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ENGINEERING CHANGE NOTICE

1. ECN 657001

Proj. ECN

2. ECN Category (mark one)	3. Originator's Name, Organization, MSIN, and Telephone No.	4. USQ Required?	5. Date
Supplemental ○ Direct Revision ◉ Change ECN ○ Temporary ○ Standby ○ Supersedure ○ Cancel/Void ○	K. G. Carothers, Process Control, R2-11, 373-4556	○ Yes ◉ No	11/17/99

6. Project Title/No./Work Order No.	7. Bldg./Sys./Fac. No.	8. Approval Designator
WRSS Campaign Number 3 Solids Volume Transferred Calculation	N/A	N/A

9. Document Numbers Changed by this ECN (includes sheet no. and rev.)	10. Related ECN No(s).	11. Related PO No.
HNF-5267, Rev. 1	N/A	N/A

12a. Modification Work	12b. Work Package No.	12c. Modification Work Completed	12d. Restored to Original Condition (Temp. or Standby ECNs only)
○ Yes (fill out Blk. 12b) ◉ No (NA Blks. 12b, 12c, 12d)	N/A	N/A Design Authority/Cog. Engineer Signature & Date	N/A Design Authority/Cog. Engineer Signature & Date

13a. Description of Change

13b. Design Baseline Document? ○ Yes ◉ No

Complete revision of document to include the following changes.

Page 1, Section 3.0, Paragraph 1, Sentence 3 - Change to "The mass flow meter provides the initial indication of the amount of sludge transferred."

Page 2, Section 4.0, Paragraph 1, Sentence 4 - Change to "Because the mass flow meter provides a real time direct measure of the mass transfer, it provides the initial indication of sludge removed during a sluice batch."

Page 2, Section 4.0, Paragraph 1, Sentence 6 - Change to "Consequently, these methods serve to verify the mass transfer results determined from the initial mass flow meter data."

Page 40, Section 7.0, Item 2 - Change to "The amount of sludge removed from tank 241-C-106 as determined from the corrected mass flow meter method compares to within 10 percent of the amount determined from the sediment level/dissolved solids method."

14a. Justification (mark one)	14b. Justification Details
Criteria Change ◉ Design Improvement ○ Environmental ○ Facility Deactivation ○ As-Found ○ Facilitate Const. ○ Const. Error/Omission ○ Design Error/Omission ○	This change updates pages 1, 2 and 40 to make the document more clear.

15. Distribution (include name, MSIN, and no. of copies)

See attached distribution.

RELEASE STAMP

DATE: NOV 17 1999 HANFORD RELEASE STA: 4 ID: 2

ENGINEERING CHANGE NOTICE

1. ECN (use no. from pg. 1): 657001

16. Design Verification Required	17. Cost Impact — ENGINEERING		17. Cost Impact — CONSTRUCTION		18. Schedule Impact (days)
○ Yes	Additional ○	$ ______	Additional ○	$ ______	Improvement ○ ______
◉ No	Savings ○	$ ______	Savings ○	$ ______	Delay ○ ______

19. Change Impact Review: Indicate the related documents (other than the engineering documents identified on Side 1) that will be affected by the change described in Block 13. Enter the affected document number in Block 20.

SDD/DD	☐	Seismic/Stress Analysis	☐	Tank Calibration Manual	☐
Functional Design Criteria	☐	Stress/Design Report	☐	Health Physics Procedure	☐
Operating Specification	☐	Interface Control Drawing	☐	Spares Multiple Unit Listing	☐
Criticality Specification	☐	Calibration Procedure	☐	Test Procedures/Specification	☐
Conceptual Design Report	☐	Installation Procedure	☐	Component Index	☐
Equipment Spec.	☐	*Maintenance Procedure*	☐	*ASME Coded Item*	☐
Const. Spec.	☐	Engineering Procedure	☐	Human Factor Consideration	☐
Procurement Spec.	☐	Operating Instruction	☐	Computer Software	☐
Vendor Information	☐	Operating Procedure	☐	Electric Circuit Schedule	☐
OM Manual	☐	Operational Safety Requirement	☐	ICRS Procedure	☐
FSAR/SAR	☐	IEFD Drawing	☐	Process Control Manual/Plan	☐
Safety Equipment List	☐	Cell Arrangement Drawing	☐	Process Flow Chart	☐
Radiation Work Permit	☐	Essential Material Specification	☐	Purchase Requisition	☐
Environmental Impact Statement	☐	Fac. Proc. Samp. Schedule	☐	Tickler File	☐
Environmental Report	☐	Inspection Plan	☐	______	☐
Environmental Permit	☐	Inventory Adjustment Request	☐	______	☐

20. Other Affected Documents: (NOTE: Documents listed below will not be revised by this ECN.) Signatures below indicate that the signing organization has been notified of other affected documents listed below.

Document Number/Revision	Document Number/Revision	Document Number/Revision

21. Approvals

	Signature	Date		Signature	Date
Design Authority	J.W. Bailey [signature]	11/17/99	Design Agent		
Cog. Eng.	K.G. Carothers [signature]	11/17/99	PE		
Cog. Mgr.	N.W. Kirch [signature]	11/17/99	QA		
QA			Safety		
Safety			Design		
Environ.			Environ.		
Other	L.A. Stauffer [signature]	11/17/99	Other		

DEPARTMENT OF ENERGY

Signature or a Control Number that tracks the Approval Signature

ADDITIONAL

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Waste Retrieval Sluicing System Campaign Number 3 Solids Volume Transferred Calculation

K. G. Carothers, L. A. Stauffer, and J. W. Bailey
Lockheed Martin Hanford Corp.
Richland, WA 99352

U.S. Department of Energy Contract DE-AC06-96RL13200

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11/17/99

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RECORD OF REVISION

(1) Document Number: HNF-5267

Page 1

(2) Title
Waste Retrieval Sluicing System Campaign Number 3 Solids Volume Transferred Calculation

Change Control Record

(3) Revision	(4) Description of Change - Replace, Add, and Delete Pages	Authorized for Release	
		(5) Cog. Engr.	(6) Cog. Mgr. Date
0	(7) Original release.	LA Stauffer	NW Kirch
1	Incorporate per ECN-657000.	KG Carothers	NW Kirch
2 RS	Incorporate per ECN-657001	KG KGC Carothers	NW Kirch NWKirch 11/17/99

A-7320-005 (10/97)

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1.0 INTRODUCTION

Waste Retrieval Sluicing System (WRSS) operations at tank 241-C-106 began on Wednesday, November 18, 1998. The purpose of this system is to retrieve and transfer the high-heat sludge from the tank for storage in double-shell tank 241-AY-102, thereby resolving the high-heat safety issue for the tank, and to demonstrate modernized past-practice retrieval technology for single-shell tank waste. Performance Agreement (PA) TWR 1.2.2, C-106 Sluicing, was established by the Department of Energy, Office of River Protection (ORP) for achieving completion of sluicing retrieval of waste from tank 241-C-106 by September 30, 1999. This level of sludge removal is defined in the PA as either removal of approximately 72 inches of sludge or removal of 172,000 gallons of sludge (approximately 62 inches) and less than 6,000 gallons (approximately 2 inches) of sludge removal per 12 hour sluice batch for three consecutive batches.

Preliminary calculations of the volume of tank 241-C-106 sludge removed as of September 29, 1999 were provided to ORP documenting completion of PA TWR 1.2.2 (Allen 1999a). The purpose of this calculation is to document the final sludge volume removed from tank 241-C-106 up through September 30, 1999. Additionally, the results of an extra batch completed October 6, 1999 is included to show the total volume of sludge removed through the end of WRSS operations. The calculation of the sludge volume transferred from the tank is guided by engineering procedure HNF-SD-WM-PROC-021, Section 15.0, Rev. 3, sub-section 4.4, "Calculation of Sludge Transferred."

2.0 SCOPE

This calculation determines the amount of sludge transferred out of tank 241-C-106 from the start of sluicing in November 1998 through sluice batch 3.2.9 completed on October 6, 1999. The sludge volume calculation uses process control procedures and strategies outline in the WRSS Process Control Plan (HNF-SD-WM-PCP-013, Rev. 2) and detailed in HNF-SD-WM-PROC-021, Section 15.0, Rev. 3.

3.0 METHOD OF ANALYSIS

Guidance for calculating the sludge volume removed from tank 241-C-106 is contained in HNF-SD-WM-PROC-021, Section 15.0, Rev. 3, sub-section 4.4, "Calculation of Sludge Transferred." Four methods are detailed. The mass flow meter provides the initial indication of the amount of sludge transferred. All other methods are used to provide a level of verification for the mass flow meter. The calculation methods in sub-section 4.4 of the procedure include:

1. Mass Transfer Based on Mass Flow Meter (sub-section 4.4.1)
2. Mass Transfer Based on ENRAF[1] Densitometer Density Profiles (sub-section 4.4.2)
3. Mass Transfer Based on ENRAF™ Densitometer Sediment Levels (sub-section 4.4.3)
4. Mass Transfer Based on Dissolved Solids (sub-section 4.4.4)

[1] ENRAF is a trademark of the ENRAF Corporation, Houston , Texas.

4.0 MASS TRANSFER CALCULATIONS

The amount of tank 241-C-106 sludge transferred to tank 241-AY-102 is measured real time during sluicing batches using the mass flow meter installed on the slurry pipeline. This instrument provides a direct measurement of the mass of slurry flowing through the pipe and its density. From these measurements, the solids loading in the slurry stream can be determined and thus the mass of solids transferred. Because the mass flow meter provides a real time direct measure of the mass transfer, it provides the initial indication of sludge removed during a sluice batch. All other methods involve measurements made after the waste has been dispersed in the large volume of waste in tank 241-AY-102 and, therefore, provide an indirect measure of the sludge transferred. Consequently, these methods serve to verify the mass transfer results determined from the initial mass flow meter data. Following are the summary calculations for the mass flow meter and other methods discussed in Section 3. This section presents the batch wise calculations detailed in HNF-SD-WM-PROC-021, Section 15.0, Rev. 3. Evaluation of the results from the different calculation methods is addressed in Section 5.

4.1 MASS TRANSFER BASED ON MASS FLOW METER

The initial volume of tank 241-C-106 sludge transferred to tank 241-AY-102 is calculated using the method described in HNF-SD-WM-PROC-021, Section 15.0, Rev. 3, sub-section 4.4.1. A summary of the initial input densities and sludge volumes calculated for each batch using the mass flow meter method is provided in Table 4-1.

The mass flow meter calculations are based on an estimated average carrier solution density. This density is input into the Data Acquisition System (DAS) before each sluicing batch begins. The carrier solution density is used by DAS to calculate the mass fraction of solids in the slurry.

After a sluicing batch is complete, the carrier solution density is sometimes corrected based on the ENRAF™ densitometer data and grab sample data (if available). This correction is made because the carrier solution density typically does not remain constant during a sluice batch. A carrier solution density more representative of a batch from beginning to end is selected. The corrected input densities and sludge volumes for each batch are summarized in Table 4-1. Table 4-2 contains a sample of the calculations done to revise the mass flow meter sludge volumes based on the new input carrier fluid densities. Table 4-3 contains a sample of the formulas used in the spreadsheet in Table 4-2.

Table 4-1. WRSS Mass Flow Meter Solids Volume Calculation Summary

Date	Batch	Initial Input Density (g/mL)	Initial Sludge Transferred (gal)	Corrected Input Density (g/mL)	Corrected Sludge Transferred (gal)	Corrected Sludge Transferred (inches)
11/18/98	1.1.1	1.0540	7,958	N/A	7,958	2.89
12/16/98	1.1.2 (Phase I)	1.0370	2,322	N/A	2,322	0.84
	1.1.3 (Phase II)	1.0610	22,556	1.05700	23,870	8.68
3/28/99	1.2.1 (Phase III)	1.0950	18,889	1.07800	42,870	15.59
4/23/99	2.1.1	1.1110	2,350	1.09510	1,869	0.68
4/28/1999 & 4/30/99	2.1.2	1.0913	14,965	N/A	14,965	5.44
5/24/99	2.2.1	1.0960	8,688	N/A	8,688	3.16
6/3/99	2.2.2	1.1070	24,350	1.08550	36,865	13.41
7/21/1999 & 7/22/99	3.1.1	1.1027	17,419	N/A	17,419	6.33
8/4/99	3.1.2	1.1038	253	1.10590	137	0.05
8/20/99	3.1.3	1.1097	3,687	1.10590	5,498	2.00
9/10/99	3.2.1	1.1057	7,776	1.10778	6,764	2.46
9/14/99	3.2.2	1.1100	5,778	1.11000	5,767	2.10
9/16/99	3.2.3	1.1100	14,558	1.11099	13,905	5.06
9/21/99	3.2.4	1.1118	6,417	1.11221	7,572	2.75
9/24/99	3.2.5	1.1126	4,697	1.11248	4,761	1.73
9/26/99	3.2.6	1.1126	2,899	1.11251	3,250	1.18
9/28/99	3.2.7	1.1126	1,103	1.11320	974	0.35
9/30/99	3.2.8	1.1137	711	1.11330	845	0.31
10/6/99	3.2.9	1.1129	314	1.11329	261	0.09

Note: N/A = Not Applicable (density not corrected)

Table 4-2. Sample Calculations for Mass Flow Meter Revised Sludge Volumes

	WRSS DAS Dataset 9/24/99			Calculations		
	DI-0621A Slurry Density	**DI-0621B Solids Loading**	**FI-0623 Slurry Mass Flow Rate**	Solids Density (p_p) =	2.61	
	Slurry Density (g/cc)	**Solids Loading (% solids)**	**Slurry Mass Flow Rate (lbs/min)**	Avg. Fluid Density (p_f) =	1.11248	
Minimum	0	0	0.00			
Maximum	1.128	2.416	3505.00	**% solids C_m**	**Slurry (lbs.)**	**Solid (lbs.)**
Average	1.006	1.182	2963.89	1.44		
Standard Deviation	0.323	0.762	1082.846			
Sum	3686	4330	10856709		1809452	24607
9/24/99 13:50:30	1.11497	0.37813	3253.75	0.386	542.29	2.09
9/24/99 13:50:40	1.11544	0.4375	3242.5	0.459	540.42	2.48
9/24/99 13:50:50	1.11544	0.44688	3245.3125	0.459	540.89	2.48
9/24/99 13:51:00	1.11553	0.45625	3243.4375	0.473	540.57	2.56
9/24/99 13:51:10	1.11563	0.47188	3232.5	0.488	538.75	2.63
9/24/99 13:51:20	1.11544	0.45	3232.1875	0.459	538.70	2.47
9/24/99 13:51:30	1.11544	0.44375	3248.75	0.459	541.46	2.49
9/24/99 13:51:40	1.11544	0.43437	3245.3125	0.459	540.89	2.48
9/24/99 13:51:50	1.11544	0.4375	3245.3125	0.459	540.89	2.48
9/24/99 13:52:00	1.11534	0.42812	3237.5	0.443	539.58	2.39
9/24/99 13:52:10	1.11534	0.44375	3246.5625	0.443	541.09	2.40
9/24/99 13:52:20	1.11534	0.42188	3246.5625	0.443	541.09	2.40
9/24/99 13:52:30	1.11506	0.38438	3245.9375	0.400	540.99	2.16
9/24/99 13:52:40	1.11534	0.43437	3244.375	0.443	540.73	2.40
9/24/99 13:52:50	1.11534	0.42188	3244.0625	0.443	540.68	2.40

Table 4-3. Sample Calculation Formulas for Mass Flow Meter Revised Sludge Volumes (2 sheets)

	WRSS DAS Dataset 9/24/99		
	DI-0621A Slurry Density	**DI-0621B Solids Loading**	**FI-0623 Slurry Mass Flow Rate**
	Slurry Density (g/cc)	**Solids Loading (% solids)**	**Slurry Mass Flow Rate (lbs/min)**
Minimum	=ROUND(MIN(B$10:B$3661),3)	=ROUND(MIN(C$10:C$3661),3)	=ROUND(MIN(D$10:D$3661),3)
Maximum	=ROUND(MAX(B$10:B$3661),3)	=ROUND(MAX(C$10:C$3661),3)	=ROUND(MAX(D$10:D$3661),3)
Average	=ROUND(AVERAGE(B$10:B$3661),3)	=ROUND(AVERAGE(C$10:C$3661),3)	=ROUND(AVERAGE(D$10:D$3661),3)
Standard Deviation	=ROUND(STDEV(B$10:B$3661),3)	=ROUND(STDEV(C$10:C$3661),3)	=ROUND(STDEV(D$10:D$3661),3)
Sum	=ROUND(SUM(B$10:B$3661),1)	=ROUND(SUM(C$10:C$3661),1)	=ROUND(SUM(D$10:D$3661),1)
36427.5767361111	1.11497	0.37813	3253.75
36427.5768518519	1.11544	0.4375	3242.5
36427.5769675926	1.11544	0.44688	3245.3125
36427.5770833333	1.11553	0.45625	3243.4375
36427.5771990741	1.11563	0.47188	3232.5
36427.5773148148	1.11544	0.45	3232.1875
36427.5774305556	1.11544	0.44375	3248.75
36427.5775462963	1.11544	0.43437	3245.3125
36427.577662037	1.11544	0.4375	3245.3125
36427.5777777778	1.11534	0.42812	3237.5
36427.5778935185	1.11534	0.44375	3246.5625
36427.5780092593	1.11534	0.42188	3246.5625
36427.578125	1.11506	0.38438	3245.9375
36427.5782407407	1.11534	0.43437	3244.375
36427.5783564815	1.11534	0.42188	3244.0625

Table 4-3. Sample Calculation Formulas for Mass Flow Meter Revised Sludge Volumes (2 sheets)

Calculations		
Solids Density (p_p) =	2.61	
Avg. Fluid Density (p_f) =	1.11248	
% solids C_m	**Slurry (lbs.)**	**Solid (lbs.)**
=AVERAGE(E10:E3661)		
	=SUM(F10:F3661)	=SUM(G10:G3661)
=100*(F3*(B10-F4))/(B10*(F3-F4))	=D10*10/60	=F10*E10/100
=100*(F3*(B11-F4))/(B11*(F3-F4))	=D11*10/60	=F11*E11/100
=100*(F3*(B12-F4))/(B12*(F3-F4))	=D12*10/60	=F12*E12/100
=100*(F3*(B13-F4))/(B13*(F3-F4))	=D13*10/60	=F13*E13/100
=100*(F3*(B14-F4))/(B14*(F3-F4))	=D14*10/60	=F14*E14/100
=100*(F3*(B15-F4))/(B15*(F3-F4))	=D15*10/60	=F15*E15/100
=100*(F3*(B16-F4))/(B16*(F3-F4))	=D16*10/60	=F16*E16/100
=100*(F3*(B17-F4))/(B17*(F3-F4))	=D17*10/60	=F17*E17/100
=100*(F3*(B18-F4))/(B18*(F3-F4))	=D18*10/60	=F18*E18/100
=100*(F3*(B19-F4))/(B19*(F3-F4))	=D19*10/60	=F19*E19/100
=100*(F3*(B20-F4))/(B20*(F3-F4))	=D20*10/60	=F20*E20/100
=100*(F3*(B21-F4))/(B21*(F3-F4))	=D21*10/60	=F21*E21/100
=100*(F3*(B22-F4))/(B22*(F3-F4))	=D22*10/60	=F22*E22/100
=100*(F3*(B23-F4))/(B23*(F3-F4))	=D23*10/60	=F23*E23/100
=100*(F3*(B24-F4))/(B24*(F3-F4))	=D24*10/60	=F24*E24/100

4.2 MASS TRANSFER BASED ON ENRAF™ DENSITOMETER - DENSITY PROFILE

The method used to calculate the volume of tank 241-C-106 sludge transferred to tank 241-AY-102 using the ENRAF™ densitometer density profile data is described in HNF-SD-WM-PROC-021, Section 15.0, Rev. 3, sub-section 4.4.2. A summary of the sludge volumes calculated using the ENRAF™ densitometer density profile method is provided in Table 4-4. The formulas used from HNF-SD-WM-PROC-021 and definitions of the terms are also provided in the table. The ENRAF™ densitometer density profile data used to calculate the sludge volumes for each batch are provided in Table 4-5.

Table 4-4. WRSS ENRAF™ Densitometer Solids Volume Calculation Summary

Date	Batch	Date of Densitometer Reading	H_W (inch)	H_0 (inch)	H_{W0} (inch)	ρ_{LS} (g/mL)	ρ_{L0} (g/mL)	$\Delta H_{6C}\rho_{6CSL}$ (lbs)	V_{SL-E} (gal)	H_{SL-E} (inch)
11/18/99	1.1.1	11/18/98 21:38	169.67	9.11	167.71	1.04557	1.03814	74,065	5724	2.08
12/16/99	1.1.2 (Phase I)	12/17/98 11:38	169.75	12.11	169.61	1.07345	1.05129	83,540	6457	2.35
3/7/99	1.1.3 (Phase II)	3/8/99 1:46	170.52	11.93	169.54	1.08736	1.06742	96,601	7466	2.72
3/28/99	1.2.1 (Phase III)	3/29/99 3:19	170.61	18.05	170.55	1.08835	1.07879	34,958	2702	0.98
4/23/99	2.1.1	4/24/99 1:22	178.76	25.88	170.6	1.08509	1.07887	223,892	17305	6.29
4/28/99 & 4/30/99	2.1.2	5/1/99 1:12	185.18	27.96	178.86	1.10398	1.08752	217,145	16783	6.10
5/24/99	2.2.1	5/25/99 1:47	187.51	35.18	185.22	1.09570	1.08731	86,506	6686	2.43
6/3/99	2.2.2	6/4/99 1:26:17	199.9	38.69	187.59	1.11788	1.09401	397,444	30718	11.17
7/21/99 & 7/22/99	3.1.1	7/22/99 18:31	202.95	46.66	190.96	1.10838	1.09655	344,198	26603	9.67
8/4/99	3.1.2	8/5/99 9:11	196.68	51.40	203.02	1.11921	1.11635	-152,922	-11819	-4.30
8/20/99	3.1.3	8/20/99 19:19	207.61	50.98	196.63	1.12220	1.11925	292,670	22620	8.23
9/10/99	3.2.1	9/11/99 9:42	210.3	52.88	199.28	1.11861	1.11034	310,740	24017	8.73
9/14/99	3.2.2	9/15/99 3:19	212.36	55.66	210.24	1.11522	1.11442	57,094	4413	1.60
9/16/99	3.2.3	9/17/99 2:03	215.31	55.66	212.34	1.12311	1.11442	107,808	8332	3.03
9/21/99	3.2.4	9/22/99 1:04	215.95	64.72	215.24	1.12013	1.11638	31,207	2412	0.88
9/24/99	3.2.5	9/25/99 1:45	220.08	65.82	215.95	1.12326	1.11761	125,920	9732	3.54
9/26/99	3.2.6	9/27/99 1:04	220.96	67.12	220.06	1.11848	1.12108	13,989	1081	0.39
9/28/99	3.2.7	9/27/99 1:07	218.98	68.21	220.96	1.11860	1.11751	-47,019	-3634	-1.32
9/30/99	3.2.8	10/1/99 0:42	226.21	68.7	218.99	1.11730	1.11949	177,581	13725	4.99
10/6/99	3.2.9	10/1/99 0:45	224.07	68.92	226.17	1.11664	1.11784	-58,150	-4494	-1.63

H_W = AY-102 level after batch transferred

H_0 = Average height of sludge layer before transfer

H_{W0} = Initial waste level in AY-102 before transfer

ρ_{L0} = Average initial liquid density before transfer

$\Delta H_{6C}\rho_{6CSL} = [(H_W - H_0)\rho_{LS} - [(H_{W0} - H_0)\rho_{L0}]$ (2750 gal/in)(lb/453.493 g)(3785 mL/gal)

$V_{SL-E} = \Delta H_{6C}\rho_{6CSL}\,(1/\rho_{6CSL})$ (453.493 g/lb.) (7.4805 gal/28,317 mL)

ρ_{6CSL} = Density of Tank 241-C-106 sludge

ρ_{6CSL} = 1.55 g/mL

ρ_{LS} = Average density of slurry suspended solids after transfer

Table 4-5. WRSS ENRAF™ Densitometer Density Profiles (10 sheets)

Batch 1.1.1						
Date/Time	**Elevation (inch)**	**Density (g/cm^3)**		**Date/Time**	**Elevation (inch)**	**Density (g/cm^3)**
11/15/98 12:13	155.95	1.04229		11/18/98 21:38	155.95	1.05129
11/15/98 12:16	131.96	1.04228		11/18/98 21:41	143.95	1.05137
11/15/98 12:19	107.95	1.04127		11/18/98 21:44	131.95	1.05048
11/15/98 12:22	83.95	1.03282		11/18/98 21:47	119.95	1.04683
11/15/98 12:25	59.97	1.03484		11/18/98 21:50	107.95	1.04607
11/15/98 12:29	35.96	1.03534		11/18/98 21:55	95.98	1.04431
SEDIMENT LEVEL				11/18/98 21:58	83.95	1.03892
11/15/98 10:14	9.11			11/18/98 22:01	71.95	1.04048
				11/18/98 22:04	59.95	1.04247
				11/18/98 22:07	47.95	1.04331
				11/18/98 22:10	35.95	1.0443
				11/18/98 22:13	23.95	1.04695
				SEDIMENT LEVEL		
				11/18/98 18:40	9.46	
Batch 1.1.2 (Phase I)						
Date/Time	**Elevation (inch)**	**Density (g/cm^3)**		**Date/Time**	**Elevation (inch)**	**Density (g/cm^3)**
12/7/98 13:46	155.95	1.05675		12/17/98 11:38	155.95	1.07896
12/7/98 13:49	143.95	1.05725		12/17/98 11:41	143.95	1.07897
12/7/98 13:52	131.95	1.05617		12/17/98 11:44	131.95	1.07851
12/7/98 13:55	119.95	1.05297		12/17/98 11:47	119.95	1.0757
12/7/98 13:58	107.95	1.05189		12/17/98 11:50	107.95	1.07518
12/7/98 14:01	95.95	1.05		12/17/98 11:53	95.95	1.07263
12/7/98 14:04	83.95	1.04599		12/17/98 11:56	83.95	1.06728
12/7/98 14:07	71.95	1.04668		12/17/98 11:59	71.95	1.06843
12/7/98 14:10	59.95	1.04791		12/17/98 12:02	59.95	1.06959
12/7/98 14:13	47.95	1.0489		12/17/98 12:05	47.95	1.07067
12/7/98 14:16	35.95	1.04914		12/17/98 12:08	35.95	1.0713
12/7/98 14:19	23.95	1.05186		12/17/98 12:11	23.95	1.07415
SEDIMENT LEVEL				**SEDIMENT LEVEL**		
12/7/98 13:09	12.11			12/17/98 10:42	12.14	

Table 4-5. WRSS ENRAF™ Densitometer Density Profiles (10 sheets)

Batch 1.1.3 (Phase II)						
Date/Time	**Elevation (inch)**	**Density (g/cm^3)**		**Date/Time**	**Elevation (inch)**	**Density (g/cm^3)**
3/4/99 12:45	155.95	1.0723		3/8/99 1:46	155.95	1.08458
3/4/99 12:48	143.95	1.07215		3/8/99 1:49	143.95	1.08343
3/4/99 12:51	131.95	1.07116		3/8/99 1:52	131.95	1.08255
3/4/99 12:54	119.95	1.06879		3/8/99 1:55	119.95	1.08021
3/4/99 12:57	107.95	1.0688		3/8/99 1:58	107.95	1.08071
3/4/99 13:00	95.95	1.06768		3/8/99 2:01	95.95	1.08659
3/4/99 13:03	83.95	1.06249		3/8/99 2:04	83.95	1.08241
3/4/99 13:06	71.95	1.06363		3/8/99 2:07	71.95	1.08599
3/4/99 13:09	59.95	1.06465		3/8/99 2:10	59.95	1.08989
3/4/99 13:12	47.95	1.06459		3/8/99 2:13	47.95	1.09292
3/4/99 13:15	35.95	1.06557		3/8/99 2:16	35.95	1.09495
3/4/99 13:18	23.95	1.06724		3/8/99 2:19	23.95	1.10413
SEDIMENT LEVEL				**SEDIMENT LEVEL**		
3/4/99 10:03	11.93			3/8/99 1:02	12.55	

Batch 1.2.1 (Phase III)						
Date/Time	**Elevation (inch)**	**Density (g/cm^3)**		**Date/Time**	**Elevation (inch)**	**Density (g/cm^3)**
3/25/99 9:32	155.95	1.08044		3/29/99 3:19	155.95	1.07761
3/25/99 9:35	143.95	1.08058		3/29/99 3:22	143.95	1.07811
3/25/99 9:38	131.95	1.07941		3/29/99 3:25	131.95	1.08782
3/25/99 9:41	119.95	1.07723		3/29/99 3:28	119.95	1.08731
3/25/99 9:44	107.95	1.07536		3/29/99 3:31	107.95	1.08495
3/25/99 9:47	95.95	1.07267		3/29/99 3:34	95.95	1.08336
3/25/99 9:50	83.95	1.0776		3/29/99 3:37	83.95	1.08846
3/25/99 9:53	71.95	1.07821		3/29/99 3:40	71.95	1.09008
3/25/99 9:56	59.95	1.08018		3/29/99 3:43	59.95	1.09344
3/25/99 9:59	47.95	1.08175		3/29/99 3:46	47.95	1.09772
3/25/99 10:02	35.95	1.0833		3/29/99 3:49	35.95	1.10302
SEDIMENT LEVEL				**SEDIMENT LEVEL**		
3/25/99 9:24	18.05			3/29/99 3:11	18.74	

Table 4-5. WRSS ENRAF™ Densitometer Density Profiles (10 sheets)

Batch 2.1.1						
Date/Time	**Elevation (inch)**	**Density (g/cm^3)**		**Date/Time**	**Elevation (inch)**	**Density (g/cm^3)**
4/21/99 13:06	155.95	1.08119		4/24/99 1:22	155.95	1.08322
4/21/99 13:09	143.95	1.08067		4/24/99 1:26	143.95	1.08228
4/21/99 13:12	131.95	1.07826		4/24/99 1:29	131.95	1.08161
4/21/99 13:15	119.95	1.07529		4/24/99 1:32	119.95	1.08332
4/21/99 13:18	107.95	1.07416		4/24/99 1:35	107.95	1.08196
4/21/99 13:21	95.95	1.07321		4/24/99 1:38	95.95	1.08058
4/21/99 13:24	83.95	1.07784		4/24/99 1:41	83.95	1.08492
4/21/99 13:27	71.95	1.07897		4/24/99 1:44	71.95	1.08648
4/21/99 13:30	59.95	1.08207		4/24/99 1:47	59.95	1.08844
4/21/99 13:33	47.95	1.08235		4/24/99 1:50	47.95	1.08897
4/21/99 13:36	35.95	1.08353		4/24/99 1:53	35.95	1.09419
SEDIMENT LEVEL				**SEDIMENT LEVEL**		
4/21/99 12:50	25.88			4/24/99 1:11	26.05	

Batch 2.1.2						
Date/Time	**Elevation (inch)**	**Density (g/cm^3)**		**Date/Time**	**Elevation (inch)**	**Density (g/cm^3)**
4/26/99 17:31	155.95	1.08862		5/1/99 1:12	168.12	1.10355
4/26/99 17:34	143.95	1.08815		5/1/99 1:15	155.95	1.10563
4/26/99 17:37	131.95	1.08747		5/1/99 1:18	143.95	1.10549
4/26/99 17:40	119.95	1.08524		5/1/99 1:21	131.95	1.10433
4/26/99 17:43	107.95	1.08395		5/1/99 1:24	119.95	1.10086
4/26/99 17:47	95.95	1.0831		5/1/99 1:27	107.95	1.09954
4/26/99 17:50	83.95	1.08837		5/1/99 1:30	95.95	1.09828
4/26/99 17:53	71.95	1.08696		5/1/99 1:33	83.95	1.10345
4/26/99 17:56	59.95	1.08944		5/1/99 1:36	71.95	1.10489
4/26/99 17:59	47.95	1.08979		5/1/99 1:39	59.95	1.10824
4/26/99 18:02	35.95	1.09161		5/1/99 1:42	47.95	1.10948
SEDIMENT LEVEL				**SEDIMENT LEVEL**		
4/26/99 17:24	27.96			5/1/99 1:05	30.5	

Table 4-5. WRSS ENRAF™ Densitometer Density Profiles (10 sheets)

Batch 2.2.1						
Date/Time	**Elevation (inch)**	**Density (g/cm^3)**		**Date/Time**	**Elevation (inch)**	**Density (g/cm^3)**
5/18/99 9:27	168.13	1.08938		5/25/99 1:47	179.95	1.08982
5/18/99 9:30	155.95	1.08948		5/25/99 1:50	167.95	1.09171
5/18/99 9:33	143.95	1.08891		5/25/99 1:53	155.95	1.09281
5/18/99 9:36	131.95	1.08713		5/25/99 1:56	143.95	1.09191
5/18/99 9:39	119.95	1.08433		5/25/99 1:59	131.95	1.08924
5/18/99 9:42	107.95	1.08319		5/25/99 2:02	119.95	1.09385
5/18/99 9:45	95.95	1.08156		5/25/99 2:05	107.95	1.09293
5/18/99 9:48	83.95	1.08596		5/25/99 2:08	95.95	1.09161
5/18/99 9:51	71.95	1.08818		5/25/99 2:11	83.95	1.09679
5/18/99 9:54	59.95	1.09063		5/25/99 2:14	71.95	1.0991
5/18/99 9:57	47.95	1.09162		5/25/99 2:17	59.95	1.10133
SEDIMENT LEVEL				5/25/99 2:20	47.95	1.11733
5/18/99 9:15	35.18			**SEDIMENT LEVEL**		
				5/25/99 1:39	35.29	

Batch 2.2.2						
Date/Time	**Elevation (inch)**	**Density (g/cm^3)**		**Date/Time**	**Elevation (inch)**	**Density (g/cm^3)**
6/2/99 10:19:12	179.95	1.09218		6/4/99 1:26:17	179.95	1.11519
6/2/99 10:22:13	167.95	1.09462		6/4/99 1:29:18	167.95	1.11749
6/2/99 10:25:14	155.95	1.09629		6/4/99 1:32:19	155.95	1.11955
6/2/99 10:28:15	143.95	1.09602		6/4/99 1:35:20	143.95	1.11946
6/2/99 10:31:16	131.95	1.0942		6/4/99 1:38:21	131.95	1.11757
6/2/99 10:34:17	119.95	1.09148		6/4/99 1:41:22	119.95	1.11493
6/2/99 10:37:18	107.95	1.08992		6/4/99 1:44:23	107.95	1.11337
6/2/99 10:40:19	95.95	1.0896		6/4/99 1:47:24	95.95	1.11248
6/2/99 10:43:20	83.95	1.09334		6/4/99 1:50:25	83.95	1.11606
6/2/99 10:46:21	71.95	1.09602		6/4/99 1:53:26	71.95	1.11924
6/2/99 10:49:22	59.95	1.09764		6/4/99 1:56:27	59.95	1.12137
6/2/99 10:52:23	47.95	1.09681		6/4/99 1:59:28	47.95	1.1279
SEDIMENT LEVEL				**SEDIMENT LEVEL**		
6/2/99 10:12:29	38.69			6/4/99 1:16:30	39.94	

Table 4-5. WRSS ENRAF™ Densitometer Density Profiles (10 sheets)

Batch 3.1.1						
Date/Time	**Elevation (inch)**	**Density (g/cm^3)**		**Date/Time**	**Elevation (inch)**	**Density (g/cm^3)**
7/12/99 13:21	179.95	1.09461		7/22/99 18:31	192.03	1.10861
7/12/99 13:24	167.95	1.09662		7/22/99 18:34	179.95	1.11073
7/12/99 13:27	155.95	1.09846		7/22/99 18:37	167.95	1.11166
7/12/99 13:30	143.95	1.09982		7/22/99 18:40	155.95	1.11165
7/12/99 13:33	131.95	1.09901		7/22/99 18:43	143.95	1.11143
7/12/99 13:36	119.95	1.09706		7/22/99 18:46	131.95	1.10826
7/12/99 13:39	107.95	1.09487		7/22/99 18:49	119.95	1.10435
7/12/99 13:42	95.95	1.09249		7/22/99 18:53	107.95	1.10313
7/12/99 13:45	83.95	1.0959		7/22/99 18:56	95.95	1.10424
7/12/99 13:48	71.95	1.09599		7/22/99 18:59	83.95	1.10445
7/12/99 13:51	59.95	1.09722		7/22/99 19:02	71.95	1.1083
				7/22/99 19:05	59.95	1.11372
SEDIMENT LEVEL				**SEDIMENT LEVEL**		
7/12/99 13:14	46.66			7/22/99 18:23	48.86	
Batch 3.1.2						
Date/Time	**Elevation (inch)**	**Density (g/cm^3)**		**Date/Time**	**Elevation (inch)**	**Density (g/cm^3)**
8/2/99 14:04	178.98	1.11525		8/5/99 9:11	172.72	1.11921
8/2/99 14:07	166.98	1.11897		**SEDIMENT LEVEL**		
8/2/99 14:10	154.98	1.11861		8/5/99 9:00	51.34	
8/2/99 14:13	142.98	1.12044				
8/2/99 14:16	130.98	1.1189				
8/2/99 14:19	118.98	1.11844				
8/2/99 14:22	106.98	1.11626				
8/2/99 14:25	94.98	1.11489				
8/2/99 14:28	82.98	1.11299				
8/2/99 14:31	70.98	1.11421				
8/2/99 14:34	58.98	1.11092				
SEDIMENT LEVEL						
8/2/99 13:12	51.4					

Table 4-5. WRSS ENRAF™ Densitometer Density Profiles (10 sheets)

Batch 3.1.3						
Date/Time	**Elevation (inch)**	**Density (g/cm^3)**		**Date/Time**	**Elevation (inch)**	**Density (g/cm^3)**
8/13/99 13:01	179.95	1.12188		8/20/99 19:19	191.95	1.1222
8/13/99 13:04	167.95	1.12206		8/20/99 19:22	179.95	1.12154
8/13/99 13:07	155.95	1.12275		8/20/99 19:25	167.95	1.12135
8/13/99 13:10	143.95	1.12251		8/20/99 19:28	155.95	1.1221
8/13/99 13:14	131.95	1.12059		8/20/99 19:31	143.95	1.12473
8/13/99 13:17	119.95	1.11801		8/20/99 19:34	131.95	1.12351
8/13/99 13:20	107.95	1.11718		8/20/99 19:37	119.95	1.12125
8/13/99 13:23	95.95	1.11659		8/20/99 19:40	107.95	1.12092
8/13/99 13:26	83.95	1.11483		8/20/99 19:43	95.95	1.12161
8/13/99 13:29	71.95	1.11753		8/20/99 19:46	83.95	1.12043
8/13/99 13:32	59.95	1.11786		8/20/99 19:49	71.95	1.12272
				8/20/99 19:52	59.95	1.12406
SEDIMENT LEVEL				**SEDIMENT LEVEL**		
8/13/99 12:55	50.98			8/20/99 19:12	51.37	

Batch 3.2.1						
Date/Time	**Elevation (inch)**	**Density (g/cm^3)**		**Date/Time**	**Elevation (inch)**	**Density (g/cm^3)**
8/30/99 10:18	191.95	1.10888		9/11/99 9:42	192.02	1.1127
8/30/99 10:21	179.95	1.11006		9/11/99 9:45	179.95	1.11427
8/30/99 10:24	167.95	1.11188		9/11/99 9:48	167.95	1.1156
8/30/99 10:27	155.95	1.11339		9/11/99 9:51	155.95	1.11741
8/30/99 10:30	143.95	1.11348		9/11/99 9:54	143.95	1.11766
8/30/99 10:33	131.95	1.11181		9/11/99 9:57	131.95	1.11507
8/30/99 10:36	119.95	1.10816		9/11/99 10:00	119.95	1.11163
8/30/99 10:39	107.95	1.10612		9/11/99 10:04	107.95	1.10948
8/30/99 10:42	95.95	1.10453		9/11/99 10:07	95.95	1.1085
8/30/99 10:45	83.95	1.10898		9/11/99 10:10	83.95	1.11186
8/30/99 10:48	71.95	1.11201		9/11/99 10:13	71.95	1.11418
8/30/99 10:51	59.95	1.11475		9/11/99 10:16	59.95	1.17498
SEDIMENT LEVEL				**SEDIMENT LEVEL**		
8/30/99 10:10	52.88			9/11/99 9:34	53.88	

Table 4-5. WRSS ENRAF™ Densitometer Density Profiles (10 sheets)

Batch 3.2.2					
Date/Time	**Elevation (inch)**	**Density (g/cm^3)**	**Date/Time**	**Elevation (inch)**	**Density (g/cm^3)**
9/12/99 11:08	191.98	1.11458	9/15/99 3:19	188.32	1.10624
9/12/99 11:11	179.95	1.11594	9/15/99 3:22	176.32	1.10539
9/12/99 11:14	167.95	1.11668	9/15/99 3:25	164.32	1.10666
9/12/99 11:17	155.95	1.11812	9/15/99 3:28	152.32	1.11324
9/12/99 11:20	143.95	1.11894	9/15/99 3:31	140.32	1.11553
9/12/99 11:23	131.95	1.11586	9/15/99 3:34	128.32	1.1217
9/12/99 11:26	119.95	1.11303	9/15/99 3:37	116.32	1.12233
9/12/99 11:29	107.95	1.11147	9/15/99 3:40	104.32	1.1225
9/12/99 11:32	95.95	1.11133	9/15/99 3:43	92.32	1.11999
9/12/99 11:35	83.95	1.11005	9/15/99 3:46	80.32	1.11809
9/12/99 11:38	71.95	1.11263	9/15/99 3:49	68.32	1.11573
SEDIMENT LEVEL			**SEDIMENT LEVEL**		
9/12/99 10:25	55.66		9/15/99 3:11	57.04	

Batch 3.2.3					
Date/Time	**Elevation (inch)**	**Density (g/cm^3)**	**Date/Time**	**Elevation (inch)**	**Density (g/cm^3)**
9/12/99 11:08	191.98	1.11458	9/17/99 2:03	204.04	1.11242
9/12/99 11:11	179.95	1.11594	9/17/99 2:06	191.95	1.11539
9/12/99 11:14	167.95	1.11668	9/17/99 2:09	179.95	1.12382
9/12/99 11:17	155.95	1.11812	9/17/99 2:12	167.95	1.12596
9/12/99 11:20	143.95	1.11894	9/17/99 2:15	155.95	1.12814
9/12/99 11:23	131.95	1.11586	9/17/99 2:18	143.95	1.12852
9/12/99 11:26	119.95	1.11303	9/17/99 2:21	131.95	1.12671
9/12/99 11:29	107.95	1.11147	9/17/99 2:24	119.95	1.12465
9/12/99 11:32	95.95	1.11133	9/17/99 2:27	107.95	1.12189
9/12/99 11:35	83.95	1.11005	9/17/99 2:30	95.95	1.12021
9/12/99 11:38	71.95	1.11263	9/17/99 2:33	83.95	1.12377
			9/17/99 2:36	71.95	1.12584
SEDIMENT LEVEL			**SEDIMENT LEVEL**		
9/12/99 10:25	55.66		9/17/99 1:56	60.97	

Table 4-5. WRSS ENRAF™ Densitometer Density Profiles (10 sheets)

Batch 3.2.4						
Date/Time	**Elevation (inch)**	**Density (g/cm^3)**		**Date/Time**	**Elevation (inch)**	**Density (g/cm^3)**
9/19/99 9:47	203.99	1.1127		9/22/99 1:04	203.96	1.11351
9/19/99 9:50	191.95	1.11533		9/22/99 1:07	191.95	1.11666
9/19/99 9:53	179.95	1.11527		9/22/99 1:10	179.95	1.11764
9/19/99 9:56	167.95	1.11871		9/22/99 1:13	167.95	1.12244
9/19/99 9:59	155.95	1.11976		9/22/99 1:16	155.95	1.12484
9/19/99 10:02	143.95	1.11968		9/22/99 1:19	143.95	1.12389
9/19/99 10:05	131.95	1.12006		9/22/99 1:22	131.95	1.12336
9/19/99 10:08	119.95	1.11568		9/22/99 1:25	119.95	1.12098
9/19/99 10:11	107.95	1.1136		9/22/99 1:28	107.95	1.11816
9/19/99 10:14	95.95	1.11263		9/22/99 1:31	95.95	1.11677
9/19/99 10:17	83.95	1.11524		9/22/99 1:34	83.95	1.12034
9/19/99 10:20	71.95	1.11795		9/22/99 1:37	71.95	1.12301
SEDIMENT LEVEL				**SEDIMENT LEVEL**		
9/19/99 9:00	64.72			9/22/99 0:57	64.56	

Batch 3.2.5						
Date/Time	**Elevation (inch)**	**Density (g/cm^3)**		**Date/Time**	**Elevation (inch)**	**Density (g/cm^3)**
9/24/99 9:24	203.96	1.11388		9/25/99 1:45	203.95	1.11584
9/24/99 9:27	191.95	1.11667		9/25/99 1:48	191.95	1.11799
9/24/99 9:30	179.95	1.11643		9/25/99 1:51	179.95	1.11789
9/24/99 9:34	167.95	1.11879		9/25/99 1:54	167.95	1.12075
9/24/99 9:37	155.95	1.12121		9/25/99 1:57	155.95	1.12275
9/24/99 9:40	143.95	1.12108		9/25/99 2:00	143.95	1.12444
9/24/99 9:43	131.95	1.12028		9/25/99 2:03	131.95	1.12382
9/24/99 9:46	119.95	1.11724		9/25/99 2:06	119.95	1.12035
9/24/99 9:49	107.95	1.11465		9/25/99 2:09	107.95	1.11807
9/24/99 9:52	95.95	1.11315		9/25/99 2:12	95.95	1.11727
9/24/99 9:55	83.95	1.11696		9/25/99 2:15	83.95	1.12109
9/24/99 9:58	71.95	1.11925		9/25/99 2:18	71.95	1.12368
9/24/99 10:01	67.77	1.1194		9/25/99 2:21	68.65	1.1584
SEDIMENT LEVEL				**SEDIMENT LEVEL**		
9/24/99 9:13	65.82			9/25/99 1:37	66.69	

Table 4-5. WRSS ENRAF™ Densitometer Density Profiles (10 sheets)

Batch 3.2.6						
Date/Time	**Elevation (inch)**	**Density (g/cm^3)**		**Date/Time**	**Elevation (inch)**	**Density (g/cm^3)**
9/25/99 9:36	203.95	1.11364		9/27/99 1:04	204.12	1.11351
9/25/99 9:39	191.95	1.11651		9/27/99 1:07	191.95	1.11589
9/25/99 9:42	179.95	1.11714		9/27/99 1:10	179.95	1.11585
9/25/99 9:45	167.95	1.11938		9/27/99 1:13	167.95	1.11862
9/25/99 9:48	155.95	1.12119		9/27/99 1:16	155.95	1.12038
9/25/99 9:51	143.95	1.12099		9/27/99 1:19	143.95	1.12154
9/25/99 9:54	131.95	1.11872		9/27/99 1:22	131.95	1.11986
9/25/99 9:57	119.95	1.1162		9/27/99 1:25	119.95	1.11691
9/25/99 10:00	107.95	1.11393		9/27/99 1:28	107.95	1.11435
9/25/99 10:03	95.95	1.11254		9/27/99 1:31	95.95	1.11306
9/25/99 10:06	83.95	1.11613		9/27/99 1:34	83.95	1.11814
9/25/99 10:09	71.95	1.11875		9/27/99 1:37	71.95	1.12099
9/25/99 10:12	69.09	1.16891		9/27/99 1:40	69.62	1.13117
SEDIMENT LEVEL				**SEDIMENT LEVEL**		
9/25/99 8:46	67.12			9/27/99 0:57	67.67	

Batch 3.2.7						
Date/Time	**Elevation (inch)**	**Density (g/cm^3)**		**Date/Time**	**Elevation (inch)**	**Density (g/cm^3)**
9/27/99 10:23	203.95	1.11457		9/29/99 0:50	203.95	1.11394
9/27/99 10:26	191.95	1.11681		9/29/99 0:53	191.95	1.11613
9/27/99 10:29	179.95	1.11705		9/29/99 0:56	179.95	1.11653
9/27/99 10:33	167.95	1.11952		9/29/99 0:59	167.95	1.11932
9/27/99 10:36	155.95	1.12124		9/29/99 1:02	155.95	1.12112
9/27/99 10:39	143.95	1.12196		9/29/99 1:05	143.95	1.12206
9/27/99 10:42	131.95	1.11964		9/29/99 1:08	131.95	1.12087
9/27/99 10:45	119.95	1.11629		9/29/99 1:11	119.95	1.11813
9/27/99 10:48	107.95	1.11428		9/29/99 1:14	107.95	1.11602
9/27/99 10:51	95.95	1.11315		9/29/99 1:18	95.95	1.1144
9/27/99 10:54	83.95	1.11695		9/29/99 1:21	83.95	1.11883
9/27/99 10:57	71.95	1.12007		9/29/99 1:24	71.95	1.12144
9/27/99 11:00	70.16	1.11607		9/29/99 1:26	70.21	1.12296
SEDIMENT LEVEL				**SEDIMENT LEVEL**		
9/27/99 9:33	68.21			9/29/99 0:42	68.26	

Table 4-5. WRSS ENRAF™ Densitometer Density Profiles (10 sheets)

Batch 3.2.8						
Date/Time	**Elevation (inch)**	**Density (g/cm^3)**		**Date/Time**	**Elevation (inch)**	**Density (g/cm^3)**
9/29/99 9:45	203.95	1.11465		10/1/99 0:42	216.1	1.11252
9/29/99 9:48	191.95	1.11704		10/1/99 0:45	203.95	1.11375
9/29/99 9:51	179.95	1.11823		10/1/99 0:48	191.95	1.117
9/29/99 9:54	167.95	1.12009		10/1/99 0:51	179.95	1.11725
9/29/99 9:57	155.95	1.12215		10/1/99 0:54	167.95	1.1197
9/29/99 10:00	143.95	1.12246		10/1/99 0:57	155.95	1.12173
9/29/99 10:03	131.95	1.12004		10/1/99 1:00	143.95	1.12224
9/29/99 10:06	119.95	1.11781		10/1/99 1:03	131.95	1.12046
9/29/99 10:09	107.95	1.1151		10/1/99 1:06	119.95	1.1171
9/29/99 10:12	95.95	1.11377		10/1/99 1:09	107.95	1.11495
9/29/99 10:15	83.95	1.11815		10/1/99 1:12	95.95	1.1133
9/29/99 10:18	71.95	1.12073		10/1/99 1:15	83.95	1.11757
9/29/99 10:21	70.66	1.13319		**SEDIMENT LEVEL**		
SEDIMENT LEVEL				10/1/99 0:34	69.37	
9/29/99 8:54	68.7					

Batch 3.2.9						
Date/Time	**Elevation (inch)**	**Density (g/cm^3)**		**Date/Time**	**Elevation (inch)**	**Density (g/cm^3)**
10/4/99 12:35	216.11	1.11431		10/7/99 1:06	215.95	1.11348
10/4/99 12:38	203.95	1.1151		10/7/99 1:09	203.95	1.1142
10/4/99 12:41	191.95	1.11821		10/7/99 1:12	191.95	1.11773
10/4/99 12:45	179.95	1.11825		10/7/99 1:15	179.95	1.117
10/4/99 12:48	167.95	1.12051		10/7/99 1:18	167.95	1.11935
10/4/99 12:51	155.95	1.12172		10/7/99 1:21	155.95	1.12115
10/4/99 12:54	143.95	1.12165		10/7/99 1:24	143.95	1.12116
10/4/99 12:57	131.95	1.11966		10/7/99 1:27	131.95	1.11903
10/4/99 13:00	119.95	1.11714		10/7/99 1:30	119.95	1.11651
10/4/99 13:03	107.95	1.11545		10/7/99 1:33	107.95	1.1139
10/4/99 13:06	95.95	1.11414		10/7/99 1:36	95.95	1.1128
10/4/99 13:09	83.95	1.11696		10/7/99 1:39	83.95	1.1169
10/4/99 13:12	71.95	1.11959		10/7/99 1:42	71.95	1.11998
10/4/99 13:15	70.88	1.11702		10/7/99 1:45	70.68	1.10973
SEDIMENT LEVEL				**SEDIMENTLEVEL**		
10/4/99 9:54	68.92			10/7/99 0:59	68.72	

4.3 MASS TRANSFER BASED ON ENRAF™ DENSITOMETER - SEDIMENT LEVELS

The calculation of the volume of tank 241-C-106 solids which settle in tank 241-AY-102 is accomplished using the ENRAF™ densitometer and the calculational methods identified in HNF-SD-WM-PROC-021, Section 15.0, Rev. 3, sub-section 4.4.3. A summary of the settled solids volumes calculated for sluicing batches and/or increments is provided in Table 4-6. The solids settling behavior experienced during Increments 3.1and 3.2 are presented in Figures 4-1 and 4-2, respectively.

Three sediment level methods are discussed in general in HNF-SD-WM-PROC-021, Section 15.0, Rev. 3, sub-section 4.4.3. The equations developed for each of these methods are provided below.

METHOD 1: $L_{F(i)} = (L_{M(i)} - L_{I(i)})(L_{F(b)} / L_{M(b)})$

Where: $L_{F(i)}$ is the final compacted solids level increase associated with the batch i transfer
$L_{M(i)}$ is the maximum settled solids level associated with the batch i transfer
$L_{I(i)}$ is the initial solids level before the batch i transfer
$L_{F(b)}$ is the baseline final compacted solids level increase
$L_{M(b)}$ is the baseline maximum solids level increase

METHOD 2: $L_{F(i)} = (L_{M(i)} - L_{I(i)}) - (L_{FS(i)}(L_{TS(b)} / L_{FS(b)}))$

Where: $L_{F(i)}$ is the final compacted solids level increase associated with the batch i transfer
$L_{M(i)}$ is the maximum settled solids level associated with the batch i transfer
$L_{I(i)}$ is the initial solids level before the batch i transfer
$L_{FS(i)}$ is the batch i fast settling solids level decrease
$L_{TS(b)}$ is the baseline total settling solids level decrease
$L_{FS(b)}$ is the baseline fast settling solids level decrease

METHOD 3: $L_{F(i)} = (L_{M(i)} - L_{I(i)}) - (L_{MedS(i)}(L_{TS(b)} / L_{MedS(b)}))$

Where: $L_{F(i)}$ is the final compacted solids level increase associated with the batch i transfer
$L_{M(i)}$ is the maximum settled solids level associated with the batch i transfer
$L_{I(i)}$ is the initial solids level before the batch i transfer
$L_{MedS(i)}$ is the batch i medium settling solids level decrease
$L_{TS(b)}$ is the baseline total settling solids level decrease
$L_{MedS(b)}$ is the baseline medium settling solids level decrease

A baseline comparison ratio is used to determine the applicability of methods 2 and 3 for a batch. This ratio is simply a comparison of the ratio of the initial solids level increase to the fast or medium settling rate solids level decrease of a batch or increment with the equivalent ratio for the baseline batch (i.e. sluice batch 1.1.1). If the ratio for a method differs significantly from 1, then that method is not used in the sediment level calculations. Table 4-6 includes the baseline comparison ratios for methods 2 and 3, where applicable.

The ENRAF™ densitometer-sediment level method only accounts for the fraction of sludge removed from tank 241-C-106 that is insoluble and forms the settled solids layer in tank 241-AY-102. The amount of dissolved solids determined in Section 4.4 must be considered together with the sediment level results to arrive at the total volume of sludge transferred.

Bailey 1999 and Allen 1999b provided documentation of the detailed ENRAF™ densitometer sediment level data through sluice batch 3.1.1. Although Table 4-6 summarized the data for all of the sluice batches, only supporting data for the batches making up Increments 3.1 and 3.2 are included in Figures 4-1 and 4-2, respectively.

The solids settling behavior experienced in sluicing operations changed from sluice batches 3.1.2 and beyond. The lack of both fast and medium settling periods during these batches precluded the use of Methods 2 and 3. Consequently, only Method 1 could be applied as reflected in Table 4-6.

In sluicing batch 3.1.2 and beyond the solids settling time was reduced by a factor of approximately two during these batches when compared to the initial sluicing operations. This increased settling rate occurred despite the fact that the liquid density had increased. The increased liquid density would have produced slower settling rates if all other factors had remained constant. From the rapid settling experienced, it can be concluded that either the particle size and/or particulate density had increased during this period.

One possible explanation for the change in solids settling behavior is that the sluicing operations initially preferentially removed the lighter/smaller particulate material which was the easiest to mobilize and maintain in suspension. As a result, the final WRSS operations encountered wastes that contained mainly the larger/denser solids which were more difficult to mobilize for transport to tank 241-AY-102.

Table 4-6. WRSS Settled Solids Volume Calculation Summary (2 sheets)

Date	Batch	Settled Solids Calc. Method	Initial Solids Level	Max. Solids Level	Fast Settling Solids Level	Medium Settling Solids Level	Level Change Ratio - Baseline (Current)	Base-line Compar-ison Ratio	Solids Level Increase Calculated By Method	Final Solids Level Increase (Average of viable Methods)	Comments
11/18/98	1.1.1	1	9.11	12.9	12.47	12.2	N/A	N/A	2.82	2.82	Calculation documented in HNF-4379
12/16/98	1.1.2 Phase I	1	See comments	See comments	See comments	See comments	N/A	N/A	Included above	Included above	Calculation documented in HNF-4379
3/7/99	1.1.3 Phase II	1	See comments	See comments	See comments	See comments	N/A	N/A	4.79	4.79	Calculation documented in HNF-4379
3/28/99	1.2.1 PhaseIII	1	See comments	See comments	See comments	See comments	N/A	N/A	6.61	6.61	Calculation documented in HNF-4379
4/23/99	2.1.1	N/A	25.88	N/A	N/A	N/A	N/A	N/A	See comments	See comments	Included in Batch 2.1.2 below
4/30/99	2.1.2	1	25.88	37.59	36.38	36.18	N/A	N/A	8.71	8.85	
		2	25.88	37.59	36.38	36.18	8.81	0.91	8.98	--	
			--	--	--	--	9.68	--	--	--	
		3	25.88	37.59	36.38	36.18	5.41	0.65	--	--	Not used - poor comparison ratio
			--	--.	--	--	8.30	--	--	--	
5/24/99	2.2.1	1	35.12	39.26	38.69	N/A	N/A	N/A	3.08	12.20	Final value = (3.08+9.21+12.12)/2
		2	35.12	39.26	38.69	N/A	8.81	1.21	--	--	Not used - poor comparison ratio
			--	--	--	--	7.26	--	--	--	
		3	35.12	39.26	38.69	N/A	N/A	N/A	--	--	Not used - poor comparison ratio
6/3/99	2.2.2	1	38.69	51.07	49.94	48.18	N/A	N/A	9.21		
		2	38.69	51.07	49.94	48.18	8.81	0.80	--	--	Not used - poor comparison ratio
			--	--	--	--	10.96	--	--	--	
		3	38.69	51.07	49.94	48.18	5.41	1.26	--	--	Not used - poor comparison ratio
			--	--	--	--	4.28	--	--	--	
	2.2	2	35.12	51.07	49.37	N/R	8.81	0.94	12.12		Method 2 calculated against entire Increment 2.2 due to improved comparison ratio.
7/21/99 & 7/22/99	3.1.1	1	46.66	51.8	N/A	51.25	N/A	N/A	3.82	3.82	
		2	46.66	51.8	N/A	51.25	N/A	N/A	N/A	--	Not used - lack of data
		3	46.66	51.8	N/A	51.25	5.41	0.58	--	--	Not used - poor comparison ratio
			--	--	--	--	9.35	--	--		--

Table 4-6. WRSS Settled Solids Volume Calculation Summary (2 sheets)

Date	Batch	Settled Solids Calc. Method	Initial Solids Level	Max. Solids Level	Fast Settling Solids Level	Medium Settling Solids Level	Level Change Ratio - Baseline (Current)	Base-line Compar-ison Ratio	Solids Level Increase Calculated By Method	Final Solids Level Increase (Average of viable Methods)	Comments
8/4/99	3.1.2	1	51.25	51.34	N/A	N/A	N/A	N/A	0.07	0.07	Data to support the use of Methods 2 and 3 is not available
8/20/99	3.1.3	1	50.98	53.34	N/A	N/A	N/A	N/A	1.76	1.76	Same comment as above
9/10/99	3.2.1	1	52.7	57.04	N/A	N/A	N/A	N/A	3.23	3.23	Same comment as above
9/14/99	3.2.2	1	57.04	N/A	N/A	N/A	N/A	N/A	Included below	Included below	Same comment as above
9/16/99	3.2.3	1	57.04	64.72	N/A	N/A	N/A	N/A	5.71	5.71	Same comment as above
9/21/99	3.2.4	1	64.31	65.82	N/A	N/A	N/A	N/A	1.12	1.12	Same comment as above
9/24/99	3.2.5	1	N/A	N/A	N/A	N/A	N/A	N/A	Included below	Included below	Same comment as above
9/26/99	3.2.6	1	65.82	68.26	N/A	N/A	N/A	N/A	1.82	1.82	Same comment as above
9/28/99	3.2.7	1	68.21	68.7	N/A	N/A	N/A	N/A	0.36	0.36	Same comment as above
9/30/99	3.2.8	1	68.7	69.37	N/A	N/A	N/A	N/A	0.50	0.5	Same comment as above
10/6/99	3.2.9	1	68.72	68.83	N/A	N/A	N/A	N/A	0.08	0.08	Same comment as above

Figure 4-1. Increment 3.1 Settled Solids Data

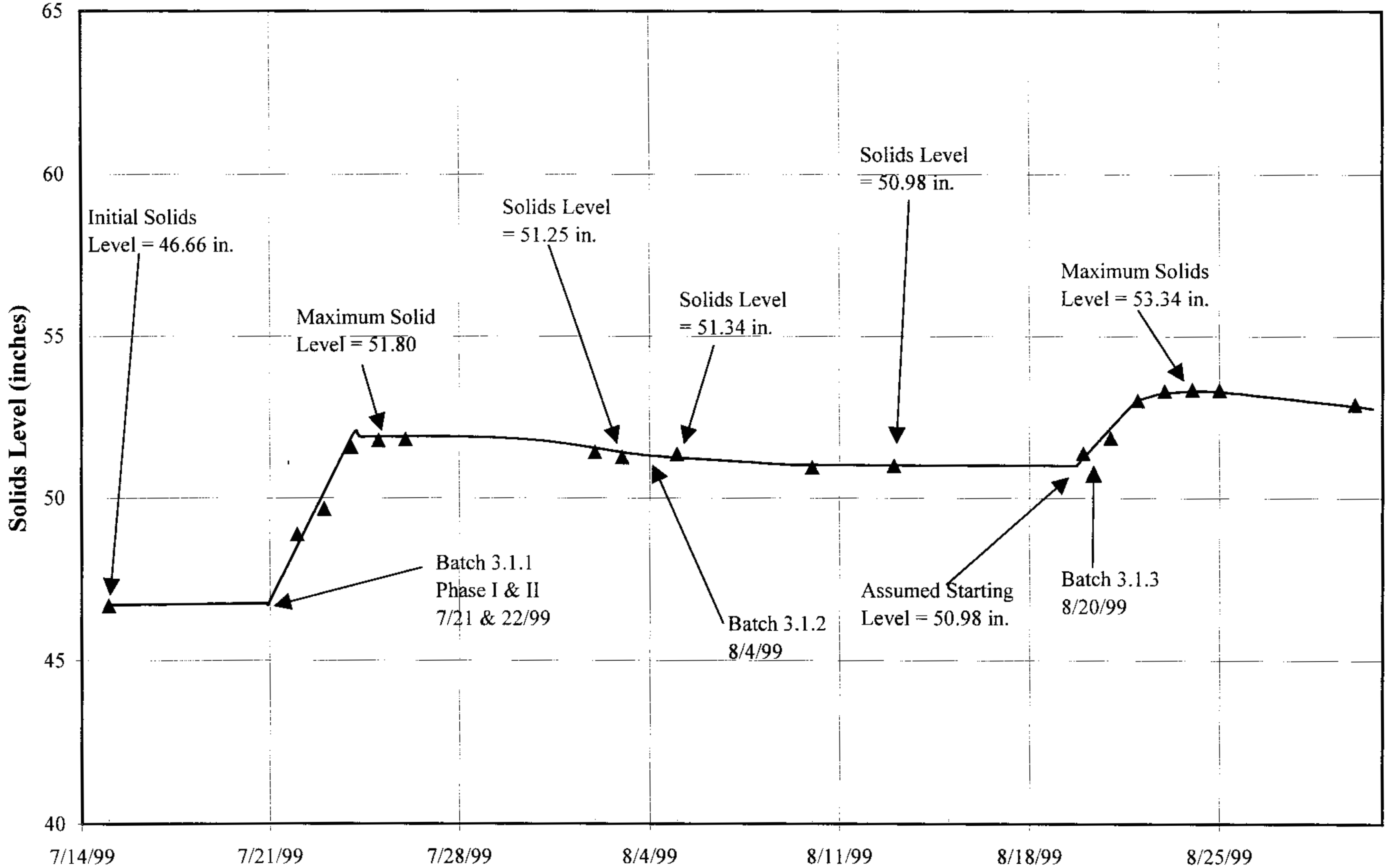
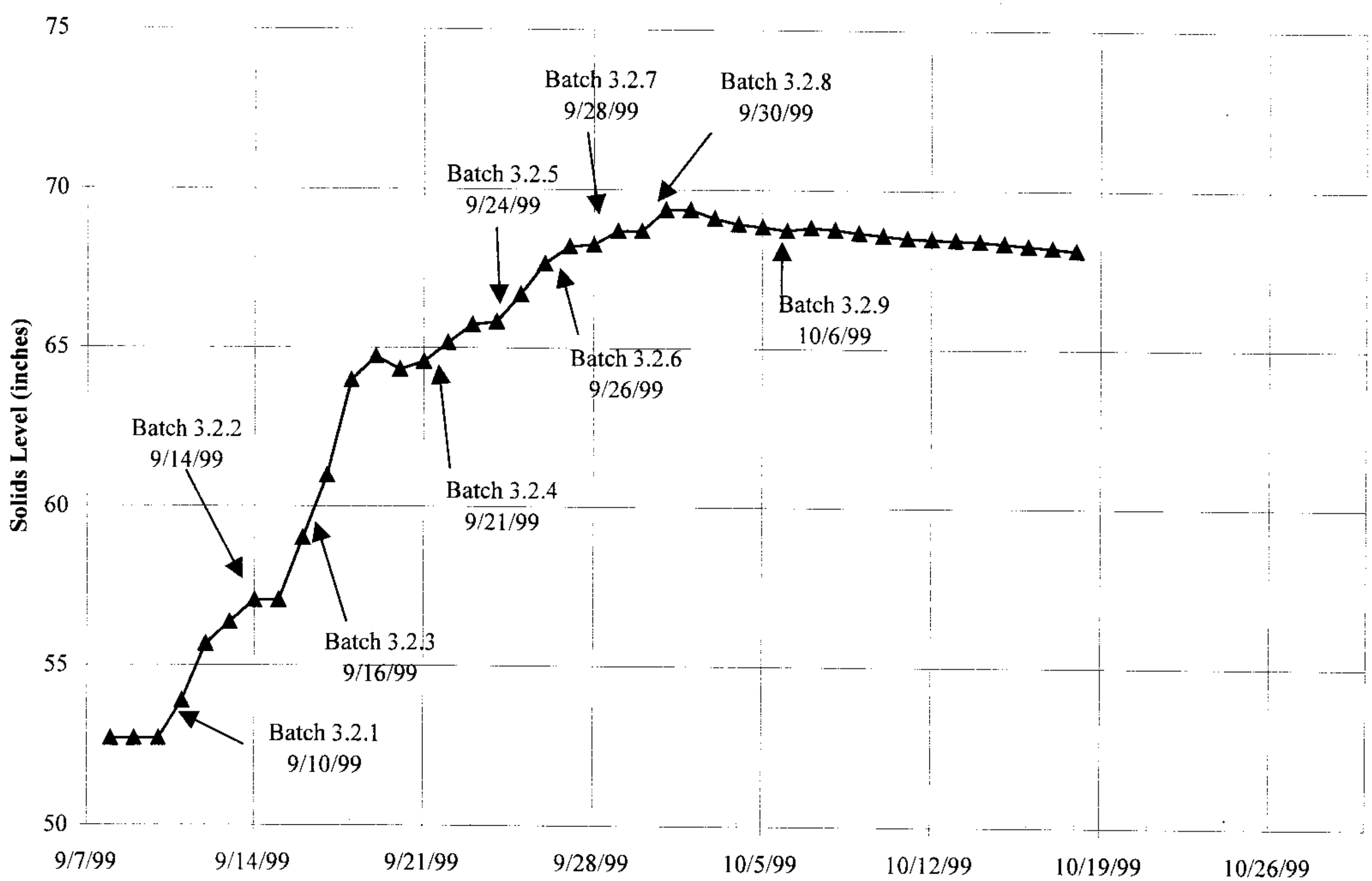


Figure 4-2. Increment 3.2 Settled Solids Data



4.4 MASS TRANSFER BASED ON DISSOLVED SOLIDS

During tank 241-C-106 sluicing operations, some dissolution of the soluble sludge constituents occurs when contacted by the dilute, alkaline sluice stream from tank 241-AY-102. The quantity of sludge that dissolves is calculated following the method documented in HNF-SD-WM-PROC-021, Section 15.0, Rev. 3, sub-section 4.4.4, "Solids Mass Transfer Based on Dissolved Solids." Table 4-7 summarizes the dissolved solids results for each batch through sluice batch 3.2.9, completed on October 6, 1999. The formulas used in the calculation are shown in Table 4-8. Solids dissolution equivalent to approximately 11.1 in. of tank 241-C-106 sludge has occurred through completion of sluice batch 3.2.9.

The data used for calculating dissolved solids includes the measured tank 241-AY-102 liquid level and sediment level at the time of the maximum sediment level for a batch. Additionally, the tank 241-AY-102 supernatant density following each batch is obtained from either grab sample results when available or ENRAF™ densitometer density profiles. The last parameter, predicted tank 241-AY-102 supernatant density, is obtained from a spreadsheet model assuming only simple mixing occurs when the two wastes are combined. The calculations for this spreadsheet are included as Table 4-9.

The negative solids dissolution value for batch 1.1.1 is an artifact of the simple mixing model. At the start of sluicing operations, the density of the supernatant in tank 241-C-106 is substantially higher than the supernatant in tank 241-AY-102 (1.17 g/mL versus 1.024 g/mL, respectively). However, one assumption in the model is that the sluicing process results in ideal mixing of the liquid phases and that the initial supernatant pools from both tanks are fully mixed during the first batch. Not enough waste is transferred between the two tanks during the first batch for the supernatants to become fully mixed. This results in an actual supernatant density lower than that predicted and, consequently, the negative dissolved solids result.

The volume of tank 241-C-106 sludge transferred resulting from solids dissolution is combined with the sediment level increase data of Section 4.3 to arrive at an estimate of the total volume of sludge transferred.

Table 4-7. WRSS Dissolved Solids Volume Summary

Date	Batch	AY-102 Liquid Level (in.)	AY-102 Sediment Level[1] (in.)	AY-102 Supernatant Density[2] (g/mL)	Predicted Supernatant Density (g/mL)	Dissolved Sludge Volume (in.)
11/18/98	1.1.1	169.73	11.9	1.032	1.0356	-0.94
12/16/98	1.1.2 (Phase I)	169.83	11.28	1.056	1.0363	5.09
3/7/99	1.1.3 (Phase II)	170.55	19.16	1.063	1.0423	5.20
3/28/99	1.2.1 (Phase III)	170.7	28.45	1.091	1.0521	9.42
4/23/99	2.1.1	178.85	27.45	1.099	1.0525	11.92
4/28/99 & 4/30/99	2.1.2	185.19	36.59	1.101	1.0556	11.69
5/24/99	2.2.1	187.59	38.69	1.0968	1.0573	10.23
6/3/99	2.2.2	199.92	51.07	1.0858	1.0643	5.74
7/21/99 & 7/22/99	3.1.1	200.17	51.8	1.1056	1.0704	9.40
8/4/99	3.1.2	196.77	51.34	1.1061	1.0676	10.07
8/20/99	3.1.3	207.58	53.34	1.1057	1.0685	10.31
9/10/99	3.2.1	210.26	55.66	1.1099	1.0696	11.25
9/14/99	3.2.2	212.36	57.04	1.1102	1.0705	11.17
9/16/99	3.2.3	215.27	64.72	1.1118	1.0726	10.91
9/21/99	3.2.4	215.94	65.82	1.1126	1.0737	10.83
9/24/99	3.2.5	220.02	67.12	1.1123	1.0744	10.75
9/26/99	3.2.6	220.95	68.21	1.1127	1.0749	10.74
9/28/99	3.2.7	218.98	68.7	1.1137	1.075	10.85
9/30/99	3.2.8	226.21	69.37	1.1129	1.0752	10.99
10/6/99	3.2.9	224.07	68.83	1.1137	1.0752	11.11

1. Sediment level maximum value for batch
2. Supernatant density from grab samples except for batches 1.1.2, 2.1.1, 2.2.1, 3.1.1, 3.1.2, 3.2.1 through 3.2.8, which use ENRAF™ densitometer profiles or a combination of profiles and grab samples.

Table 4-8. Calculation Formulas for WRSS Dissolved Solids Volume Summary (2 sheets)

Date	Batch	AY-102 Liquid Level (in.)	AY-102 Sediment Level[1] (in.)	AY-102 Supernatant Density[2] (g/mL)	Predicted Supernatant Density (g/mL)	Dissolved Sludge Volume (in.)
11/18/99	1.1.1	169.73	11.9	1.032	1.0356	=((C4-D4)+0.5*(1.55*47.2)/(1.1958*78.6)*(D4-9))*(E4-F4)*(1/453.6)*(1000/1)*(3.7856/1)*(2750/1)*(1/14200)
12/16/98	1.1.2 (Phase I)	169.83	11.28	1.056	1.0363	=((C5-D5)+0.5*(1.55*47.2)/(1.1958*78.6)*(D5-9))*(E5-F5)*(1/453.6)*(1000/1)*(3.7856/1)*(2750/1)*(1/14200)
3/7/99	1.1.3 (Phase II)	170.55	19.16	1.063	1.0423	=((C6-D6)+0.5*(1.55*47.2)/(1.1958*78.6)*(D6-9))*(E6-F6)*(1/453.6)*(1000/1)*(3.7856/1)*(2750/1)*(1/14200)
3/28/99	1.2.1 (Phase III)	170.7	28.45	1.091	1.0521	=((C7-D7)+0.5*(1.55*47.2)/(1.1958*78.6)*(D7-9))*(E7-F7)*(1/453.6)*(1000/1)*(3.7856/1)*(2750/1)*(1/14200)
4/23/99	2.1.1	178.85	27.45	1.099	1.0525	=((C8-D8)+0.5*(1.55*47.2)/(1.1958*78.6)*(D8-9))*(E8-F8)*(1/453.6)*(1000/1)*(3.7856/1)*(2750/1)*(1/14200)
4/28/99 & 4/30/99	2.1.2	185.19	36.59	1.101	1.0556	=((C9-D9)+0.5*(1.55*47.2)/(1.1958*78.6)*(D9-9))*(E9-F9)*(1/453.6)*(1000/1)*(3.7856/1)*(2750/1)*(1/14200)
5/24/99	2.2.1	187.59	38.69	1.0968	1.0573	=((C10-D10)+0.5*(1.55*47.2)/(1.1958*78.6)*(D10-9))*(E10-F10)*(1/453.6)*(1000/1)*(3.7856/1)*(2750/1)*(1/14200)
6/3/99	2.2.2	199.92	51.07	1.0858	1.0643	=((C11-D11)+0.5*(1.55*47.2)/(1.1958*78.6)*(D11-9))*(E11-F11)*(1/453.6)*(1000/1)*(3.7856/1)*(2750/1)*(1/14200)
7/21/99 & 7/22/99	3.1.1	200.17	51.8	1.1056	1.0704	=((C12-D12)+0.5*(1.55*47.2)/(1.1958*78.6)*(D12-9))*(E12-F12)*(1/453.6)*(1000/1)*(3.7856/1)*(2750/1)*(1/14200)
8/4/99	3.1.2	196.77	51.34	1.1061	1.0676	=((C13-D13)+0.5*(1.55*47.2)/(1.1958*78.6)*(D13-9))*(E13-F13)*(1/453.6)*(1000/1)*(3.7856/1)*(2750/1)*(1/14200)
8/20/99	3.1.3	207.58	53.34	1.1057	1.0685	=((C14-D14)+0.5*(1.55*47.2)/(1.1958*78.6)*(D14-9))*(E14-F14)*(1/453.6)*(1000/1)*(3.7856/1)*(2750/1)*(1/14200)
9/10/99	3.2.1	210.26	55.66	1.1099	1.0696	=((C15-D15)+0.5*(1.55*47.2)/(1.1958*78.6)*(D15-9))*(E15-F15)*(1/453.6)*(1000/1)*(3.7856/1)*(2750/1)*(1/14200)
9/14/99	3.2.2	212.36	57.04	1.1102	1.0705	=((C16-D16)+0.5*(1.55*47.2)/(1.1958*78.6)*(D16-9))*(E16-F16)*(1/453.6)*(1000/1)*(3.7856/1)*(2750/1)*(1/14200)

Table 4-8. Calculation Formulas for WRSS Dissolved Solids Volume Summary (2 sheets)

Date	Batch	AY-102 Liquid Level (in.)	AY-102 Sediment Level[1] (in.)	AY-102 Supernatant Density[2] (g/mL)	Predicted Supernatant Density (g/mL)	Dissolved Sludge Volume (in.)
9/16/99	3.2.3	215.27	64.72	1.1118	1.0726	=((C17-D17)+0.5*(1.55*47.2)/(1.1958*78.6)*(D17-9))*(E17-F17)*(1/453.6)*(1000/1)*(3.7856/1)*(2750/1)*(1/14200)
9/21/99	3.2.4	215.94	65.82	1.1126	1.0737	=((C18-D18)+0.5*(1.55*47.2)/(1.1958*78.6)*(D18-9))*(E18-F18)*(1/453.6)*(1000/1)*(3.7856/1)*(2750/1)*(1/14200)
9/24/99	3.2.5	220.02	67.12	1.1123	1.0744	=((C19-D19)+0.5*(1.55*47.2)/(1.1958*78.6)*(D19-9))*(E19-F19)*(1/453.6)*(1000/1)*(3.7856/1)*(2750/1)*(1/14200)
9/26/99	3.2.6	220.95	68.21	1.1127	1.0749	=((C20-D20)+0.5*(1.55*47.2)/(1.1958*78.6)*(D20-9))*(E20-F20)*(1/453.6)*(1000/1)*(3.7856/1)*(2750/1)*(1/14200)
9/28/99	3.2.7	218.97	68.7	1.1137	1.075	=((C21-D21)+0.5*(1.55*47.2)/(1.1958*78.6)*(D21-9))*(E21-F21)*(1/453.6)*(1000/1)*(3.7856/1)*(2750/1)*(1/14200)
9/30/99	3.2.8	226.21	69.37	1.1129	1.0752	=((C22-D22)+0.5*(1.55*47.2)/(1.1958*78.6)*(D22-9))*(E22-F22)*(1/453.6)*(1000/1)*(3.7856/1)*(2750/1)*(1/14200)
10/6/99	3.2.9	224.07	68.83	1.1137	1.0752	=((C23-D23)+0.5*(1.55*47.2)/(1.1958*78.6)*(D23-9))*(E23-F23)*(1/453.6)*(1000/1)*(3.7856/1)*(2750/1)*(1/14200)

1. Sediment level maximum value for batch
2. Supernatant density from grab samples except for batches 1.1.2, 2.1.1, 2.2.1, 3.1.1, 3.1.2, 3.2.1 through 3.2.8, which use ENRAFTM densitometer profiles or a combination of profiles and grab samples.

Table 4-9. Predicted Post-Batch 241-AY-102 Supernatant Density[1] (2 sheets)

241-AY-102 Pre-Sluicing Supernatant	1.02375
241-C-106 Waste Supernatant	1.17
241-C-106 Waste Interstitial Liquid	1.1958
Combined 2AY & 6C Supernates	=((B3*157.34)+(B4*11.25))/168.59
Combined 2AY & 6C Supernate + IL in 0.2408ft sludge (1.1.1)	=((B6*168.59)+(B5*9.3453*0.2408))/(168.59+9.3453*0.2408)
Combined 2AY & 6C Supernate + IL in 0.3108ft sludge (1.1.2)	=((B6*168.59)+(B5*9.3453*0.3108))/(168.59+9.3453*0.3108)
Combined 2AY & 6C Supernate + IL in 1.0341ft sludge (1.1.3)	=((B6*168.59)+(B5*9.3453*1.0341))/(168.59+9.3453*1.0341)
Combined 2AY & 6C Supernate + IL in 2.3331ft sludge (1.2.1)	=((B6*168.59)+(B5*9.3453*2.3331))/(168.59+9.3453*2.3331)
Combined 2AY & 6C Supernate + IL in 2.3898ft sludge (2.1.1)	=((B6*168.59)+(B5*9.3453*2.3898))/(168.59+9.3453*2.3898)
Combined 2AY & 6C Supernate + IL in 2.8431ft sludge (2.1.2)	=((B6*168.59)+(B5*9.3453*2.8431))/(168.59+9.3453*2.8431)
Combined 2AY & 6C Supernate + IL in 3.1064 ft sludge (2.2.1)	=((B6*168.59)+($B5*9.3453*3.1064))/(168.59+9.3453*3.1064)
Combined 2AY & 6C Supernate + IL in 4.2239 ft sludge (2.2.2)	=((B6*168.59)+(B5*9.3453*4.2239))/(168.59+9.3453*4.2239)
Caustic Addition	=((B6*168.59)+(B5*9.3453*4.2239)+(1*1.09+1.511*1.64))/(168.59+9.3453*4.2239+1.09+1.64)
Combined 2AY & 6C Supernate + IL in 4.7514 ft sludge (3.1.1)	=((B6*168.59)+(B5*9.3453*4.7514)+(1*1.09+1.511*1.64))/(168.59+9.3453*4.7514+1.09+1.64)
Combined 2AY & 6C Supernate + IL in 4.258 ft sludge (3.1.2)	=((B6*168.59)+(B5*9.3453*4.258)+(1*1.09+1.511*1.64))/(168.59+9.3453*4.258+1.09+1.64)
Combined 2AY & 6C Supernate + IL in 4.415 ft sludge (3.1.3)	=((B6*168.59)+(B5*9.3453*4.415)+(1*1.09+1.511*1.64))/(168.59+9.3453*4.415+1.09+1.64)
Combined 2AY & 6C Supernate + IL in 4.608 ft sludge (3.2.1)	=((B6*168.59)+(B5*9.3453*4.608)+(1*1.09+1.511*1.64))/(168.59+9.3453*4.608+1.09+1.64)
Combined 2AY & 6C Supernate + IL in 4.772 ft sludge (3.2.2)	=((B6*168.59)+(B5*9.3453*4.772)+(1*1.09+1.511*1.64))/(168.59+9.3453*4.772+1.09+1.64)
Combined 2AY & 6C Supernate + IL in 5.168 ft sludge (3.2.3)	=((B6*168.59)+(B5*9.3453*5.168)+(1*1.09+1.511*1.64))/(168.59+9.3453*5.168+1.09+1.64)
Combined 2AY & 6C Supernate + IL in 5.384 ft sludge (3.2.4)	=((B6*168.59)+(B5*9.3453*5.384)+(1*1.09+1.511*1.64))/(168.59+9.3453*5.384+1.09+1.64)
Combined 2AY & 6C Supernate + IL in 5.52 ft sludge (3.2.5)	=((B6*168.59)+(B5*9.3453*5.52)+(1*1.09+1.511*1.64))/(168.59+9.3453*5.52+1.09+1.64)
Combined 2AY & 6C Supernate + IL in 5.613 ft sludge (3.2.6)	=((B6*168.59)+(B5*9.3453*5.613)+(1*1.09+1.511*1.64))/(168.59+9.3453*5.613+1.09+1.64)
Combined 2AY & 6C Supernate + IL in 5.64 ft sludge (3.2.7)	=((B6*168.59)+(B5*9.3453*5.64)+(1*1.09+1.511*1.64))/(168.59+9.3453*5.64+1.09+1.64)

Table 4-9. Predicted Post-Batch 241-AY-102 Supernatant Density[1] (2 sheets)

Combined 2AY & 6C Supernate + IL in 5.664 ft sludge (3.2.8)	=((B6*168.59)+(B5*9.3453*5.664)+(1*1.09+1.511*1.64))/(168.59+9.3453*5.664+1.09+1.64)
Combined 2AY & 6C Supernate + IL in 5.671 ft sludge (3.2.9)	=((B6*168.59)+(B5*9.3453*5.671)+(1*1.09+1.511*1.64))/(168.59+9.3453*5.671+1.09+1.64)

1. Density Units in g/mL

5 .0 MASS TRANSFER RESULTS

Section 4.0 presented the results of calculation for the amount of sludge removed from tank 241-C-106 for each sluice batch using the four methods described in engineering procedure HNF-SD-WM-PROC-021, Section 15.0, Rev. 3, sub-section 4.4, "Calculation of Sludge Transferred." These results are evaluated and combined to obtain a best estimate of the volume of sludge removed from the tank through sluice batch 3.2.9 completed on October 6, 1999. The sludge volumes are presented in terms of equivalent tank inches with one inch representing 2750 gallons.

5.1 FINAL SLUDGE VOLUME REMOVED FROM TANK 241-C-106

A final mass transfer volume of 67.8 in. as of October 6, 1999 is given in Table 5-1. The amount of sludge transferred by September 30, 1999 is 67.6 inches. The final amount of sludge removed from tank 241-C-106 is determined by averaging the mass transfer determined from the mass flow meter with the mass transfer determined from the sediment/dissolved solids methods. Of the 197,000 gallons (71.6 inches) of sludge originally thought to be stored in the tank before the start of sluicing, removal of 67.8 inches represent approximately 95 percent of the initial volume. However, the initial volume of 197,000 gallons was found to be overstated by approximately 5,000 gallons which increases the sludge recovery to 97 percent (see Section 5.2).

The amount of sludge removed from tank 241-C-106 that is based on the mass flow meter shown in Table 5-1 is adjusted from the volumes given in Table 4-1 to account for the recycle of solids in the sluice stream during batches. The total when adjusted for six percent recycle reflects a mass transfer value of 70.7 inches through batch 3.2.9 which was completed on October 6, 1999. Of the 71.6 inch sludge volume thought to be stored in the tank at the start of sluicing, removal of 70.7 inches represents approximately 99 percent of initial volume.

Combining the sludge transferred based on the sediment level results with sludge transferred based on the dissolved solids results in an estimate of the total sludge removed from tank 241-C-106 equivalent to 64.9 inches through batch 3.2.9. This amount of sludge removed differs from that estimated from the mass flow meter by approximately nine percent. Of the original 71.6 inches of sludge stored in the tank, removal of 64.9 inches represents approximately 91 percent of the initial volume.

As was reported in Bailey 1999, the ENRAF™ densitometer profile method for determining the amount of sludge transferred was found to give inconclusive results. This conclusion was again confirmed following the removal of four feet of sludge (Allen 1999b). Consequently, the ENRAF™ densitometer profile method is not used in calculating the total sludge transferred.

5.2 EFFECT OF TANK SPECIFIC DIMENSIONS ON SLUDGE VOLUME REMAINING

The original volume of sludge stored in tank 241-C-106 was estimated to be approximately 197,000 gallons. This volume was based on a measured sludge level in the tank before the start of sluicing of approximately 67 inches above the zero reference elevation and a historically assumed volume of the tank dish-shaped bottom equal to 12,500 gallons. The zero reference elevation is at the top of the dish-shaped bottom. Above this zero elevation, the tank specific volume has historically been assumed to be 2750 gallons per inch of tank height, which is equivalent to the volume of a one inch high cylinder having a 75-ft diameter.

During the latter stages of sluicing, the need arose to understand the volume of waste contained in the tank dish-shaped bottom as a function of elevation above the bottom center of the tank. On reviewing the original construction drawing (CVI 73550, Drawing 2, Rev. 6), the dish bottom was discovered to have a volume of approximately 13,380 gallons instead of the assumed volume of 12,500 gallons. These volumes have been independently verified (Hendershot 1999). The tank bottom dimensionally is an inverted dome having a radius of 570 ft with a spherical segment base radius of 33 ft – 8 7/8 inches. Additionally, the drawing shows a tank knuckle radius of 4 ft. Consequently, the volume of the tank in the knuckle region (from the tank zero reference elevation to a height of 47.9 inches) is approximately 126,000 gallons instead of an assumed volume of 131,800 gallons (47.9 x 2750). Combined, the original volume of sludge stored in the tank was overstated by approximately 5,000 gallons.

With a starting sludge volume of 192,000 gallons (i.e., 69.8 equivalent tank inches), the final mass transfer volume of 67.8 inches represents removal of approximately 97 percent of the initial sludge volume. Approximately two inches or 5,500 gallons of sludge is estimated to remain in the tank. If this amount of sludge were evenly deposited in the tank bottom, its elevation would be approximately 8 inches above the bottom center of the tank. The actual sludge distribution will not be known until the evaporation of the remaining liquid is complete.

Based on the revised initial waste volume, the mass flow meter would predict that virtually all of the sludge was retrieved, while only 93 percent would be predicted by the sediment level/dissolved solids method. The range of possible sludge volume remaining in the tank is zero to 5 inches.

Table 5-1. WRSS Mass Transfer Method Summary

Date	Batch	Mass Flow Meter Method	ENRAF™ Densitometer Sediment Level Method	Cumulative Dissolved Solids Method	Adjusted Mass Transfer	Cumulative Adjusted Mass Transfer
11/18/98 through 4/30/99	1.1.1 to 2.1.2	32.07	23.07	11.69	33.42	33.42
5/1/99 through 7/22/99	2.2.1 to 3.1.1	21.53	16.02	9.40	17.63	51.05
8/4/99	3.1.2	0.10	0.07	10.07	0.42	51.47
8/20/99	3.1.3	1.88	1.76	10.31	1.94	53.41
9/10/99	3.2.1	2.31	3.23	11.25	3.24	56.65
9/14/99	3.2.2	1.97	Included in batch 3.2.3	11.17	N/A	N/A
9/16/99	3.2.3	4.76	5.71	10.91	6.05	62.70
9/21/99	3.2.4	2.59	1.12	10.83	1.82	64.51
9/24/99	3.2.5	1.63	Included in batch 3.2.6	10.75	N/A	N/A
9/26/99	3.2.6	1.11	1.82	10.74	2.24	66.75
9/28/99	3.2.7	0.33	0.36	10.85	0.40	67.15
9/30/99	3.2.8	0.29	0.50	10.99	0.47	67.61
10/6/99	3.2.9	0.08	0.08	11.11	0.14	67.75
Total		70.65	53.74	11.11	67.75	67.75

6 .0 OTHER PROCESS CONTROL DATA EVALUATIONS

In addition to the calculation method in Section 4.0, other process control data were reviewed to determine if that information is consistent with the calculated sludge volume transfer. The process data reviewed include:

1. Tank 241-AY-102 Thermocouple Data
2. Tank 241-AY-102 MIT Thermocouple Derived Solids Level Data
3. Tank 241-C-106 Riser 8 and Riser 14 Thermocouple Tree Data

These process data were compared, as appropriate, using the thermal models developed for the sluicing process and the results were reviewed by the WRSS Technical Review Group. The process data was found to support the calculated amounts of sludge transfer through Increment 3.1. Additional details of WRSS Technical Review Group reviews can be found in the appropriate meeting minutes. A final thermal analysis will be performed after monitoring the process data following completion of sluicing operations.

6.1 TANK 241-AY-102 PROFILE, AIR LIFT CIRCULATOR, AND CONCRETE THERMOCOUPLE DATA

The tank 241-AY-102 thermocouple data shows a consistent upward temperature trend throughout the tank. The temperature trend data can be viewed in a series of WRSS process control status reports contained on the Hanford Web at address http://wwwi.pnl.gov/wrss/. An example of the temperature trend data; the averaged seven foot, twenty-one foot, and thirty-six foot radius concrete thermocouple data; is included in Figure 6-1 . The radial location of thermocouples in the tank can be seen in Figure A-1 of the above WRSS process control status reports. The tank thermocouple data have been compared to thermal models of the tank through Increment 3.1 with the resulting conclusion that these upward temperature trends are consistent with the tank 241-AY-102 thermal model projections. This conclusion has been reviewed and concurred in by the WRSS Technical Review Group.

Figure 6-1. 241-AY-102 Average Values for Insulating Concrete Temperatures

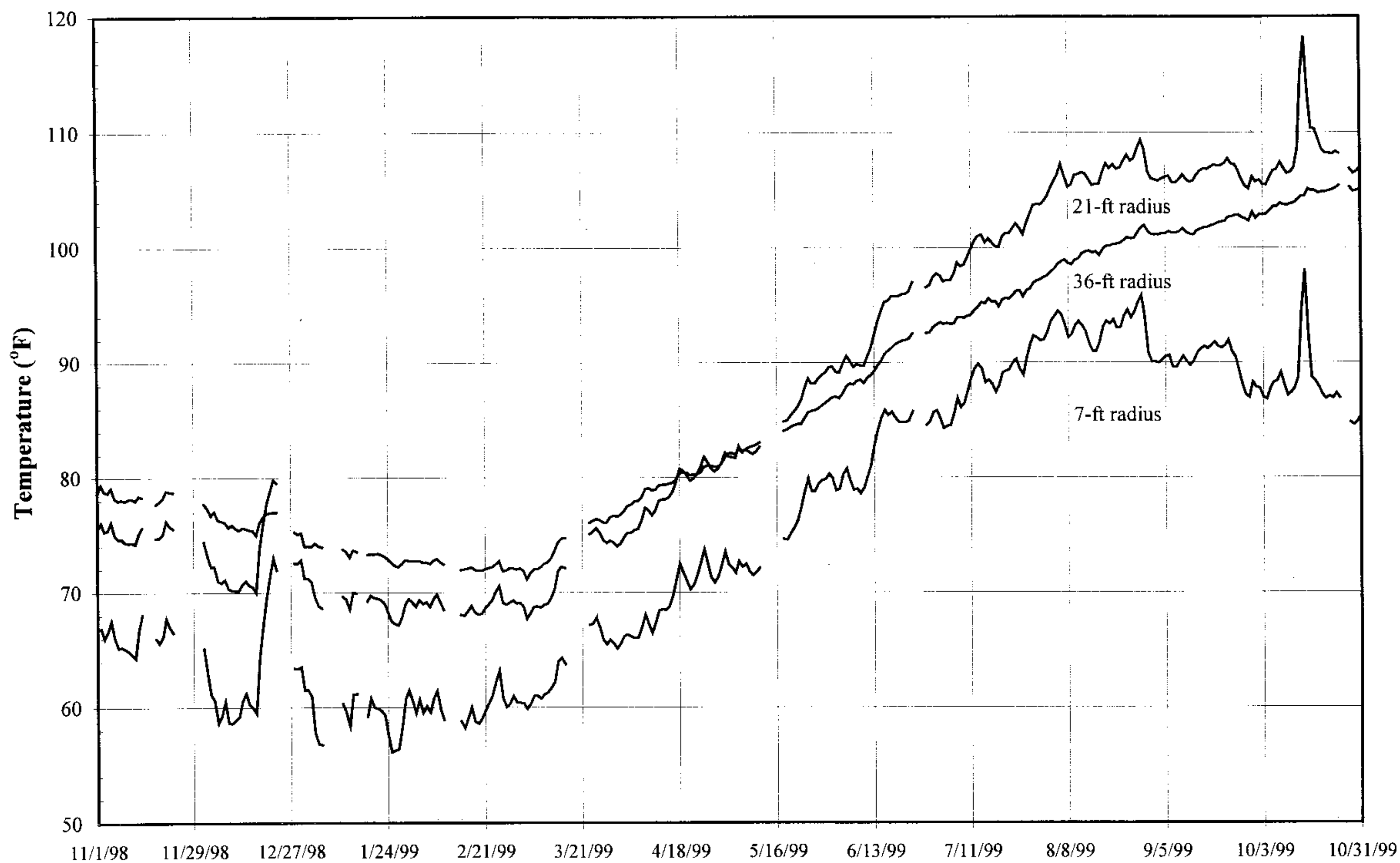
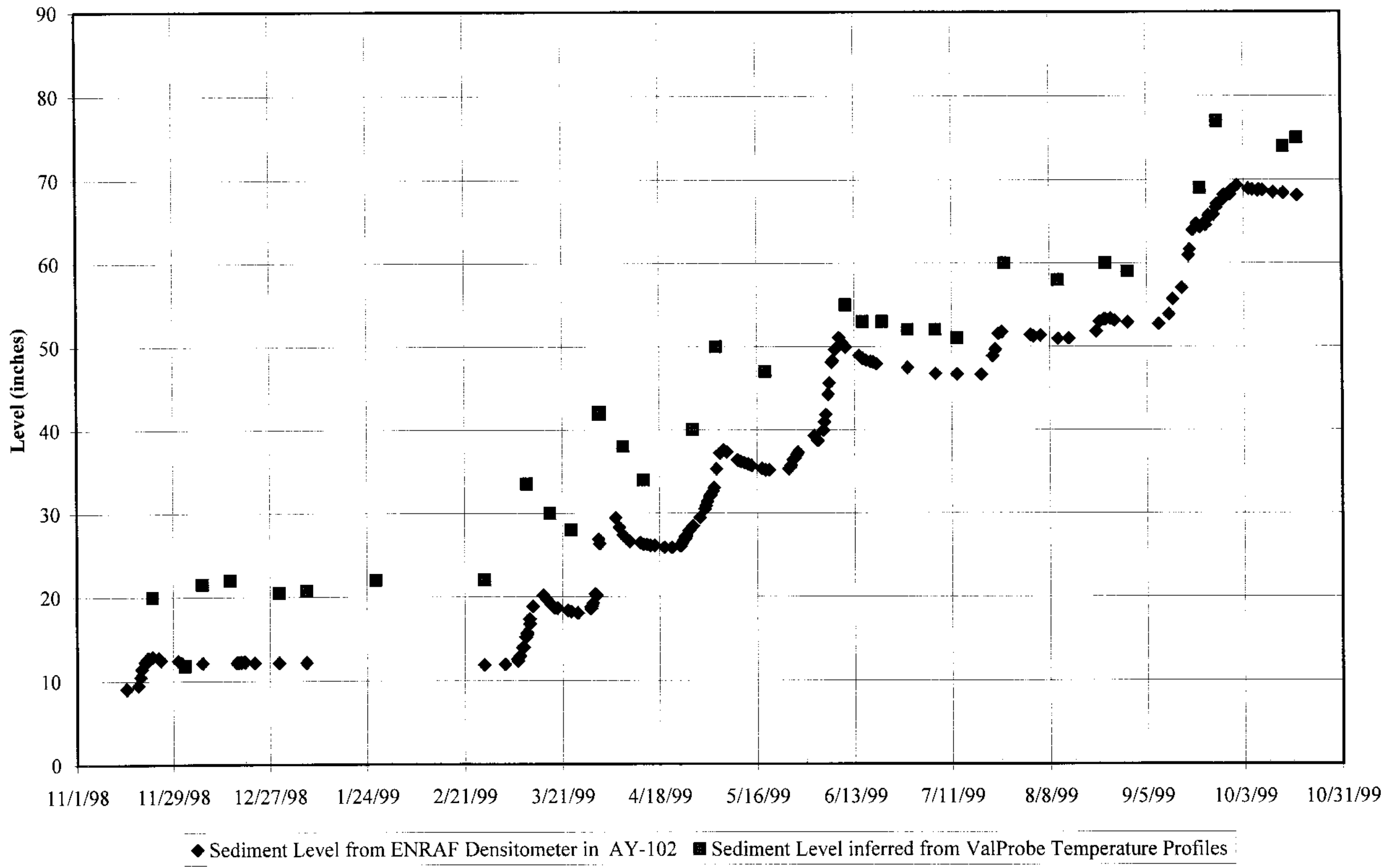


Figure 6-2. Tank 241-AY-102 Sediment Levels



6.2 TANK 241-AY-102 MIT THERMOCOUPLES DERIVED SOLIDS LEVEL DATA

The MIT thermocouple and MIT validation probe data can be seen in the WRSS process control status reports contained on the Hanford Web at address http://wwwi.pnl.gov/wrss/. Figure 6-2 shows the comparison of the ENRAF™ densitometer sediment level data with solids level data derived from MIT data by plotting the intersection of the slopes of the liquid temperature data and the sludge temperature data. The resulting tank level is the elevation of the transition between the thermally convective and non-convective zones in the tank. This interface level in the tank is physically the point at which enough solids have settled to hinder convective heat transfer.

The MIT derived level data shows a higher solids level than the densitometer sediment levels. This is not surprising given the difference in the phenomenon being measured by the two approaches. The MIT detects the convective / non-convective waste interface level. The ENRAF™ detects a preset increase in waste density. The convective / non-convective interface represents a very lightly settled layer of solids which hinders convective heat transfer. These lightly settled solids have a density increase relative to solids free liquid that cannot be sensed by the densitometer.

A review of the MIT and densitometer solids level data shows considerable variation in the differences between the MIT and densitometer reading. After the earlier sluicing batches, both solids levels would increase to a peak and then show solids compaction. The MIT measured levels would then show a greater solids compaction rate after achieving a peak level than the related densitometer measured data. This is interpreted as the lightly settled solids compacting and approaching the densitometer level readings.

Beginning with Increment 2.2 the MIT and densitometer data comparison begins to show a markedly different trend. This trend is characterized by a decreasing slope of the post peak solids level decrease as measured by the MIT. This reduced rate of solids compaction is not detected by the densitometer data until the beginning of Campaign 3. These trends indicate that the solid particles settling in tank 241-AY-102 have either become larger or denser than those transferred by earlier sluicing operations.

Based on the above qualitative comparison, the MIT data supports the sludge volume transfer calculations. The final calculated sludge volume removed of Section 5 is conservative in that the ENRAF™ densitometer sediment measurements only account for the densely settled solids. The top layer of less dense solids, which is apparent from the MIT measurements, is not included in the mass transfer calculations.

6.3 TANK 241-C-106 RISER R-8 AND R-14 THERMOCOUPLE DATA

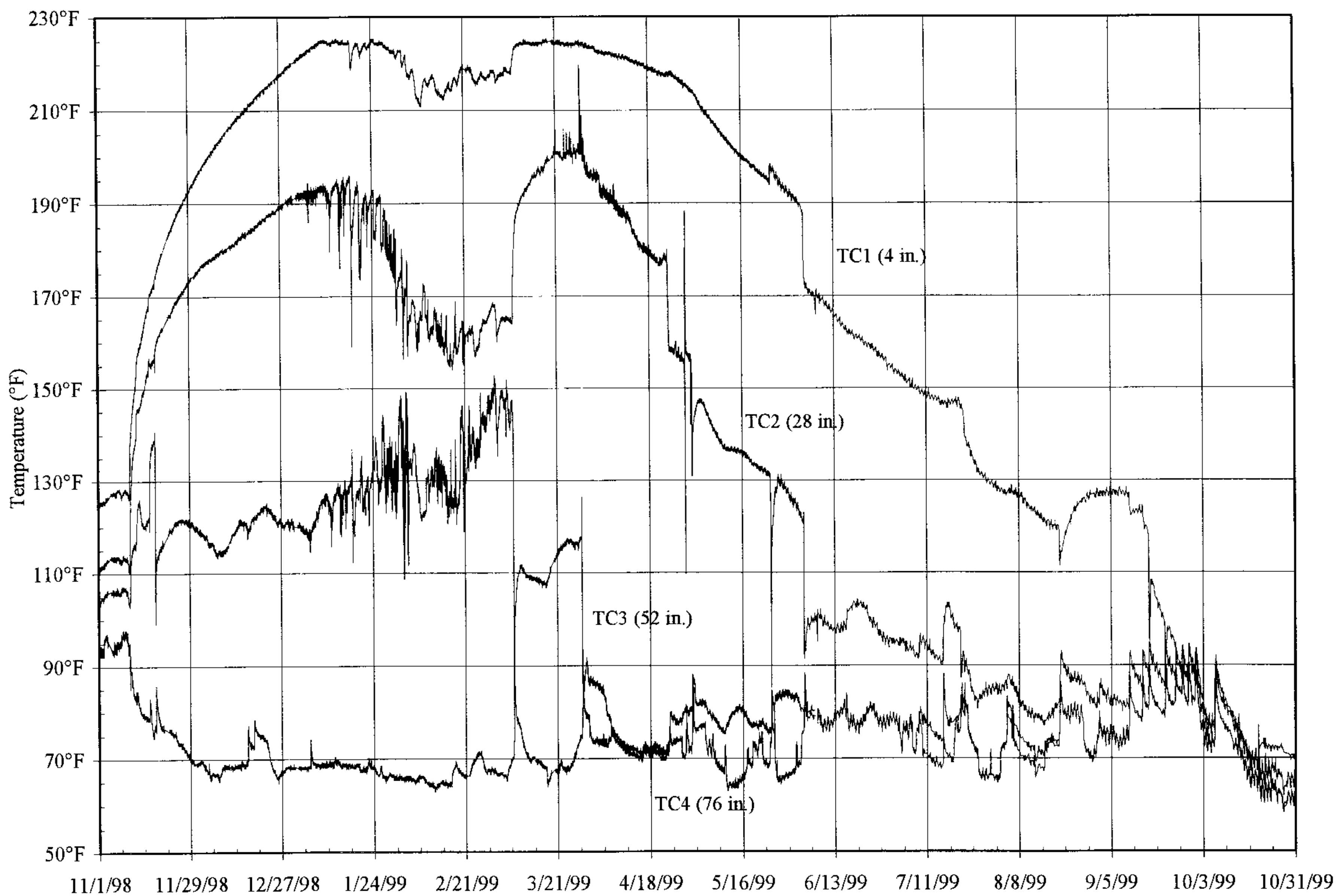
The tank 241-C-106 thermocouple data shows a consistent downward temperature trend at both of the thermocouple trees located in the tank. As in the case of tank 241-AY-102, the temperature trend data can be viewed in WRSS process control status reports available on the Hanford Web at address http://wwwi.pnl.gov/wrss/. As an example, the R-14 thermocouple tree data are provided in Figure 6-3. The radial location of thermocouples in the tank can be seen in Figure A-3 of the process control status reports. These data have been compared to thermal models of the tank through Increment 3.1, discussed below, with the resulting conclusion being that the temperatures are consistent with the model projections, i.e., the temperature data supports the calculated solids transfer volumes.

6.4 TANK 241-AY-102 AND 241-C-106 THERMAL ANALYSIS MODELS

The tanks 241-AY-102 and 241-C-106 thermal analysis models have been compared to the actual process control data from these tanks and the comparison concluded that the actual thermal response of these tanks through Increment 3.1 is bounded by the thermal analysis, i.e., the solids transfer volumes are not inconsistent with the thermal model. The conclusion of the thermal analysis comparison to process data was reviewed and concurred in by the WRSS Technical Review Group.

A final thermal analysis and comparison to process data will be performed after an appropriate monitoring period following the completion of sluice batch 3.2.9

Figure 6-3. 241-C-106 Temperatures Measured in Riser 14



7.0 CONCLUSIONS

The amount of sludge removed from tank 241-C-106 has been determined using the guidance detailed in HNF-SD-WM-PROC-021, Section 15.0, Rev. 3, sub-section 4.4, "Calculation of Sludge Volume Transferred." The conclusions from performing these calculations are as follows:

1. The amount of sludge transferred during WRSS operations through batch 3.2.8 completed on September 30, 1999 is 5.6 ft (67.6 inches). The total amount of sludge removed from tank 241-C-106 at the completion of WRSS operations is 67.8 inches.
2. The amount of sludge removed from tank 241-C-106 as determined from the corrected mass flow meter method compares to within 10 percent of the amount determined from the sediment level/dissolved solids method.
3. The original documented volume of sludge stored in tank 241-C-106 before the start of WRSS operations was overstated by approximately 5,000 gallons.
4. Approximately two inches of sludge remains in tank 241-C-106 based on the best estimate of sludge volume removal and the revised initial sludge volume in the tank. Depending on the method used, the range of remaining sludge volume is 0 – 5 inches.

8 .0 REFERENCES

Allen, D. I., 1999a, *Fiscal Year 1999 Performance Agreement TWR 1.2.2, C-106 Sluicing, Performance Expectation* (letter LMHC-9957114 to D. C. Bryson, ORP, September 29), Lockheed Martin Hanford Corp., Richland, Washington.

Allen, D. I., 1999b, *Fiscal Year 1999 Performance Agreement TWR 1.2.1, C-106 Sluicing, Performance Expectation* (letter LMHC-9956600 to D. C. Bryson, ORP, September 27), Lockheed Martin Hanford Corp., Richland, Washington

Bailey, J. W., 1999, *Waste Retrieval Sluicing System Campaign Number 1 Solids Volume Transferred Calculation*, HNF-4379, Rev. 1, Lockheed Martin Hanford Corp., Richland Washington.

Hendershot, R., 1999, *Tank Volume Adjustments*, (interoffice memo 74B40-99-116 to K. M. Hodgson, November 11), Lockheed Martin Hanford Corp., Richland, Washington.

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