-103	1400.99	546	6/1/95	11/28/96
BX	BX-106	600.00	15	6/1/95	6/16/95
S (non-WATCH LIST TANKS)	S-107, S-103, S-109, S-101, S-108, S-110, S-106	688.06	414	1/2/96	2/19/97
T	T-104, T-110, T-107	311.93	143	5/22/96	10/12/96
C	C-103	199.10	133	6/30/96	11/10/96
U	U-102, U-111, U-106, U-107, U-108, U-109, U-103, U-105	651.15	406	7/26/96	9/5/97
S (WATCH LIST TANKS)	S-102, S-112, S-111	346.63	531	10/24/96	4/8/98
A	A-101	125.73	996	12/27/96	9/19/99
AX	AX-101	125.65	761	4/22/97	5/23/99
SX	SX106,SX102, SX101,SX103, SX104,SX105	773.65	609	8/8/97	4/9/99

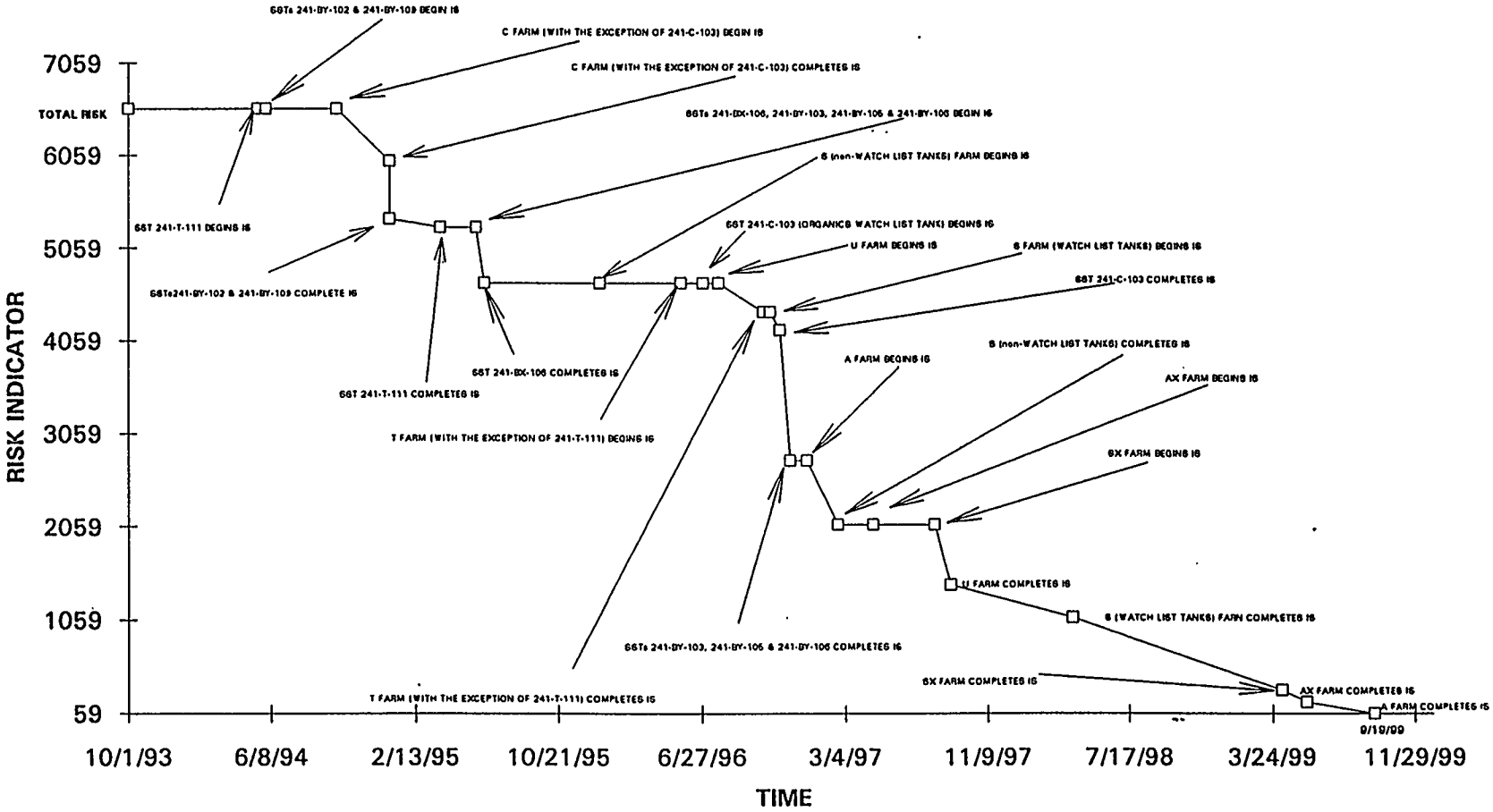
To create the Recommended Approach Schedule certain assumptions were made:

i) SSTs 241-BY-102 & 241-BY-109 preparation for pumping will be completed by 5/30/94

ii) only 3 farms are to be prepared for pumping at the same time (with the exception of 241-T-111).

FIGURE C-3

RISK EVALUATION
RECOMMENDED PUMPING SEQUENCE
BASED ON ENTIRE TANK CONTENT



IS = INTERIM STABILIZATION

TABLE C-4

TPA MILESTONE PUMPING SEQUENCE BASED ON ENTIRE TANK CONTENT

TPA MILESTONE	SST	RISK DECREASE PER MILESTONE	INTERIM STABILIZATION TIME (DAYS)	INTERIM STABILIZATION START DATE	INTERIM STABILIZATION COMPLETION DATE
		6563 (TOTAL from TABLE B-6)		10/1/93	
M-41-01-T3	BY102, BY109	623.39	215	5/30/94	12/31/94
M-41-01-T1	C102, C107, C110	568.30	92	9/30/94	12/31/94
M-41-08	U102	224.39	285	7/12/95	4/22/96
M-41-13	U106, U107, U111	323.12	509	7/12/95	12/2/96
M-41-09	S101, S103, S106, S107, S108, S109, S110	688.07	456	1/3/96	4/3/97
M-41-11	U103, U105, U108, U109	103.64	407	4/1/96	5/13/97
M-41-10	A101, AX101	251.38	984	4/18/96	12/28/98
M-41-12	BX106, BY103, BY105, BY106	2000.90	545	4/1/97	9/28/98
M-41-14	S111, S112, SX101, SX102, SX103, SX104, SX105	820.98	871	6/20/97	11/8/99
M-41-15	S102, SX106	299.19	627	6/20/97	3/9/99
M-41-16	T104, T111	267.97	153	3/24/98	8/24/98
M-41-17	T107	120.13	34	4/1/98	5/5/98
M-41-18	T110	13.17	117	4/1/98	7/27/98
M-41-19	C103	199.10	164	9/18/98	3/1/99

FIGURE C-4

RISK EVALUATION

TPA MILESTONE SCHEDULE BASED ON ENTIRE TANK CONTENT

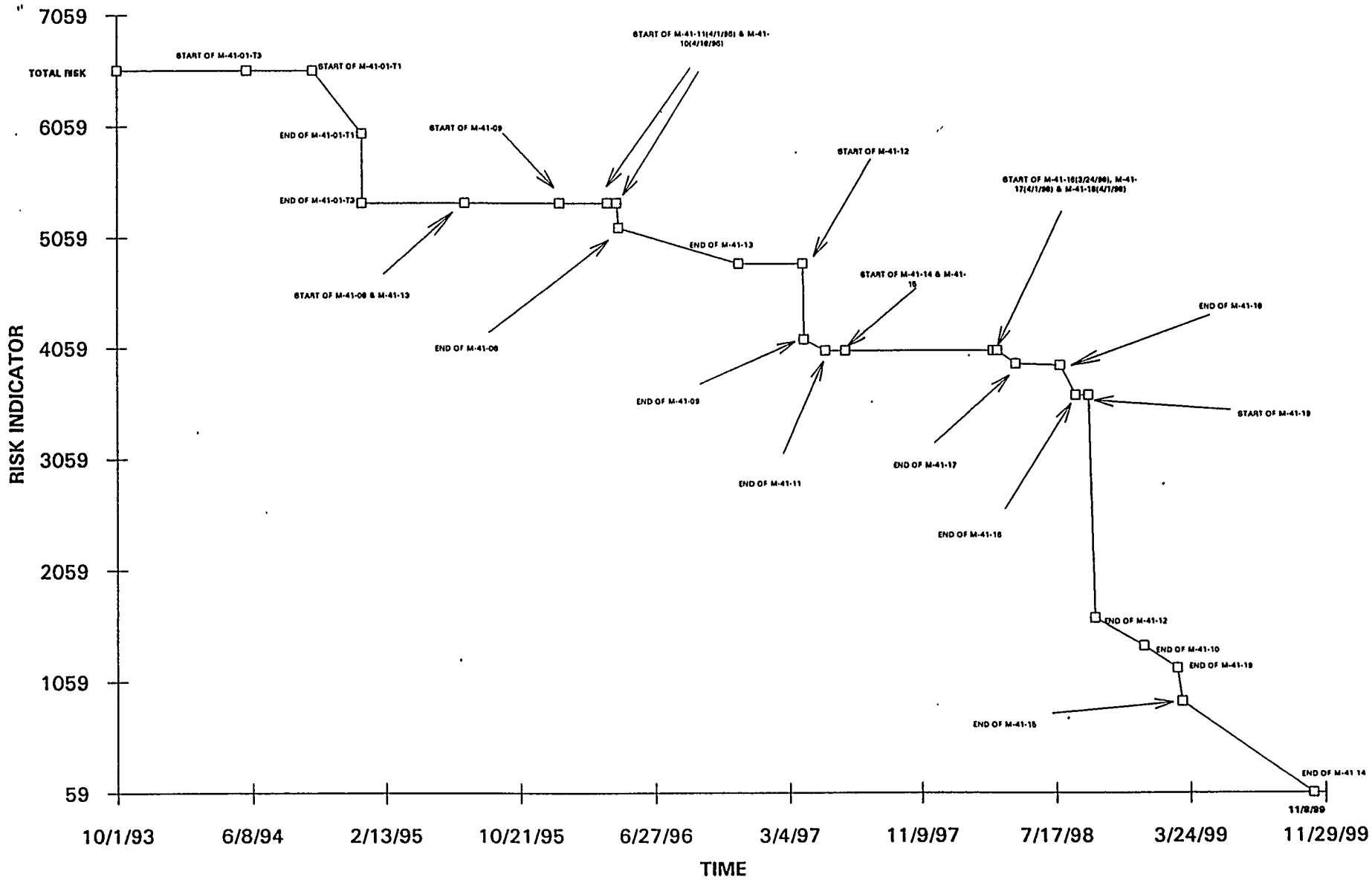
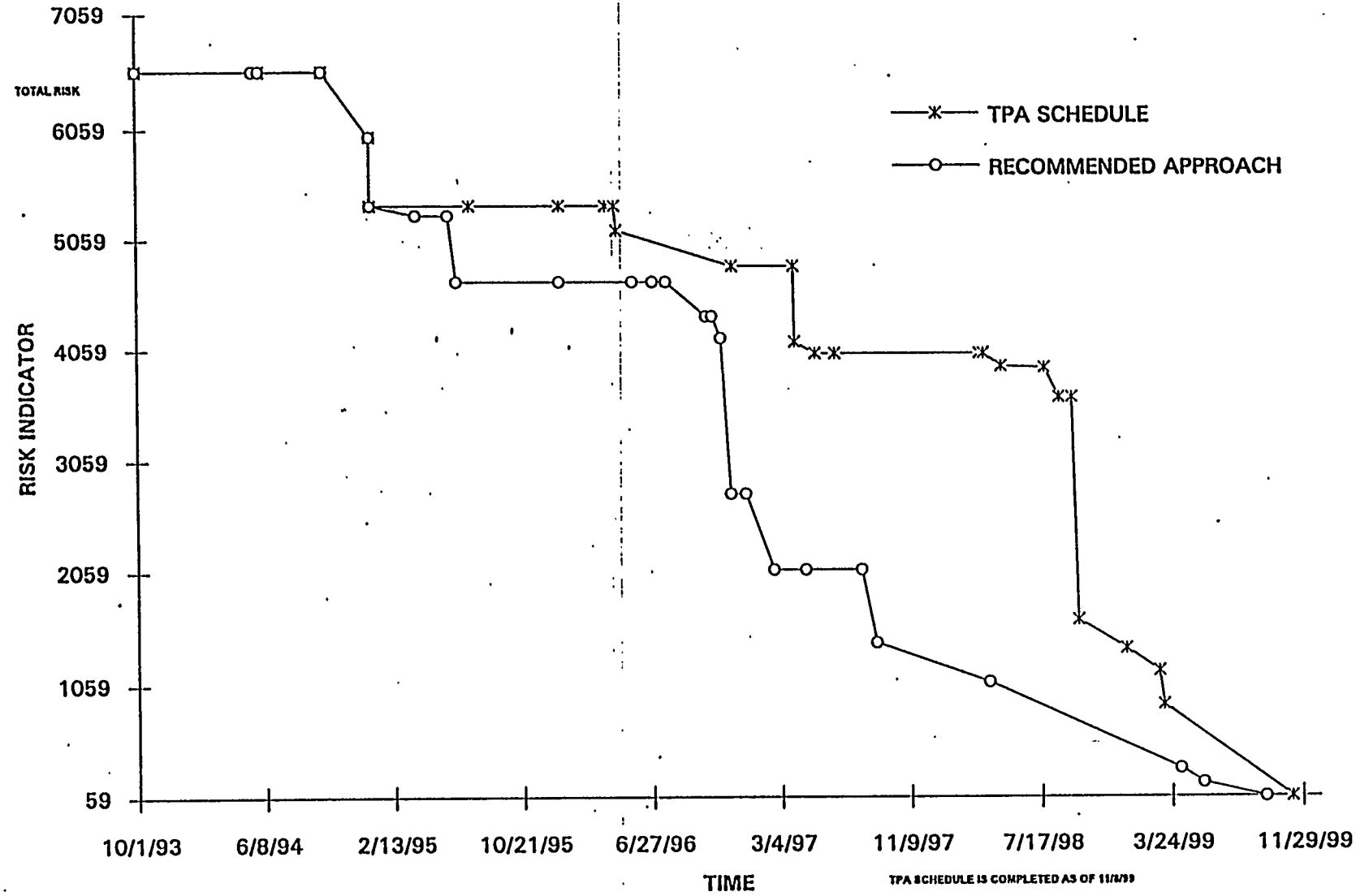


FIGURE C-5

RISK COMPARISON OF THE TPA SCHEDULE TO THE RECOMMENDED APPROACH
BASED ON ENTIRE TANK CONTENT



IS = INTERIM STABILIZATION