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IQRPE Integrity Assessment Report for the 242-A Evaporator Tank System

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U.S. Department of Energy Contract DE-AC27-99RL14047

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Abstract: This document is the assessment by an Independent Qualified Registered Professional Engineer (IQRPE) of the 242-A Evaporator Unit. This assessment is required by the RCRA Permit WA7890008967 and the Washington State Dangerous Waste Regulations (WAC 173-303-640 (2)). The report recommends the 242-A Evaporator Unit be re-assessed by an IQRPE in 10 years.

Kelly L. Wheeler 12/28/07 KLW

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IQRPE Integrity Assessment Report

for the

242-A Evaporator Tank System

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December 27, 2007

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF ATTACHMENTS

ACRONYMS

AIChE	American Institute of Chemical Engineers
ALARA	As low as reasonably achievable
AMU	Aqueous Make Up
ANSI	American National Standards Institute
ASME	American Society of Mechanical Engineers
ASTM	American Society for Testing materials
CERCLA	Comprehensive Environmental Response, Compensation and Liability Act of 1980
CFR	Code of Federal Regulations
CH2MHILL	CH2MHILL Hanford Inc.
CR	Cold Run
CS	Carbon Steel
CZE	Cooper Zeitz Engineers, Inc.
DDSSF	Dilute double shell slurry feed
DOE	U.S. Department of Energy
DQO	Data quality objectives
DSA	Documented safety analysis
DSC	Differential scanning calorimeter
DSS	Double-shell slurry
DSSF	Double-shell slurry feed
DST	Double-shell tank
DW	Dangerous Waste
Ecology	Washington State Department of Ecology
EPA	U.S. Environmental Protection Agency
ETF	Effluent Treatment Facility
FRW	filtered raw water
FY	fiscal year
HEPA	high-efficiency particulate air
HNF	Hanford facility
HVAC	heating, ventilation, and air conditioning
IA	integrity assessment
IAP	integrity assessment plan
IAR	integrity assessment report
ICD	interface control document
ID	inside diameter
IQRPE	Independent Qualified Registered Professional Engineer
LERF	Liquid Effluent Retention Facility
LMHC	Lockheed Martin Hanford Corporation

MCS	monitoring and control system
MPFL	Maximum Permissible Fire Loss
NFPA	National Fire Protection Association
NDE	non-destructive examination
OD	outside diameter
ORP	Department of Energy Office of River Protection
OSR	Operational Safety Requirement
OST	watch list tank in the double shell tank system
pH	potential of Hydrogen, where $pH \approx \log_{10} \frac{[H^+]}{1mol/L}$
PCB	Polychlorinated biphenyl
PCP	process control plan
PRR	post run report
PPE	personnel protective equipment
PRC	process condensate recycle
PRV	pressure relief valve
PUREX	Plutonium and Uranium Recovery by Extraction
QA	quality assurance
RBDA	risk based disposal approval
RCRA	Resource Conservation and Recovery Act of 1976
RCT	radiological control technician
RL	Richland Operations Office
RPP	River Protection Project
RTD	resistance temperature detector
DSA	document safety analysis
SCC	stress corrosion cracking
SDC	Hanford plant standard design criteria
SpG	specific gravity
SS	stainless steel
SSC	structures, systems, or components
SSE	safe shutdown earthquake
SSEI	shutdown earthquake
SST	Single-Shell Tank
TDI	temperature differential indicator
TEDF	Treated Effluent Disposal Facility
TGS	Techno General Services Company
TOC	total organic carbon
TRU	transuranic
TSCA	Toxic Substance Control Act
TSR	Technical Safety requirements
UBC	Uniform Building Code
UPS	uninterruptible power supply

USQ	unreviewed safety question
UT	ultrasonic testing
VLS	vapor liquid separator
VT	visual inspection
WA	Washington state
WAC	Washington State Administrative Code
WAP	Waste Analysis Plan
WF	weight factor
WHC	Westinghouse Hanford Company
WSCF	Waste Sample Characterization Facility
WVR	waste volume reduction
WVRF	waste volume reduction factor

Units

Btu/hr	British Thermal Units per hour
cc	cubic centimeters
cfm	cubic feet per minute
Ci	Curies
Ci/L	Curies per liter
cm	centimeters
cm/s	centimeters per second
cP	centipoises
ft/s	feet per second
ft^2	square feet
gal	gallons
gpm	gallons per minute
g	grams
g/L	grams per liter
g	gravity, gravitational constant, i.e. 9.81 m/s^2 (32.2 ft/s^2)
hr	hour
in	inches
in/yr	inches per year
kg	kilograms
kgal	kilogallons
kPa	kilopascals
L	liters
lbs	pounds
<u>M</u>	molarity or moles per liter
m	meters

m^2	square meters
m^3	cubic meters
m/s	meters per second
mg/L	milligram per liter
min	minute
mL	milliliters
nci/g	nanocurie per gram
ppm	parts per million
SpG	specific gravity
wt%	weight percent
yr	year
µCi/mL	microcuries per milliliter
µg/g	micrograms per gram
µg/L	micrograms per liter
µg/mL	micrograms per milliliter
µm/yr	micrometer per year
°C	degrees Celsius
°F	degrees Fahrenheit

EXECUTIVE SUMMARY

This integrity assessment report (IAR) provides documentation to satisfy the requirements of Permit WA7890008967 under the Washington State Department of Ecology (Ecology) Dangerous Waste Regulation, Washington Administrative Code (WAC) 173-303-640 (2) and the approval of both the Department of Energy Office of River Protection (ORP) and Ecology for the integrity assessment certification of the 242-A Evaporator unit. The 242-A Evaporator unit handles dangerous waste at the Hanford Site in the 200 East Area. The Washington State dangerous waste regulations require the integrity of existing dangerous waste tank systems to be assessed by an independent, qualified, registered professional engineer (IQRPE) in order to "determine that the tank system is adequately designed and has sufficient structural strength and compatibility with the waste[s] to be stored or treated to ensure that it will not collapse, rupture, or fail" (WAC 173-303-640(2)(c)).

Within this document, each of the 242-A Evaporator unit components is described, including associated ancillary equipment and piping systems evaluated as part of the 242-A Evaporator unit. The results of the integrity assessment are reported herein. This assessment is based on the following criteria:

(1) a review of available unit design documents, design drawings, and construction specifications

(2) a review of wastes processed, waste characteristics, and operational parameters from past campaigns

(3) a qualitative assessment of waste compatibility and corrosion resistance for the tank system and pipelines

(4) leak testing, non-destructive examination (ultrasonic testing [UT]), and visual inspection of the tank system and ancillary components

A separate IAR (RPP-RPT-33307, Rev.0) was prepared for the PC-5000 process condensate (PC) transfer line.

Section 1.4 provides a brief description of the 242-A Evaporator unit, process, operating parameters, and operating history. The unit has been operated 60 times from 1980 to 2007, with operating periods ranging from 5 to 215 days.

Section 2.1 provides an evaluation of the codes, standards, and regulations used to design and construct the 242-A Evaporator unit and ancillary equipment. Available design documents, design drawings, and specifications were reviewed in order to verify the configuration, materials of construction, system upgrades, and age of the tanks, piping systems, and ancillary equipment in place. The conclusions of this assessment are that the design basis was sufficient and that there are no new or revised requirements relevant to the integrity of 242-A Evaporator unit.

Section 2.2 provides an evaluation of the waste characteristics of 242-A Evaporator unit feed, concentrated slurry, and process condensate. The chemical composition of the evaporator feed, concentrated slurry, and process condensate varies from run to run. The Evaporator feed is highly alkaline (potential of Hydrogen [pH] > 13). The most significant components of these waste streams are non-radioactive inorganic salts, including sodium hydroxide, nitrites, nitrates, aluminates, carbonates, and sulfates. Minor amounts of organic material are also present. The waste constituents in the Evaporator feed, concentrated slurry, and process condensate are controlled in order to

meet the waste acceptance requirements in the 242-A Evaporator unit portion of the Hanford Site Resource Conservation and Recovery Act (RCRA) Permit.

Section 2.3 provides a compatibility assessment of the 242-A Evaporator unit tanks, piping systems, and ancillary equipment with the Evaporator feed, concentrated slurry, and process condensate with respect to process control. This evaluation confirms that the Evaporator feed, concentrated slurry, and process condensate during past campaigns met the compatibility requirements for the process controls at the 242-A Evaporator unit.

Section 2.4 provides a summary of the visual inspections of the 242-A Evaporator unit, condensate collection tank, and secondary containment system. The secondary containment system includes walls and floors in the evaporator room, condenser room, pump room, loadout room, hot equipment storage, and ion exchange rooms; secondary containment sumps, drain lines, and leak detection systems. Video tapes and digital films taken of the accessible portions of the system were examined for visible cracks, chips, potential leak sites, and other physical impairments by trained and certified technicians and the IQRPE. The visual examination found no indication of leaks from tanks, piping systems, and ancillary components; no deterioration or corrosion failure of tanks, piping systems, or ancillary components handling dangerous wastes; and no deterioration of the secondary containment system.

Section 2.5 summarizes the leak testing activities conducted to verify the integrity of the Condensate Collection Subsystem and the Vapor Liquid Separator Subsystem. Leak testing was accomplished by filling the subsystems with water and visually inspecting all accessible joints, pipelines, valves, and flanges during the 24 hour test period. Additional visual inspection of the Vapor/Liquid Separator Subsystem was conducted following the hold test to avoid a deluge condition in accordance with unit safety procedures. No liquid leaks were detected during either test. However, a small amount of solid material was noted under Nozzle E in the Evaporator Pump Room during the Vapor Liquid Separator Subsystem leak test. This apparent leak did not impact the successful completion of the leak test. A work package to fix the leak has been developed and reviewed by the IQRPE. The IQRPE recommends implementation of this work package prior to the next campaign to resolve this issue.

Section 2.6 summarizes the UT results for the Evaporator/Reboiler loop, Condensate Collection Tank, and process condensate condensers. A total 2,042 UT test data points were collected at 18 locations. Statistical evaluation of the UT results show that there has been no measurable deterioration of tank system integrity. The UT evaluation suggests that the vessels tested remain structurally sound and are not corroding due to thinning, cracking, or pitting to any appreciable extent. Potential extreme values or outliers occurred in some data sets, possibly indicating either minor errors in measurement, data recording, or minor localized pitting. The analysis of the UT results demonstrate the observed variations in the measured wall thicknesses are within the margin of error of the testing equipment. Statistical analysis of the UT results also indicate that the data typically followed uniform distributions indicative of ordinary corrosion. Data was found in all cases to be above the allowable thickness and, in many cases above the nominal thickness specified for the original construction of each vessel. Evaluation of the minimum thickness measurements and statistical mean values also demonstrate little or no loss in material thickness since previous measurements were made.

Section 2.7 summarizes the corrosion assessment completed as part of the integrity assessment. Information related to the historical use of the 242-A Evaporator unit tanks, piping systems, and ancillary components; materials of construction; waste characteristics; corrosion mechanisms; UT results; and corrosion environments was reviewed to complete this assessment. The corrosion evaluation indicates that the 242-A Evaporator unit components will not collapse, rupture, or fail.

Section 2.8 provides an evaluation of the remaining useful life of the 242-A Evaporator unit. The unit began operation in 1977, and has been in service for 30 years (2007). The original design life of the 242-A Evaporator was 10 years. Upgrades, both past and planned, have been designed to extend the useful life of the unit to the year 2034. Based on the analysis of the UT results and the other activities conducted as part of this assessment, the projected minimum remaining life of each major vessel tested is greater than (>) 20 years from the current year.

Section 3.0 provides a summary of the conclusions and recommendations resulting from this integrity assessment. The 242-A Evaporator unit was found to be adequately designed and to have sufficient structural strength and compatibility with the wastes stored and treated that it will not collapse, rupture, or fail. Only minor recommendations for unit improvement were identified.

Section 4.0 presents the recommended scheduled frequency for future integrity assessments based on findings in this IAR. The IQRPE recommends that the next integrity assessment be performed no later than 10 years after submittal of this IAR. This recommendation is based on the projected minimum remaining life of each major vessel tested of >20 years and the design basis for the upgrades initiated in order to extend the life of 242-A Evaporator unit.

Section 5.0 is the formal certification of the IAR by the IQRPE, confirming that the 242-A Evaporator unit is in compliance with the applicable sections of WAC 173-303-640 and the 242-A Evaporator unit-specific portions of the Hanford Site RCRA Permit as of the September 30, 2007 modification.

1.0 INTRODUCTION

TechnoGeneral Services Company (TGS) has prepared this Integrity Assessment Report (IAR) for the 242-A Evaporator unit in conjunction with Cooper Zietz Engineers, Inc. (CZE), at the request of CH2M HILL Hanford Group, Inc. (CH2M HILL), the project co-operator under Contract Requisition No.1440001. TGS is the Independent Qualified Registered Professional Engineer (IQRPE) of record for this project. The qualifications of personnel involved in the preparation of this IAR are provided in Attachment 17. This IAR was prepared in order to meet the requirements of Permit WA7890008967 (Ecology 2003) under the Washington State Department of Ecology (Ecology) Dangerous Waste Regulation, Washington Administrative Code (WAC) 173-303-640 (WAC 173-303) and the approval of the ORP and Ecology. A separate IAR for the PC-5000 Transfer Line (RPP-RPT-33307, Rev.0, 2007) was submitted under this contract. A copy of the WAC requirements is included as Attachment 15.

This IAR meets the provisions of WAC Section 173-303-640(2) for assessment of an existing tank system's integrity. Unless otherwise stated, an "existing tank system" is defined in this IAR as "a tank system which is currently in use for storing or treating dangerous wastes at the time of the integrity assessment (IA)." The categories of tanks that were assessed at the 242-A Evaporator unit were aboveground tanks (vapor-liquid separator, reboiler) and on-ground tanks (condensate collection tank and condensate filters) as per WAC 173-303-640(2)(c) and Publication 94-114 (Ecology 1994). The categories of ancillary equipment assessed at the 242-A Evaporator unit were process condensate transfer line within the unit, vacuum condenser system, all piping, pumps, seal pot, flanges, and couplings as per WAC 173-303-640(2)(c)(v)(B). Secondary containment includes walls and floors in the evaporator room, condensate room, and pump room, secondary containment sumps, loadout room, hot equipment storage, ion exchange room, drain lines, and leak detection systems for the 242-A Evaporator unit per WAC 173-303-640(4) and Publication 95-420 (Ecology 1995).

This IAR is organized as follows:

- Section 1—Introduction describing IA requirements, a site map of the 242-A Evaporator unit at the Hanford facility, the scope of this IA, and 242-A Evaporator unit.
- Section 2—Integrity assessment of the 242-A Evaporator unit, piping systems, ancillary components, and secondary containment systems including an evaluation of the applicable codes, standards, and regulations specifically used during the preparation of this certification; a waste characteristics and waste compatibility evaluation, the results of visual inspection activities; the results of leak testing activities; the results of ultrasonic testing; a corrosion assessment; and an evaluation of the tank system age.
- Section 3—Conclusions and Recommendations
- Section 4—Recommended schedule for future integrity assessment
- Section 5—Integrity assessment certification
- Section 6—References
- Attachments

Attachment 1 provides a complete list of documents reviewed and used in the preparation of this IAR.

1.1 General

The WAC 173-303-640 (2)(a) defines that for each existing tank system, the owner or operator must determine that the tank system is not leaking or is unfit for use and that the owner or operator must obtain and keep on file at the unit a written assessment reviewed and certified by an independent, qualified registered professional engineer (IQRPE), in accordance with WAC 173-303-810 (13)(a), that attests to the tank system's integrity for tank systems that cannot be entered for inspection.

1.2 Site Map of the Unit

Figure 1.1 is a picture of 242-A Evaporator unit. Figures 1.2 is site maps showing the location of the 242-A Evaporator unit and 242-A Evaporator unit in the 200 East Area.

1.3 Scope

The scope of this IA is based on the recommendations in the original 1993 and 1998 IARs (Westinghouse Hanford Company [WHC] 1993a, Lockheed Martin Hanford Corporation [LMHC] 1998), and the 2007 integrity assessment plan (IAP) (RPP-PLAN-

32530, Rev.1, [TGS 2007a]) for the 242-A Evaporator unit. The major tasks associated with this IA include:

- Provide the information necessary for the IQRPE to evaluate and certify the integrity of the system components to meet the requirements of WAC 173-303-640(2)(a), (2)(c), (2)(d), and (2)(e)
- Non-destructive examination (NDE) of selected locations and components of 242-A Evaporator system
- Leak testing of the evaporator/reboiler system and the condensate collection tank
- Visual inspection of the unit for signs of degradation
- Review of operating logs and occurrence reports for events which may have caused degradation to the vessels
- Review of 1993 and 1998 IARs to determine baseline status
- Review of national codes and standards and U.S. Department of Energy (DOE) orders to determine if there are significant new or revised requirements related to integrity of existing units

This IA is limited to those vessels (tanks) and ancillary equipment within the 242-A Evaporator unit which include all associated piping, drains, valves, sumps, secondary containment and tanks which receive, store, accumulate, transfer or treat Washington State Dangerous Waste (DW) or waste components within the 242-A Evaporator unit as described in the Permit WA 7890008967.

Piping systems which either introduce liquid waste streams into the building or transfer solids, liquids, or vapors to other facilities will be tested up to but not to include the last valve or flanged connection inside the TSD unit perimeter. The following items are not covered by the WAC dangerous waste regulations or the RCRA Permit for the TSD unit, and are therefore outside of the scope of this certification:

- Vessel Vent Subsystem, except for the seal pot and associated drain lines (Non-Dangerous Waste Subsystem)
- Steam Condensate Subsystem (Non-Dangerous Waste Subsystem)
- Raw Water Disposal Subsystem (Non-Dangerous Waste Subsystem)
- Plant utilities, including chemical supply storage and piping supply systems, instrument and plant air supply lines, and electrical power beyond the first upstream device or uninterruptible power supply systems that do not directly affect the ability of the system to prevent the collapse, rupture, or failure of components handling dangerous wastes.
- Structural features not related to dangerous waste secondary containment
- Architectural features not related to dangerous waste containment
- Lighting systems
- System design features related to protection of the system due to vehicular traffic
- Electrical or signal lines beyond the first upstream field termination box (FTB), motor control center (MCC), or instrument control panel (ICS). Electrical feed, including wiring, local hand switches, terminations, breakers, and other equipment or instruments located in motor control centers will be reviewed to the extent they affect the ability of the system to prevent the collapse, rupture, or failure of components handling dangerous wastes. Instrument cabling and terminations will also be limited to locally mounted devices and field termination boxes and/or local instrumentation

and control panels to the extent they affect the ability of the system to prevent the collapse, rupture, or failure of components handling dangerous wastes.
- Verification of functional logic for operation and control of the system

This certification also excludes the following aspects of the system as they relate to radionuclide and radiation control as they are outside the scope of the WAC dangerous waste regulations:
- Radiation monitoring or detection components that may be mounted at various locations throughout the system
- Requirements regarding waste feed radionuclide properties, including all radioactive and radionuclide property considerations
- Requirements developed to ensure exposure of plant operating personnel to radioactive process streams (radiation) is as-low as reasonably achievable (ALARA)
- System safety features related to the following:
  - Personnel Safety
  - Fire Protection
  - Nuclear Safety

SOURCE: WA-7890008967 , REV. 9

96080579-19CN
(PHOTO TAKEN 1996)

1.1	COOPER ZIETZ ENGINEERS, INC.	242-A Evaporator Integrity Assessment Hanford Reservation	TechnoGeneral Services Company Engineering and Construction Management
		242-A Evaporator Facility	REVISIONS

Figure 1.1 242-A Evaporator Unit

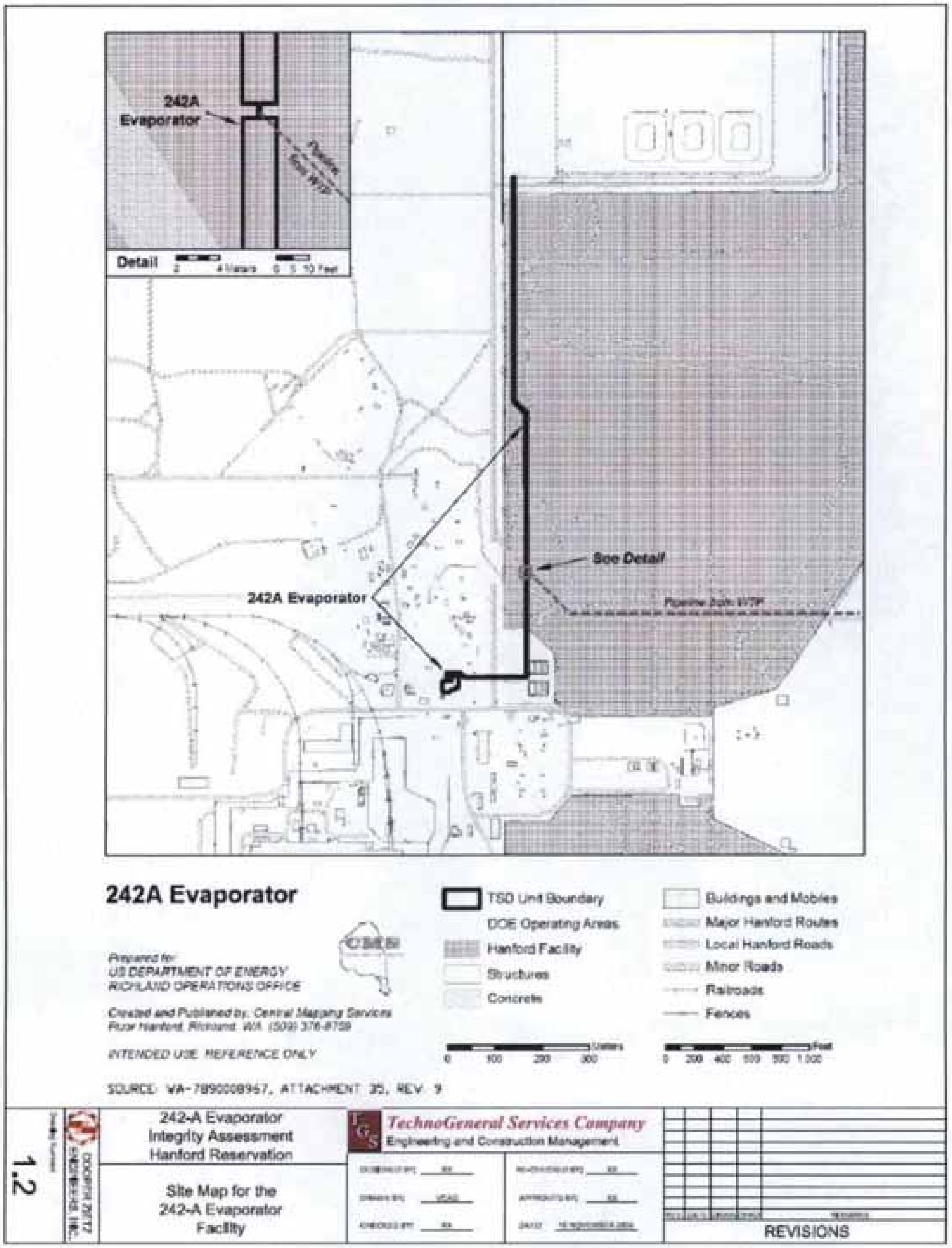


Figure 1.2 Site Map for the 242-A Evaporator Unit

1.4 242-A Evaporator System Description

The 242-A Evaporator System is assessed as three major subsystems. The three subsystems are as follows:

- Vapor-Liquid Separator Subsystem
- Condensate Collection Subsystem
- Building and Secondary Containment Subsystem

These three subsystems store, transport, or treat Washington State Dangerous Wastes. A detailed discussion of these subsystems is provided in Section 1.4.5.

Non-dangerous subsystems (vessel vent subsystem, steam condensate subsystem, and raw water disposal subsystem) are not covered by the WAC dangerous waste regulations or the RCRA Permit for the unit, and are therefore outside of the scope of this certification.

The following subsections briefly describe the background of the unit, process flow and subsystems associated with the 242-A Evaporator unit. A detailed description and figures are provided in the Permit WA7890008967, 1993 IAR, 1998 IAR, and 2007 IAP (Ecology 2003, WHC 1993, LMHC 1998, and TGS 2007a, respectively).

1.4.1 242-A Evaporator Unit Configuration

The 242-A Evaporator is located in the 200 East Area. The following four principal structures make up the 242-A Evaporator (HNF-14755 Rev 1):

- 242-A Building, main process building
- 242-AB Building, adjacent control room building
- 242-A-81 Building, water services building
- 207-A Retention Basins (including the 207-A Building).

The principal process components of the 242-A Evaporator unit include the reboiler, evaporator vessel, recirculation pump and recirculation pipe loop, slurry product pump, condensers, jet vacuum system, and the condensate collection tank. This equipment is located in the 242-A Building, which consists of two adjoining but independent structures. The first structure houses the processing and service areas and is designed and constructed to withstand a 0.25 gravity (g) seismic event. The second structure houses operating and personnel support areas such as change rooms and supply rooms. Under Project B-534, a new building, 242-AB, was constructed to house the upgraded evaporator unit control room and an electrical room (HNF-14755 Rev 1).

A computer-based monitoring and control system (MCS) is located in the 242-AB Building control room. The MCS is used to operate and monitor the 242-A Evaporator and various tank farm facilities. The 207-A Retention Basins and 207-A Building are also part of 242-A Evaporator unit that have been physically isolated from the 242-A Evaporator and are no longer in use.

1.4.2 242-A Evaporator Unit Background

The 242-A Evaporator unit was constructed in 1977 under Hanford Project B-100. The original construction design life of the 242-A Evaporator was 10 years. In a study based on 1987 waste volume projections, Westinghouse Hanford Company (WHC) determined that the 242-A Evaporator would be needed through the year 2000. Engineering studies and design efforts were initiated in fiscal year (FY) 1987 to upgrade the unit to extend the operating life by 10 years as part of B-534 Project. A major construction outage to incorporate the design changes was scheduled for FY 1990. Table 1.1 provides a summary of principal project B-534 system upgrades and modifications.

The 242-A Evaporator unit was placed in temporary shutdown in April 1989, pending determination of whether the process condensate generated at the unit was a mixed waste. Mixed waste contains both radioactive and hazardous constituents that are classified as dangerous waste by Ecology. Subsequent meetings with Ecology concluded that the process condensate is a mixed waste stream regulated by Ecology. The determination led to a 5-year shutdown of the 242-A Evaporator unit until the Liquid Effluent Retention Facility (LERF) basins were constructed for storing process condensate. The operation of the 242-A Evaporator unit for treating feed materials and generating process condensate is a key activity in supporting the goals and milestones defined in Ecology (1990) *Hanford Federal Facility Agreement and Consent Order.*

The 242-A Evaporator unit upgrades were initiated during the shutdown pending resolution of the mixed waste determination issue. The 242-AB Building was constructed to house the upgraded evaporator control room and an electrical room. The upgrades were completed in FY 1993, and operations restarted in April 1994.

Other unit changes over the operating life of the 242-A Evaporator unit include rerouting evaporator steam condensate from the 207-A Retention Basins to the Treated Effluent Disposal Facility (TEDF) in 1997, rerouting the condenser cooling water from B-Pond to TEDF in 1997, and installing a new package boiler system in 1998.

The current and future mission of the 242-A Evaporator is to support environmental restoration and remediation of the Hanford Site by optimizing the 200 East and West areas double shell tank (DST) waste volumes in support of the tank farm and vitrification contractors. To support this mission, an additional life extension study (HNF-3327 1998) *242-A Evaporator Life Extension Study*, was prepared to identify the work scope needed to extend the unit life through 2016. This study was revisited in January 2001 due to an identified need for the unit through 2019 (HNF-3327 2001) *Engineering Study for the 242-A Life Extension Upgrades for Fiscal Years 2002 Thru 2005*). A report was issued in 2001 (included as Appendix S to HNF-3327) to validate the scope identified in 1998 and identify any new scope not previously addressed. A Project Execution Plan ([PEP], River Protection Project [RPP]-8949 2002) *Project Execution Plan for 242-A Evaporator Life Extension Upgrades* was issued in 2002 to provide guidance in execution of the life extension projects. A revised PEP (RPP-PLAN-33477) was released in 2007.

Table 1.1
Summary of Principal Project B-534 System Upgrades and Modifications

Component or System	Summary Description
Reboiler	Instrumentation added to improve monitoring and control.
Recirculation pump	Upgraded to increase liquid velocity through the reboiler.
Slurry-out system	Upgraded to allow pumping double-shell slurry to receiving tank farms.
Hot side lighting	Lighting in pump room, evaporator room, condenser room, load-out and hot-equipment storage room, and loading room upgraded.
Electrical power	New substation installed such that project load not greater than 80 percent of capacity; new standby generator installed and 204-AR Waste Unloading Facility decoupled from system.
Process control	Industrial-grade microprocessor-based automatic distributive monitor and control system installed in newly constructed control room (242-AB Building).
Service crane	Television camera and second auxiliary hoist installed on bridge crane.
Communication system	New two-way intercom system installed.
Water services	Continuous strainers, backflow preventers, and other equipment housed in newly constructed Water Services Building (242-A-81 Building).
Insulation	Insulation added to vessel C-A-I to maintain a process temperature of 93.3°C (200 °F).
Vessel ventilation	Steam heater replaced with electric heater per ASME/ANSI N509 and ASME/ANSI N510; manual isolation dampers installed new instrumentation.

Source: HNF-14755 Rev 1.

As of July 2006, the following activities were completed: replacement of the slurry jumper (FY 2003), which included a new P-B-2 discharge relief valve and a Coriolis mass flow density meter (DI-CA1-3); replacement of several brass valves on the process condensate system (FY 2003); removal of the ion exchange (IX) columns (FY 2003); replacement of the IX column room and non-process area roofs (FY 2003); replacement of the E-C-2 and E-C-3 condensers and associated steam jets (FY 2004); and replacement of the electric compressors and installation of an associated closed loop cooling system (FY 2006). Progress and imminent work plans on other upgrade and replacement-in-kind projects are tracked through project schedules.

Table 1.2 compiles the list of equipment upgrades and replacement-in-kind projects at the 242-A Evaporator unit since Project B-534. Table 1.3 provides a summary of the evaluations and recommendations from the engineering studies for the 242-A Life Extension Upgrades (HNF-3327, 2001).

1.4.3 Process Description

The 242-A Evaporator process uses a conventional forced-circulation, vacuum evaporation system to concentrate mixed waste solutions from the DST System tanks. The incoming stream is separated by evaporation into two liquid streams: a concentrated slurry stream and a process condensate stream. The slurry contains the majority of the radionuclide and inorganic constituents. After the slurry is concentrated to the desired level, the slurry stream is pumped back to the DST System and stored for further treatment. Vapor from the evaporation process is condensed, producing process condensate, which is primarily water with trace amounts of organic material and a greatly reduced concentration of radionuclides. The process condensate is transferred to the LERF for storage and treatment. Vacuum for the evaporator vessel is provided by two steam jet ejectors, producing a gaseous vessel vent exhaust. The 242-A Evaporator vessel vent stream is filtered and discharged through an exhaust stack. A simplified process flow diagram for the 242-A Evaporator process is provided in Figure 1.4.

Also associated with the 242-A Evaporator are utility waste streams such as cooling water and steam condensate which are not dangerous waste.

Table 1.4 provides process flow material balances for the 242-A Evaporator system (HNF-14755 Rev 1). A detailed discussion of the 242-A Evaporator process is provided in Section 1.4.5.

Table 1.2 Equipment Upgrade and Replacement-in-Kind History

Item	Date	Title	Equipment	Reference	Work Package	Unit
1	12/15/1994	P-C100 pump replacement, base & piping modifications	P-C100	ECN 610629	EE-94-00711	Evaporator
2	2/15/1995	P-C100 pipe & drain modifications	Various piping	ECN 620353	EE-94-00711	Evaporator
3	11/10/1995	P-C106 supports, piping & valve replacement	P-C106 Valves 1-7, 1-91, 1-92	ECN 624963	EE-95-00337	Evaporator
4	2/13/1996	Pipe support modification	Various piping	ECN 629534	EE-95-00337	Evaporator
5	2/26/1996	Reroute tubing - process condensate recycle blowdown	PCV-CA1-1 Valve 5-16	ECN 629575	EE-95-337	Evaporator
6	3/18/1996	Steam Condensate Piping Revision - Add valve	Valve 1-97A	ECN 706934	EE-96-070	Evaporator
7	4/26/1996	Steam Condensate Piping Revision	Various steam condensate piping	ECN 706936	EE-96-070	Evaporator
8	3/12/1997	Steam Condensate Piping Changes	Various steam condensate piping	ECN 708083, ECN 625917	NA	Evaporator
9	7/11/2001	Change Globe Valve to Ball Valve	Valve 4-30	ECN 664324	NA	Evaporator
10	8/22/2001	Revise Jumper - add valve HV-PB2-1 & Pressure taps	Valve HV-PB2-1	ECN 664553	EL-01-00451	Evaporator
11	2/27/2002	Add C-A-1 Flow Totalizer	FQI-CA1-W	HNF-FMP-02-10182-R0	EL-01-00088/M WCN #001	Evaporator
12	3/12/2003	Replace Obsolete Control Valves	See HNF-3327, Appendix K	HNF-FMP-03-14288-R0	EL-03-1056	Evaporator
13	5/21/2003	Remove IX Columns IX-D-1, IDX-3, and IDX-4	IX-D-1, IDX-2, IDX-4	HNF-FMP-02-11381-R0C	EL-02-00367/M	Evaporator

Table 1.2 Cont' Equipment Upgrade and Replacement-in-Kind History

Item	Date	Title	Equipment	Reference	Work Package	Unit
14	2/20/2004	E-C-2 & E-C-3 replaced	E-C-2, E-C-3	ECN 721480-R0	EE-03-00085W	Evaporator
15	3/14/2005	Replace Obsolete Control Valves	HV-AIR-SUMP-1, HV-BLK-SUMP-1, HV-VENT-SUMP-1, FV-CA1-6, HV-STM-SUMP-1, HV-CA1-6, FV-EC1-1, HV-SUMP-1, FV-EC3-1, HV-RC1-3, HV-RC3-3, HV-CA1-7, HV-CA1-9, FV-C100-5, PCV-RC3-1, HV-EC1-2, FV-EA1-1, PV-CA1-7, HV-EC1-1, HV-EC2/EC3-1,	ECN 722527-R0	EL-03-00156	Evaporator
16	11/14/2006	Remove FL-CA1-7	FL-CA1-7	ECN 724205-R0	WFO-WO-05-03350	Evaporator
17	12/28/2007	Replace FIT-CA1-6	FIT-CA1-6	ECN 724241-R0	WFO-WO-07-0074	Evaporator
18	12/28/2007	Replace FIT-CA1-2	FIT-CA1-2	ECN 724240-R0	WFO-WO-07-0073	Evaporator
19	1228/2007	Replace FIT-CA1-1	FIT-CA1-1	ECN 724239-R0	WFO-WO-07-0072	Evaporator
20	9/17/2007	P-B-2 Safety relief valve	2J3-JLT-JBS-25-S-A, 2J3-JLT-JBS-E-25-S-A	HNF-FMP-02-12215-R0A	EL-01-00451	Evaporator
21	8/3/1998	Instrument air purge of LERF transfer line encasement	PCV-LRF-1, BV-LRF-1 CV-LRF-1, HV-LRF-1	ECN 647888	EL-98-00280	PC-5000
22	1/18/2001	New Piping Installation	HV-80W-002, HV-80W-002, HV-80W-003, HV-80W-004	ECN 656789	EL-00-00209	PC-5000

Table 1.3 Life Extension Study Recommendations

Component	Evaluation/Recommendations	Implementation	Reference
Slurry Sampler System	Flow test of the sample loop Replacement of the isolation valve and remote linkage	Design, work package, procurement, construction, and test & start-up completed in FY03.	HNF-3327 2001
RC-1, RC-2, & RC-3 Radiation Monitoring Equipment	Modification of existing radiation monitor with new and updated components	Design, work package, procurement, construction, and test & start-up completed in FY03.	HNF-3327 2001
P-B-2 relief Valve	Replace relief valve every 5 years to extend the life of Evaporator to the year 2019.	Design, work package, procurement, construction, and test & start-up completed in FY03.	HNF-3327 2001
Specific Gravity Instrumentation	Current dip tube based instrumentation is not designed for the level of accuracy now required for effective process control. Install Coriolis mass flow/density meters.	Design, work package, procurement, construction, and test & start-up completed in FY03.	HNF-3327 2001
Process condensate (PC) valves	Valves in the PC system installed with M-5 pipe code are not compatible with high ammonia levels currently present in PC. Replace a total of 34 gate valves and 5 ball valves as listed in HNF-3327 (2001) Table 5-1 and Attachment 2 of Appendix E.	Design, work package, procurement, construction, and test & start-up have been completed for a portion of the valves; the remainder are scheduled for replacement in the out years.	HNF-3327 2001
Slurry Jumper Nozzle C to 13	Installed in 1991 and the remaining life is indeterminate due to existing valve seats deterioration from the accumulation of radiation dose. Replace with Worcester 3-way valves, equipped with radiation resistant, non-adjustable seats to last through the year 2019.	Design, work package, procurement, construction, and test & start-up completed in FY03.	HNF-3327 2001

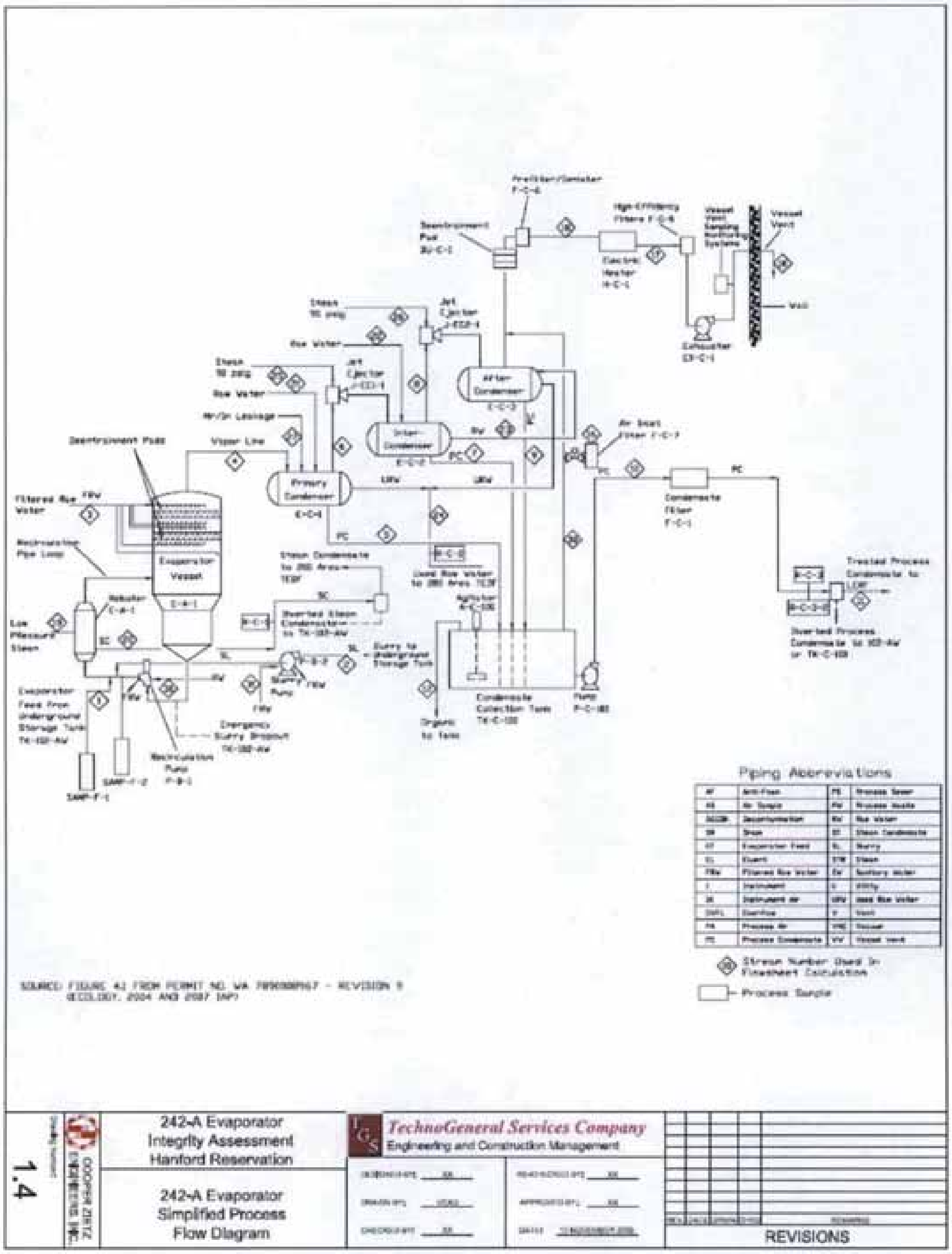


Figure 1.4 242-A Evaporator Simplified Process Flow Diagram

1.4.3.1 Operating Parameters

Operating parameters for the 242-A Evaporator include the flow rate, pressure, and temperature ranges and limits for the system. Each evaporator campaign has different operating conditions; the conditions during past campaigns may not be representative of future campaigns due to changing contents of the DSTs. Data, including process control plans (PCP) and post run reports (PRR), were gathered during the IA in order to evaluate the operating parameters for the 242-A Evaporator unit. The design operating limits listed in Table 1.5 were compiled from a variety of sources in the IAP (TGS 2007a). The operational design limits in Table 1.6 were compiled from the Documented Safety Analysis (HNF-14755 Rev 1).

1.4.4 Historical Campaign Data

Table 1.7 presents historical campaign data for the 242-A Evaporator unit since 1980. The unit has been operated 60 times between 1980 to 2007 for periods ranging from 5 to 215 days. Total feed volume for each campaign has ranged between 324 kilogallons (kgal) to 7,651 kgal. Vapor-liquid separator operating parameters are monitored to provide an indication of process problems such as slurry foaming, de-entrainer flooding, or excessive vapor temperatures. Instrumentation also monitors the liquid level in the vapor-liquid separator. Interlocks are activated when high pressures or high- or low-liquid levels are detected, shutting down the evaporation process and placing the unit in a safe configuration.

1.4.5 242-A Evaporator Subsystems

The 242-A Evaporator system is comprised of three subsystems according to the function or process of each subsystem. A brief description of these subsystems is provided below. Most of the description, figures and tables are taken from Permit WA7890008967, the 1993 IAR, the 1998 IAR, and the 2007 IAP (Ecology 2003, WHC 1993, LMHC 1998, and TGS 2007a, respectively).

The vessel vent subsystem, steam condensate subsystem, and raw water disposal subsystem are non-dangerous subsystems not covered by the WAC dangerous waste regulations or the RCRA Permit. They are outside of the scope of the IA and are not addressed in this IAR.

1.4.5.1 Vapor-Liquid Separator Subsystem

The major components of this system include the reboiler, vapor-liquid separator, recirculation pump, recirculation loop, and slurry system. Figure 1.5 is a simplified process flow diagram showing the major components of the vapor-liquid separator subsystem. The following subsections describe the vapor-liquid separator subsystem components.

Reboiler (E-A-1). Waste is heated as the waste passes through the reboiler before entering the vapor-liquid separator. The reboiler is a vertical tube unit with steam on the shell-side and process solution on the tube-side. The 364 tubes in the reboiler are enclosed in a 1.03-meter (3.38-feet) outside diameter, 4.6-meter (15.09-feet) long stainless steel shell. Both the reboiler shell and tubes are constructed of 304L stainless steel.

Table 1.4 Process Flow Material Balances

Stream	Temperature °C (°F)	Flow, L/min (gal/min)		Specific Gravity
		Average	Range	
Evaporator Feed	18-49 (65-120)	340 (90)	265-494 (70-130)	1.0-1.5
Concentrated Slurry	18-66 (65-150)	170 (45)	~115-265 (~30-70)	1.0-1.6
Process Condensate	27-43 (80-110)	190 (50)	75-230 (20-60)	1.0
Steam Condensate	32-71 (90-160)	300 (80)	NA	1.0
Raw Water (Cooling Water)	2-24 (35-75)	10,410 (2,750)	NA	1.0

Notes:

LERF Liquid Effluent Treatment Facility
NA Not Applicable
SC Steam Condensate
TEDF Treated Effluent Disposal Facility

Source:

HNF-14755 Rev 1.

Table 1.5 Operating Parameters

COMPONENT	PRESSURE/FLOW	TEMPERATURE (F)
C-A-1 Evaporator		
Vapor Section	<0.8 psia (0.06 kg/cm^2)	120
Lower Circulation Pipe	14,000 gpm (53,000 liter/min)	200
E-A-1 Reboiler		
Tube Side (Waste)	14,000 gpm (53,000 liter/min)	200
Shell Side (Steam)	29.7 psia (2.08 kg/cm^2)	250
E-C-1 Primary Condenser		
Tube Side (Cooling Water)	3,500 gpm (FDM) (13,249 liter/min)	72
Shell Side (Waste Vapor)	0.8 psia (0.06 kg/cm^2)	95
E-C-2 Intermediate Condenser		
Tube Side (Cooling Water)	150 gpm (568 liter/min)	72
Shell Side (Waste Vapor)	1.0 psia (0.07 kg/cm^2)	150
E-C-3 Final Condenser		
Tube Side (Cooling Water)	150 gpm (568 liter/min)	95
Shell Side (Waste Vapor)	14.0 psia (1.0 kg/cm^2)	170
TK-C-100 Condensate Catch Tank	14.0 psia (1.0 kg/cm^2)	151

Source: TGS 2007a

Table 1.6 242-A Evaporator Unit System Operational Design Basis

Component	Design Pressure kPa (absolute)	Operating Pressure kPa (absolute)	Design Temperature (°C)	Operating Temperature (°C)	Length (cm)	Width (cm)	Height (cm)	Construction Material
C-A-1	0	6.7	NA	38-70	NA	428 D	1254	SS
E-A-1	791	6.7	177.00	38-70	NA	103 D	457	SS
P-B-1	164	205	93.00	38-70	NA	122	318	SS
P-B-2	2.313	350	82.00	70	297	89	94	SS
E-C-1	0	6.7	66.00	25	533	216 D	NA	CS
E-C-2	Shell 0 & 791 Tubes 791	5.5	177.00	39	221	41 D	NA	CS
E-C-3	Shell 0 & 791 Tubes 791	101	177.00	66	238	20D	NA	CS
TK-C-100	NA	101	NA	27	NA	428 D	642	SS

Notes:

CS Carbon Steel

SS Stainless Steel

NA Not Applicable

D Diameter

Source: HNF-14755 Rev 1.

Table 1.7 242-A Evaporator Historical Campaign Data

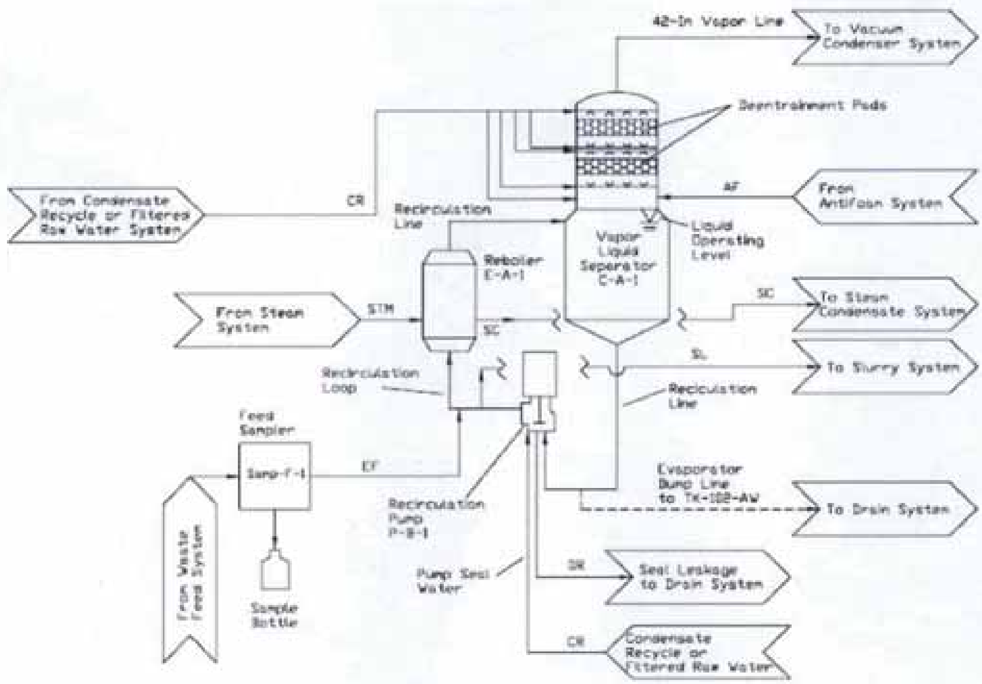
CAMPAIGN	Post Run Report No. / RMIS Ref.	ACT START	FINISH	DURATION* (days)	FEED VOL. (kgal)	SLURRY VOL. (kgal)
1980-1	RHO-CD-80-1045-1	10/10/1979	10/19/1979	10	776	506
1980-2	RHO-CD-80-1045-2	10/28/1979	11/6/1979	9	1,030	587
1980-3	RHO-CD-80-1045-3	11/15/1979	12/22/1979	37	2,000	550
1980-4	RHO-CD-80-1045-4	2/21/1980	3/1/1980	9	726	327
1980-5	RHO-CD-80-1045-5	3/12/1980	4/4/1980	23	1,340	333
1980-6	RHO-CD-80-1045-6	4/10/1980	4/27/1980	17	674	215
1980-7	SD-WM-PE-003	6/9/1980	6/29/1980	20	1,172	354
1980-8	SD-WM-PE-004	7/4/1980	8/7/1980	34	752	268
1980-9	SD-WM-PE-005	8/14/1980	8/30/1980	16	1,801	1,103
1980-10	SD-WM-PE-006	9/3/1980	10/4/1980	31	1,522	950
1981-01	SD-WM-PE-007	10/7/1980	11/3/1980	27	1,521	1,022
1982-01	SD-WM-PE-002	11/3/1981	12/4/1981	31	2,181	598
1982-02	SD-WM-PE-012	9/19/1982	10/21/1982	32	2,028	537
1983-01	SD-WM-PE-014	10/24/1983	11/22/1983	29	1,518	754
1983-02	65950-82-635 (PCP)	N/A	N/A	13	1090	N/A
1983-03	65950-82-679 (PCP)	N/A	N/A	17	723	N/A
1983-04	65950-82-686 (PCP)	N/A	N/A	21	1,090	N/A
1983-05	SD-RE-PE-003	2/3/1983	2/8/1983	5	578	630
1984-01	SD-WM-PE-015	9/19/1983	9/30/1983	11	643	288
1984-02	SD-WM-PE-016	11/12/1983	11/29/1983	17	324	147
1984-03	SD-WM-PE-018	12/8/1983	3/24/1984	107	4,287	1,169
1984-04	SD-WM-PE-017	4/7/1984	5/11/1984	34	2,132	1,182
1984-05	SD-WM-PE-022	5/15/1984	10/22/1984	160	4,152	877
1985-01	SD-WM-PE-019	10/29/1984	11/13/1984	15	1,740	961

Table 1.7 242-A Evaporator Historical Campaign Data

CAMPAIGN	Post Run Report No. RMIS Ref.	ACT START	FINISH	DURATION* (days)	FEED VOL. (kgal)	SLURRY VOL. (kgal)
1985-02	SD-WM-PE-020	12/8/1984	12/16/1984	8	878	793
1985-03	SD-WM-PE-023	12/23/1984	4/14/1985	112	3,687	1,152
1985-04	SD-WM-PE-027	4/17/1985	11/6/1985	203	4,028	1,476
1986-01	SD-WM-PE-026	11/7/1985	1/21/1986	75	4,472	1,029
1986-02	SD-WM-PE-028	2/8/1986	2/16/1986	8	986	663
1986-03	SD-WM-PE-029	3/2/1986	4/1/1986	30	2,411	1,053
1986-04	SD-WM-PE-031	4/1/1986	6/10/1986	70	3,208	898
1986-05	SD-WM-PE-032	6/23/1986	7/5/1986	12	1,632	1,078
1987-01	SD-WM-PE-034	10/4/1986	12/31/1986	88	3,838	341
1987-02	SD-WM-PE-035	2/1/1987	2/22/1987	21	1,550	833
1987-03	SD-WM-PE-033	5/15/1987	10/2/1987	140	4,978	2,026
1988-01	SD-WM-PE-036 draft	2/16/1988	9/18/1988	215	7,651	2,066
1989-01	SD-WM-PE-037	9/29/1988	2/18/1989	142	3,805	3,726
1989-02	SD-WM-PE-038	2/25/1989	4/12/1989	46	918	130
1994-01	WHC-SD-WM-PCP-009	4/15/1994	6/14/1994	60	2,870	477.0
1994-02	WHC-SD-WP-PE-054	9/22/1994	11/19/1994	57	3,210	392.0
1995-01	WHC-SD-WP-PE-055	6/6/1995	7/27/1995	49	2,470	278.0
1996-01	WHC-SD-WP-PE-056	5/6/1996	5/26/1996	20	1,260	429.0
242-A Evaporator Facility Transitioned from TFC to FH in FY1997						
1997-01	HNF-SD-WP-PE-057	2/26/1997	4/3/1997	37	1,040	670.0
1997-02	HNF-SD-WM-PCP-014 (PCP)	9/15/1997	10/2/1997	18	913	482.1
1998-CR	HNF-3382	8/13/1988	8/25/1988	12	N/A	N/A
1999-01	HNF-5181	7/24/1999	8/13/1999	20	1,010	158.0

Table 1.7 242-A Evaporator Historical Campaign Data

CAMPAIGN	Post Run Report No. RMIS Ref.	ACT START	FINISH	DURATION* (days)	FEED VOL. (kgal)	SLURRY VOL. (kgal)
2000-01	HNF-5997 (PCP)	4/20/2000	5/5/2000	15	1334	622.9
2001-01	HNF-8588	3/4/2001	3/29/2001	25	840	N/A
2002-01	FH-0202362 (closeout letter)	3/27/2002	4/5/2002	10	0	0.0
2002-02	HNF-12204	11/7/2002	11/22/2002	17	1,018	602.0
2003-01	HNF-13061 (PCP)	1/8/2003	1/17/2003	10	1,074	762.0
2003-02	HNF-14803 (PCP)	2/26/2003	3/5/2003	8	966	685.0
242-A Evaporator Facility Transitioned from FH to TFC on May 23, 2003.						
2003-03	RPP-16514 (PCP)	6/28/2003 07/05/2003	06/30/03 07/12/2003	13	1,194	697.0
2003-04	RPP-16916 (PCP)	8/28/2003	9/3/2003	7	604.3	414.2
2004-01	RPP-21925 (Post Run)RPP-PLAN-23668 (PCP)PER-2004-1902	3/16/2004	4/2/2004	18	974.2	780.2
2005-01	RPP-PLAN-23668 (PCP)PER-2005-2831 Internal Letter 7T100-MRK-05-011	3/17/2005	3/30/2005	10	519.3	328.1
2006-CR	RPP-PLAN-27610 (PCP)PER-2006-1298 Internal Letter 7T500-VLW-06-001	3/22/2006	4/5/2006	15	0	0.0
2006-01	RPP-31420 (Post Run - Draft)RPP-PLAN-29976 (PCP)	8/29/2006	9/10/2006	12	553.4	285.2
2007-01	RPP-PLAN-33127PM-WFO-07-040	6/26/2007	7/22/2007	29	2162	0.0
2007-02	RPP-PLAN-33127 PM-WFO-07-040	8/4/2007	9/3/2007	32	1568	845.0



Piping Abbreviations

AF	Anti-Foam	PS	Process Sewer
AS	Air Sample	PW	Process Waste
DECON	Decontamination	RW	Raw Water
DR	Drain	SC	Steam Condensate
EF	Evaporator Feed	SL	Slurry
EL	Eluent	STM	Steam
FRW	Filtered Raw Water	SW	Sanitary Water
I	Instrument	U	Utility
IA	Instrument Air	CW	Cooling Water
OVFL	Overflow	V	Vent
PA	Process Air	VAC	Vacuum
PC	Process Condensate	VV	Vessel Vent
CR	Condensate Recycle		

SOURCE: FIGURE 4.1 FROM PERMIT NO. WA 7890008967 - REVISION 9 (ECOLOGY, 2004 AND 2007 IAP)

1.5

242-A Evaporator Integrity Assessment Hanford Reservation

242-A Evaporator Process Loop

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Engineering and Construction Management

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Figure 1.5 242-A Evaporator Process Loop

The shell is 0.64 centimeter (0.25 inch) thick and the tubes are 14-gauge steel. The reboiler is designed to distribute steam evenly and to prevent tube damage from water droplets that may be present in the steam.

Vapor-Liquid Separator (C-A-1). Process solution from the reboiler enters the vapor liquid separator (VLS) via the upper recirculation line. Some of the solution flashes into vapor, which exits through a vapor line at the top of the VLS. The remaining solution (slurry) exits through the recirculation line at the bottom.

The separator consists of a lower and upper section. The lower (liquid) section is a stainless steel shell 4.3 meters (14.1 feet) in diameter having an 85,200 to 94,600 liter (22,510 to 24,993 gallons) normal operating capacity (including recirculation loop and reboiler). The maximum design capacity for storage is 103,000 liters (27,292 gallons). The upper (vapor) section is a stainless steel shell 3.5 meters (11.48 feet) in diameter containing two de-entrainment pads. These wire mesh pads remove liquids and solids that entrain into the vapor section of the vessel. Spray nozzles, using recycled process condensate or filtered raw water, wash collected solids from the de-entrainment pads and vessel walls. Both sections of the VLS are constructed of 0.95-centimeter (0.374-inch) thick stainless steel.

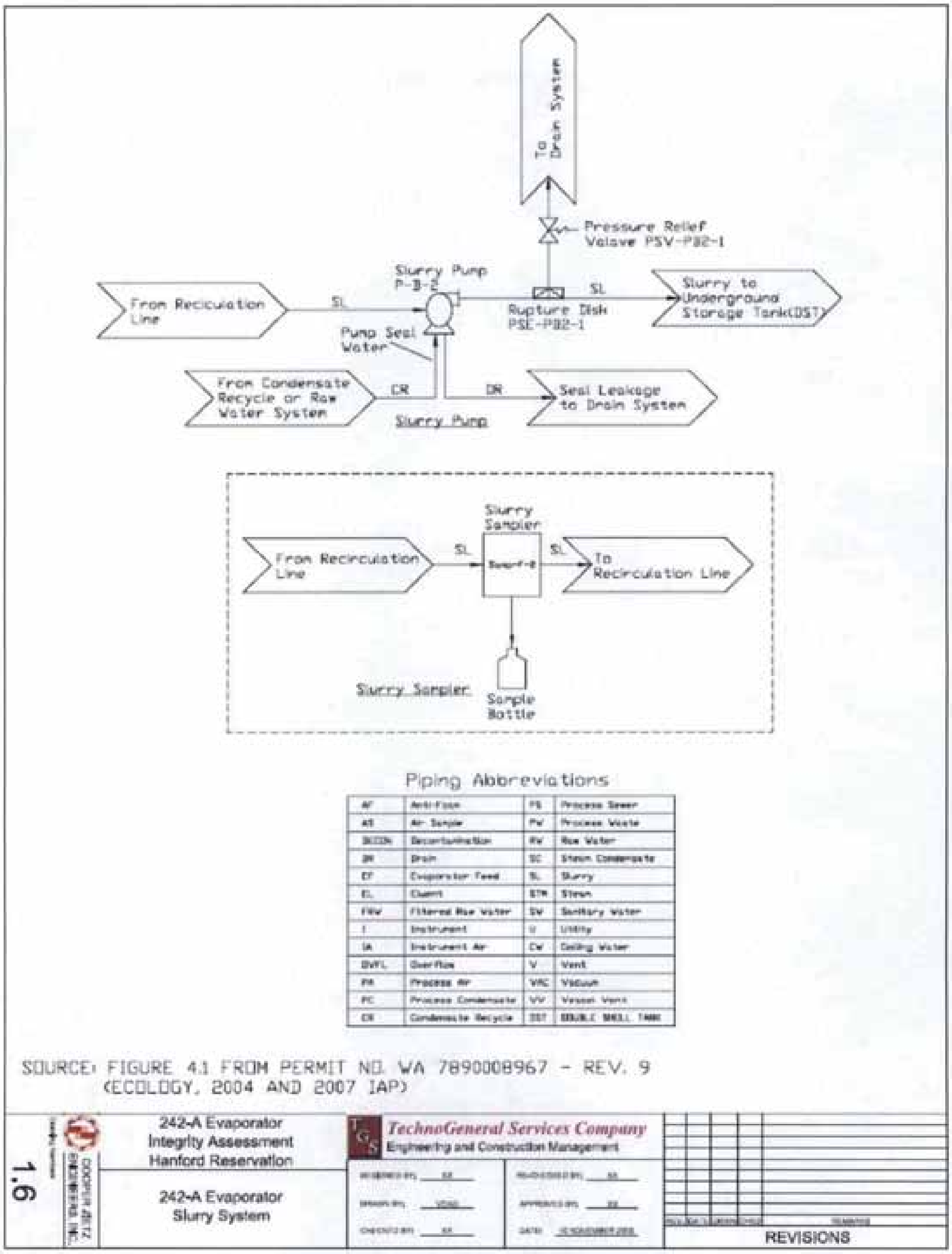
Recirculation Pump. The stainless steel recirculation pump (P-B-1), is constructed as part of the recirculation loop to the reboiler. The 28-inch (71.12 centimeter) diameter axial flow pump has 5,300 liters per minute (1,400 gallons per minute) output with a 4.0 meter (13.2 feet) total dynamic head. The recirculation pump is designed to handle slurry up to 30 percent un-dissolved solids by volume at specific gravities up to 1.8. The recirculation pump moves waste at high velocities through the reboiler to improve heat transfer, keep solids in suspension, and reduce fouling of the heat transfer surfaces.

The recirculation pump is equipped with shaft seals with high-pressure recycled process condensate (or water) introduced between the seals to prevent the waste solution from leaking out of the system. Seal water pressure and flow are monitored and controlled to shut down the recirculation pump if conditions are not adequate to prevent waste liquid from migrating into the seal water. The used seal water is routed to the feed tank.

Recirculation Loop. The recirculation loop consists of a 71.12 centimeter (28 inch) diameter stainless steel pipe that connects the vapor-liquid separator to the recirculation pump and reboiler. The lower loop runs from the bottom of the vapor-liquid separator to the recirculation pump inlet. The upper loop connects the pump discharge to the reboiler and the reboiler to the vapor-liquid separator. The feed line from the feed tank and the slurry line to underground storage tanks are connected to the upper recirculation line.

Slurry System. The slurry system draws a portion of the concentrated waste from the upper recirculation loop and transfers it to the DST System. Figure 1.6 shows a simplified flow diagram of the slurry system.

The slurry pump (P-B-2) is used to transfer slurry from the recirculation loop to the DSTs. The pump has a total dynamic head of 152 meter (500 feet) and is constructed of 304 L stainless steel. It is a single stage, horizontal, centrifugal pump driven by a variable speed motor of 121 to 416 liters per minute (32 to 110 gallons per minute) normal flow. The slurry pump is designed to generate high pressures to alleviate the possibility of a transfer line plugging.



Piping Abbreviations

AF	Anti-Foam	PS	Process Sewer
AS	Air Sample	PW	Process Waste
DECON	Decontamination	RW	Raw Water
DR	Drain	SC	Steam Condensate
EF	Evaporator Feed	SL	Slurry
EL	Eluent	STM	Steam
FRW	Filtered Raw Water	SW	Sanitary Water
I	Instrument	U	Utility
IA	Instrument Air	CW	Cooling Water
OVFL	Overflow	V	Vent
PA	Process Air	VAC	Vacuum
PC	Process Condensate	VV	Vessel Vent
CR	Condensate Recycle	DST	DOUBLE SHELL TANK

Figure 1.6 242-A Evaporator Slurry System

Interlocks control the operation of the slurry pump. The slurry pump (P-B-2) is shutdown if any of the following occur:

- Excessive pressure is detected in the slurry lines to 241-AW Tank Farm
- A leak is detected in the slurry transfer lines secondary containment
- A leak is detected in the 241-AW Tank Farm process pits where the transfer lines enter the DST System

The slurry pump uses a shaft seal with recycled process condensate (or water) and pressure and flow controls similar to the system described above for the recirculation pump.

All slurry transfer pipelines are encased in a secondary containment pipe and equipped with leak detectors between the primary and encasement piping. The portion of the slurry transfer pipelines located outside the walls of the 242-A Evaporator unit building are not regulated by the 242-A Evaporator unit RCRA Permit and are not within the scope of this IA. The pipelines are sloped to drain to the valve pit. The detection of a leak in the transfer will automatically shut off the slurry pump.

The flow rate of the slurry transfer to the DST System is monitored and a decrease in flow below a specified value automatically will shut down the slurry pump (P-B-2) and initiate a line flush with water. The objective of flushing the transfer line is to prevent settling of solids, which precludes plugging the slurry transfer lines.

Samples can be taken from the slurry line when needed via a sampler (SAMP-F-2) that is located near the feed sampler in the load-out and hot equipment storage room.

1.4.5.2 Condensate Collection Subsystem

The condensate collection subsystem collects process condensate via the condensers in the vacuum condenser system, filters the condensate, and pumps the process condensate to the LERF. Figure1.7 provides a simplified process flow diagram showing the major components of the process condensate collection subsystem. The following major components make up the process condensate collection subsystem:

- Vacuum condenser system
- Condensate collection tank (TK-C-100)
- Process condensate pump (P-C-100)
- Condensate filters (F-C-1 and F-C-3)
- Process condensate radiation monitoring, sampling system and diversion system (RC3)
- Seal pot
- Process condensate recycle system

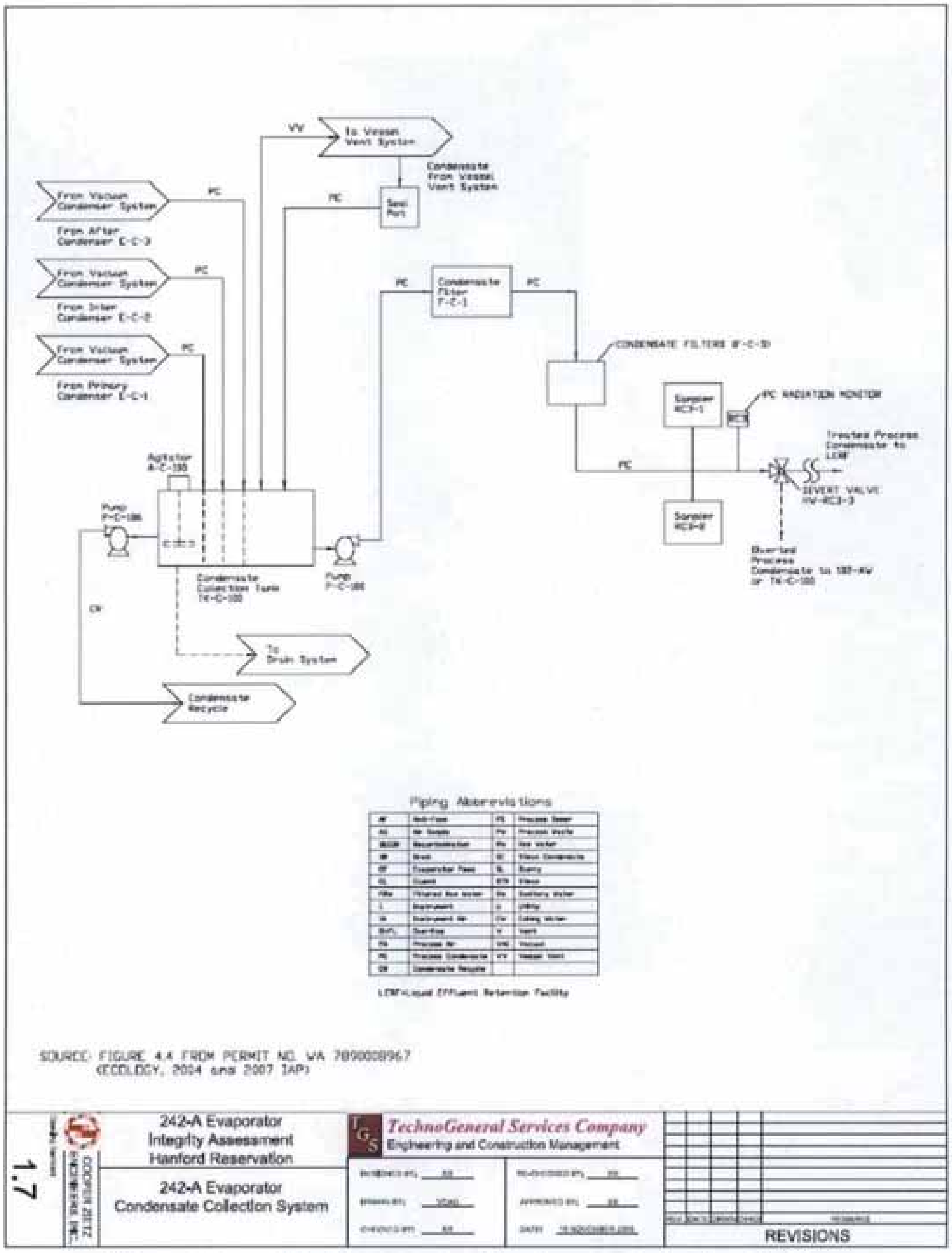


Figure 1.7 242-A Evaporator Condensate Collection System

Vacuum Condenser System

Vapors removed from the vapor-liquid separator flow to a series of three condensers where the vapors are condensed using raw water (cooling water). Condensate drains to the condensate collection tank (TK-C-100). The vacuum condenser system consists of the following major components:

- Primary condenser (E-C-1)
- Intercondenser (E-C-2)
- Aftercondenser (E-C-3)
- Steam jet ejectors (J-EC1-1 and J-EC2-1)

Figure 1.8 provides a simplified process flow diagram showing the major components of the vacuum condenser system. These system components are discussed in the following sections.

Primary Condenser (E-C-1). Vapors drawn from the vapor-liquid separator flow through the 1.07 meter (3.5 feet) vapor line, into the E-C-1 condenser where the majority of the condensation takes place. Non-condensed vapors exit to the intercondenser (E-C-2) while the condensed vapors (process condensate) drain to the condensate collection tank (TK-C-100). Cooling water passes through the cooling tubes and exits to TEDF.

The carbon steel condenser shell measures approximately 5.3 meters (17.4 feet) long and has a 2.2-meter (7.2 feet) inside diameter. The condenser consists of 2,950 equally spaced carbon steel tubes that are 3.6 meters (11.8 feet) long with a 1.9-centimeter (0.75 inches) outside diameter.

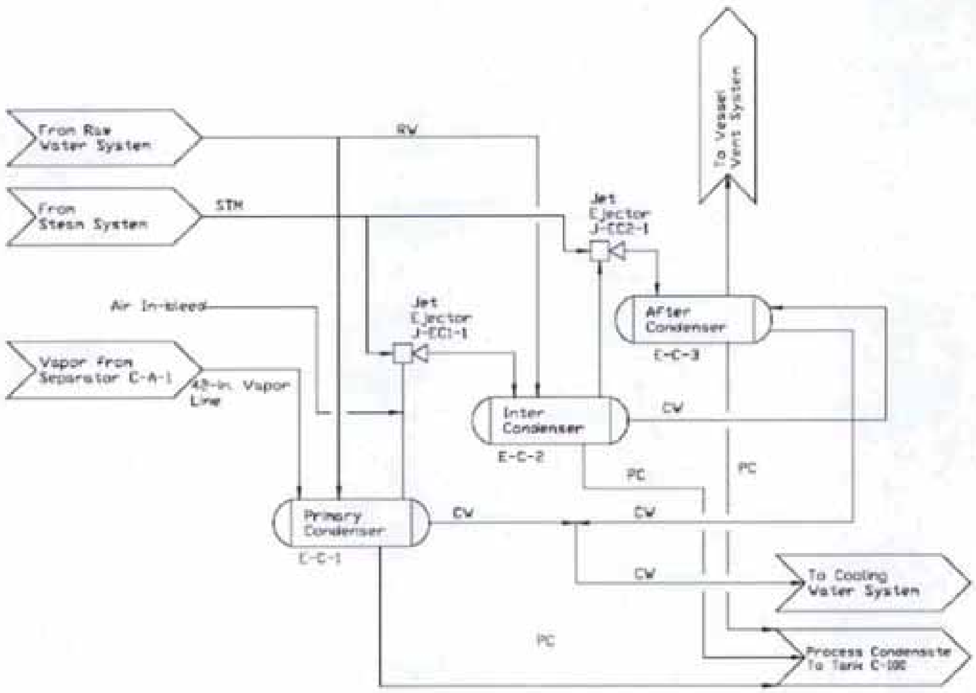
Intercondenser (E-C-2). Noncondensed vapors from E-C-1 enter the intercondenser. The vapor stream contacts the cooling tubes in the condenser where cooling water provides additional condensation. The condensate drains to the condensate collection tank (TK-C-100). Noncondensed vapors and used cooling water are routed to the aftercondenser.

The carbon steel intercondenser measures 2.2 meters (7.2 feet) long with a 0.39 meter (1.3 feet) inside diameter. This heat exchanger contains 144 tubes that are 1.7 meters (5.6 feet) long with a 1.9-centimeter (0.75 inches) outside diameter.

Aftercondenser (E-C-3). Vapor discharged from the intercondenser enters the aftercondenser. Cooling is supplied to the aftercondenser by the cooling water from the intercondenser. Condensate is routed to the condensate collection tank (TK-C-100), while the noncondensed vapors are filtered, monitored, and discharged to the atmosphere through the vessel ventilation system. The cooling water is discharged to TEDF.

The carbon steel aftercondenser measures 2.3 meters (7.5 feet) long and has a 0.20-meter (0.66 feet) inside diameter. This heat exchanger contains 45 tubes that are 1.8 meters (5.9 feet) long with a 1.9-centimeter (0.75 inches) outside diameter.

Steam Jet Ejectors. The vacuum that draws the vapors from C-A-1 into the condensers is created by a two-stage steam jet ejector system. The first-stage jet ejector (J-EC1-1) maintains a vacuum on the primary condenser, which in turn creates a vacuum on the vapor-liquid separator. The ejector consists of a steam jet, pressure controller, and air bleed-in valve. Steam and non-condensed vapors from the primary condenser are ejected from J-EC1-1 into the intercondenser. The desired vacuum is obtained by controlling steam pressure and bleeding ambient air as necessary into the vapor header through an air intake filter. The second-stage jet ejector (J-EC2-1) creates the vacuum that moves vapors from the intercondenser through the aftercondenser.



Piping Abbreviations

AF	Anti-Foam	PS	Process Sewer
AS	Air Sample	PW	Process Waste
DECON	Decontamination	RW	Raw Water
DR	Drain	SC	Steam Condensate
EF	Evaporator Feed	SL	Slurry
EL	Eluent	STM	Steam
FRW	Filtered Raw Water	SW	Sanitary Water
I	Instrument	U	Utility
IA	Instrument Air	CW	Cooling Water
OVFL	Overflow	V	Vent
PA	Process Air	VAC	Vacuum
PC	Process Condensate	VV	Vessel Vent
CR	Condensate Recycle		

SOURCE: FIGURE 4.5 FROM PERMIT NO. WA 7890008967
(ECOLOGY, 2004 AND 2007 IAP)

1.8

COOPER ZIETZ ENGINEERS, INC.

242-A Evaporator
Integrity Assessment
Hanford Reservation

242-A Evaporator
Vacuum Condenser
System

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Figure 1.8 242-A Evaporator Vacuum Condensate System

Condensate Collection Tank (TK-C-100). Process condensate from the primary condenser, intercondenser, aftercondenser, and the vessel ventilation system drain to the condensate collection tank (TK-C-100). The tank is 4.3 meters (14.1 feet) in diameter, 5.8 meters (19 feet) high, and is constructed of 0.79-centimeter (0.31 inches)-thick stainless steel. The tank has a maximum design capacity of 67,400 liters (17,805 gallons). Normal operating volume is approximately 50 percent of the tank capacity. A carbon steel base supports the tank. An agitator is installed but not used.

In the event of a tank overflow, the solution is routed through an overflow line to the drain system, which returns waste to the feed tank (241-AW-102). Overflow occurs when the volume exceeds about 60,600 liters (16,009 gallons). The overflow line is equipped with a liquid filled trap to isolate the drain system from the tank.

Process feed samples are evaluated for the presence of a separate organic layer and process controls are used to reduce the risk of the condensate collection tank to receive small amounts of immiscible organics with the condensed waste. If detected, the organic layer is removed by overflowing tank TK-C-100 back to the feed tank 241-AW-102. The liquid level in the tank is controlled well above the discharge pump intake point and a controlled overflow is conducted upon completion of each processing cycle (campaign) to ensure that an organic layer does not accumulate and cannot be pumped to the LERF.

Process Condensate Pump (P-C-100). This pump moves the process condensate from tank TK-C-100 through the condensate filter to LERF. The process condensate pump is a centrifugal pump constructed of 316 stainless steel.

Condensate Filters. After leaving the condensate collection tank, the process condensate is filtered to remove solids using two condensate filters. The primary condensate filter (F-C-1) has a welded steel housing. A second filter system (F-C-3), installed downstream is also used to filter the process condensate that is routed to sampler SAMP-RC3-1. This system has a cast iron housing. Both filters employ a filter material that is compatible with the process condensate.

Process Condensate Radiation Monitoring, Sampling and Diversion System. The process condensate transferred to LERF is monitored continuously for radiation. If radiation levels exceed established limits, an alarm is received and interlocks immediately divert the stream back to the condensate collection tank (or the feed tank) and shut off the process condensate pump. This ensures process condensate containing excessive radionuclides due to an accidental carryover from the vapor-liquid separator is not transferred to LERF.

Seal Pot. The condensate collection tank receives condensed liquids from the vessel ventilation system. A seal pot collects the drainage before discharge into the condensate collection tank and isolates the tank from the vessel ventilation system. The seal pot discharge is a hazardous waste.

Process Condensate Recycle System For waste minimization, a portion of the process condensate from tank TK-C-100 is recycled for use as decontamination solution for the de-entrainment pad sprays and seal water for the recirculation pump (P-B-1) and slurry pump (P-B-2). Use of process condensate instead of raw water results in approximately 10 percent reduction in waste volume generated during continuous operation of the 242-A Evaporator unit. Filtered raw water also is available as a backup for sprays and seal water. A 2-inch (5.1 centimeters) diameter carbon steel line, stainless steel centrifugal pump (P-C-106), and filters (F-C-5 and F-C-6) supply process condensate from tank TK-C-100 to the pad sprays and pump seals. The filters are disposable cartridge filters in carbon steel housings arranged in parallel with one filter in service while the other is in standby.

1.4.5.3 Building and Secondary Containment Subsystem

This section describes the 242-A Building secondary containment and transfer line containment for the 242-A Evaporator.

1.4.5.3.1 242-A Building Secondary Containment

The 242-A Building serves as a secondary containment vault for the vapor-liquid separator (C-A-1), condensate collection tank (TK-C-100), and ancillary equipment used for transferring mixed waste at the 242-A Evaporator. Figure 1-9 shows the 242-A Building Structural Components. The concrete for the operating area was poured to form a monolithic structure. Where needed, joints in the concrete were fabricated with preformed filler conforming to the standards of the American Society of Testing and Materials. Joint filler is sealed with a polysulfide sealant per the requirements of the construction specifications (Vitro 1974).

Before restart in 1994, a new acrylic special protective coating was applied to the concrete in the pump, evaporator, and condenser rooms. The coating meets the requirements of the construction specifications (Vitro 1974), including resistance to very high radiations doses, temperatures of 77°C (171°F), and spills of 25 percent caustic solution.

The following five rooms have historically contained equipment process or store mixed waste. The loadout and hot equipment rooms no longer are used for the storage of liquid waste.

- Pump room
- Evaporator room
- Condenser room
- Load out room (used for temporary storage of mixed waste)
- Hot equipment storage room

Additionally the Ion exchange room has a single pipe with no valves that may be used to recycle process condensate within the 242-A Evaporator unit. This room also has a special protective coating.

Pump Room (Figure 1.10). The pump room secondary containment walls are 0.38 to 0.56-meter (1.25 to 1.84-feet) thick reinforced concrete. The secondary containment floor is 0.51-meter (1.67-feet) thick reinforced concrete. The pump room floor is lined with 0.64-centimeter (0.25-inch) stainless steel and the concrete walls and ceiling cover blocks are painted with a special protective coating. The pump room contains pipe jumpers used to transport feed and slurry solutions between the vapor-liquid separator and the DST System, and the process recirculation loop, recirculation pump (P-B-1), and slurry pump (P-B-2).

Leaks in the pump room collect in the pump room sump, a 1.5-meter (4.9-feet) by 1.5-meter (4.9-feet) by 1.8-meter (5.9 feet) deep sump with a 0.64-centimeter (0.25-inch) stainless steel liner. The pump room sump as part of the secondary containment collects spills from various sources for transfer to the feed tank, 241-AW-102.

Figure 1.13 provides a simplified process flow schematic of sources, which drain to the pump room sump. Drainage to the sump includes:

- Loadout room floor drain
- Hot equipment storage room floor drain
- Leaks to the pump room floor from equipment in the pump room
- Evaporator room floor drain
- Raw water backflow preventer drain

Solution in the pump room sump is transferred to the feed tank (241-AW-102) using a steam jet. A 25.4-centimeter (10-inch) secondary containment overflow line is provided for draining large volumes of solution should a catastrophic tank failure occur. Because the overflow line provides a direct path between the air space of tank 241-AW-102 and the pump room, a minimum level of water must be maintained in the sump to prevent cross ventilation. A leak into the pump room sump would be detected by a rise in the sump level. Instrumentation provides alarms on high sump level.

The recirculation and slurry pumps in the pump room are equipped with mechanical seals having pressurized water introduced between the seals. The seal water is maintained at a pressure that exceeds the process pressure at the seal to ensure water leaks into the process solution, but waste solution does not leak out. Water from seal leak is collected in funnels in the pump room and routed to feed tank 241-AW-102 via the 10-inch (25.4-centimeter) overflow line described previously.

Evaporator Room (Figure 1.11). The evaporator room secondary containment walls are 0.56 meter (1.84-feet) thick reinforced concrete. The secondary containment floor is 0.51 meter (1.67 feet) thick reinforced concrete. The evaporator room contains the vapor-liquid separator vessel (C-A-1), part of the recirculation loop, the reboiler, the 1.07 meter (3.5 feet) vapor line, and drain line used to empty the vapor-liquid separator to feed tank 241-AW-102.

Leaks in the evaporator room flow to a floor drain that routes through a 3-inch (7.62-centimeter) line to the pump room sump. A leak in the evaporator room would be detected by a rise in the pump room sump level. The floor of the evaporator room and a portion of the pump room floor are 3.0 meters (9.84 feet) below grade to contain the entire contents of the vapor-liquid separator, reboiler, and recirculation loop in the event of a catastrophic failure. The floor and walls of the evaporator room up to an elevation of 1.8 meters (5.9 feet) are painted with a special protective coating.

Condenser Room (Figure 1.12). The condenser room secondary containment walls are 0.36- to 0.56-meter (1.18 to 1.84-feet) thick reinforced concrete. The secondary containment floor is 0.51 meter (1.67 feet) thick reinforced concrete. The condenser room contains all the components of the process condensate system, including tank TK-C-100.

Leaks in the condenser room flow to two floor drains that join and route through a 6-inch (15.24-centimeter) line to feed tank 241-AW-102. Leaks in the condenser room are detected by the following:

- Unexpected changes in liquid level in tank TK-C-100. Instrumentation is provided to monitor liquid level in the tank, including high- and low-level alarms.
- Daily visual inspections of process condensate system components and piping

The floor and walls of the condenser room up to an elevation of 1.2 meters (3.94 feet) are painted with a special protective coating.

Load out and Hot Equipment Storage Rooms. The load out and hot equipment storage rooms secondary containment walls are 0.30- to 0.56-meter (0.98- to 1.84-feet) thick reinforced concrete. The secondary containment floors are 0.15-meter (0.49-feet) thick reinforced concrete. The room contains two recirculation lines and samplers used to sample the feed and slurry streams. The lines and samplers are located in a shielded enclosure adjacent to the pump room wall.

The load out and hot equipment storage room contains two sumps: the drain sump and decontamination sump. The sumps are 0.91 meter (2.99 feet) in diameter, about 1.2 meters (3.94 feet) deep, and lined with stainless steel. Both sumps drain via a 7.62 centimeter (3-inch) drain line to the pump room sump. The sumps, floor, and walls of the load out and hot equipment storage room up to an elevation of 3.8 meters (12.47 feet) are painted with a special protective coating.

Leaks in the sampler piping, flow into two drains in the sample enclosure, which drain to the DST (Figure 1.13) via a 5.1 centimeter (2 inch) line to the DST. Leaks in the sampler piping are sensed by leak detectors in the sampler enclosures.

Ion Exchange Room. The Ion Exchange room is a small room connected to the Condenser room. This room previously contained an ion exchange column that has since been removed from the processing unit. The room contains a single pipeline used to transfer process condensate during a campaign, when the process condensate is used as part of the cooling system during recirculation. During non campaign periods this transfer line is drained. The pipeline runs vertically through the room and contains no valves, or other components that could release waste into the ion exchange room other than a rupture of the line. The floor and the walls of the ion exchange room are coated with a protective coating up to the ceiling. The ceiling is also treated with a protective coating.

Leaks in the ion exchange room are detected by daily visual inspection during the campaign. No inspections are required when process condensate is not present in the transfer line or during non-campaign periods.

1.4.5.3.2 242-A Building Drain Lines

Figure 1.13 provides a simplified process flow schematic of sources routed to the 242-A Building drain lines. The 242-A Evaporator System RCRA Permit unit boundary includes these lines up until they exit the 242-A Building through the exterior wall. At this point, the lines are considered DST system components. Four lines serve to drain the 242-A Building and equipment to feed tank 241-AW-102:

- Pump room sump drain line (DR-334): a 25.4 centimeter (10-inch) carbon steel line that transfers process condensate overflow/diverted liquids and empty-out of the pump room sump to the feed tank.
- Vapor-liquid separator vessel drain line (DR-335): a 25.4 centimeter (10 inch) carbon steel line that allows gravity drain of the vessel to the feed tank
- Condenser room drain line (DR-343): a 15.24 centimeter (6-inch) carbon steel line that drains potential leak from the condenser room

- Diverted process condensate drain line (DR-338): process condensate liquid drains through DR-338 into sump drain line (DR-334) which drains to 241-AW-102

The four lines are sloped to drain about 170 meters (558 feet) to feed tank 241-AW-102 via the drain pit (241-AW-02D). Although WAC 173-303-640(1)(c) exempts systems that serve as secondary containment from requiring secondary containment, drain lines DR-334, DR-335, and DR-338 have outer encasement piping.

The drain lines are connected to a cathodic protection system to prevent external corrosion from contact with the soil. The cathodic protection system consists of:

- A rectifier that converts supplied alternating current voltage to an adjustable direct current voltage
- Numerous anodes buried near the underground piping and connected to the rectifier
- Return wiring that connects the piping to the rectifier, completing the circuit

The rectifiers are inspected to assure component degradation has not occurred. Test stations along the system are checked annually to verify 0.85 volt is maintained on the system, as required by the National Association of Corrosion Engineers.

Further detail regarding design and construction of DR-334,-335,-338 and -343 is provided in DOE/Richland Operations Office [RL]DOE/RL-90-39 (DOE-RL,1991) *Hanford Facility Dangerous Waste Permit Application Double-Shell Tank Systems.* Further detail regarding the design, operation, maintenance, and inspection of the cathodic protect system for these lines are also provided in DOE (1991).

1.4.5.3.3 Secondary Containment Sumps

Two sumps are located in the Load-Out and Hot-Equipment Storage Room. The load-out sumps are of identical construction and are concrete lined with stainless steel. Each sump is 91 cm (36 in) in diameter and 1.2 m (4 ft) deep. Construction details for these sumps are shown on Drawings H-2-69337, H-2-69338, and H-2-69366.

The west sump is used as a decontamination sump and is depicted as "Decon Sump" on Drawing H-2-98995 (Sheet 2). The sump receives influent from line 2"DR-420-M27 from SAMP-F-1 and SAMP-F-2 and from line ¾"DECON-805-M9. The sump is drained by line 3"DR-368-M27, which drains to line 3"DR-350-M27, which drains to the pump room sump (shown on Drawing H-2-98995, Sheet 2).

The east sump is used as a drain sump and is depicted as "Drain Sump" on Drawing H-2-98995 (Sheet 2). The sump is used as a drain sump for the Load-Out Room. Influent is not shown entering the sump. The sump is drained by line 3"DR-350-M27, which drains to the pump room sump (shown on Drawing H-2-98995, Sheet 2).

A third sump is located in the Pump Room. The sump is concrete and is lined with uncoated ¼" stainless steel. The Pump Room sump is 152 cm (60 in) by 152 cm (60 in) by 183 (72 ¼ in) deep. Construction details for this sump are shown on Drawings H-2-69337, H-2-69338, and H-2-69369. The Pump Room sump has an open top and is kept partially filled in order to maintain a liquid seal for the building ventilation system between the 242-A Evaporator building and AW-102. The Evaporator Building drains to the sump via a series of 1 ½- to 3-inch drain lines, as follows:

- Drain line 3"DR-350-M27 (which in turn collects effluent from multiple sources including line 3"FD [Loading Dock Room], line 3"FD [Load-Out Room], the Drain Sump [Load-Out Room], and the Decon Sump [Load-Out Room])
- Drain line 2"DR-351-M27
- Drain line 2"DR-M8 (which in turn collects effluent from multiple sources including line 1½"DR from the P-B-2 drip pan and line ½"SEAL WTR OUT from the P-B-2 pump seal via line 6"DF [Pump Room], and line 2"DR-402-M8 from the P-B-1 pump seal via line 6"DF [Pump Room])
- Drain line 1 ½"DR-400-M9 (which in turn collects effluent from line 1"DR-401-M5 via line 3"DF [Evaporator Room])
- Drain line 3"DR-369-M27, which collects effluent from line 3"FD (Evaporator Room)
- Drain line 3"SL-M27 (from PSV-PB2-1)

The pump room sump is drained by a 10" overflow line (10"DR 334), which drains by gravity to tank 241-AW-102 in tank farm 241-AW.

1.4.5.3.4 Variances from Secondary Containment Requirements

The RCRA Permit (WA7890008967, Attachment 35) for the 242-A Evaporator unit includes a description of variances for the following components of the secondary containment (Ecology 2003). The variances are described in Appendix 4B (the 1998 IAR).

Pump Room Sump. The pump room sump does not comply with secondary containment requirements because liquid must be kept in the sump to provide a seal to prevent airflow between the pump room and feed tank 241-AW-102. Although the sump has a 0.63-centimeter (0.25-inch) thick stainless steel liner to prevent corrosion of the concrete floor, the sump does not have secondary containment.

Routine Discharges through Secondary Containment. The configuration of the 242-A Evaporator unit requires routine, batch discharges of dangerous waste through secondary containment drain lines. These routine discharges include the following:

- Steam condensate, cooling water, and process condensate sample stations drain to the feed tank (241-AW-102) through drain line DR-343. Total discharge is about 38 liters (10 gallons) per month during operation.
- Sample bottle water sprays down in the feed and slurry sample stations drain to the decontamination sump in the load-out and hot equipment storage room. The decontamination sump then drains to the pump room sump. Total discharge is about 76 liters per month during operation.

Transfer Piping Wall Penetrations. Three dangerous waste transfer line piping sections passing through the 242-A Building wall are single-walled, meaning, no secondary containment exists inside the wall (about 56-centimeter-thick reinforced concrete).

These exceptions were identified to Ecology on October 28, 1993. Ecology's response stated, "No physical revision of the pipe wall penetrations or the floor drains in the evaporator pump room will be required prior to evaporator restart." The response required the following:

- If at any time a leak is seen or detected from these installations, or if for any reason these installations are repaired or rebuilt, they will be rebuilt or repaired in accordance with regulations.
- Should a spill occur in the evaporator pump room, the sump and the piping shall be rinsed three times as required in WAC 173-303-160, as appropriate. 'Appropriate' in this case means that the original regulation was written for a free container, not a sump, so that judgment will have to be used in the application of the regulation. The rinse shall be transferred to the double-shell tanks

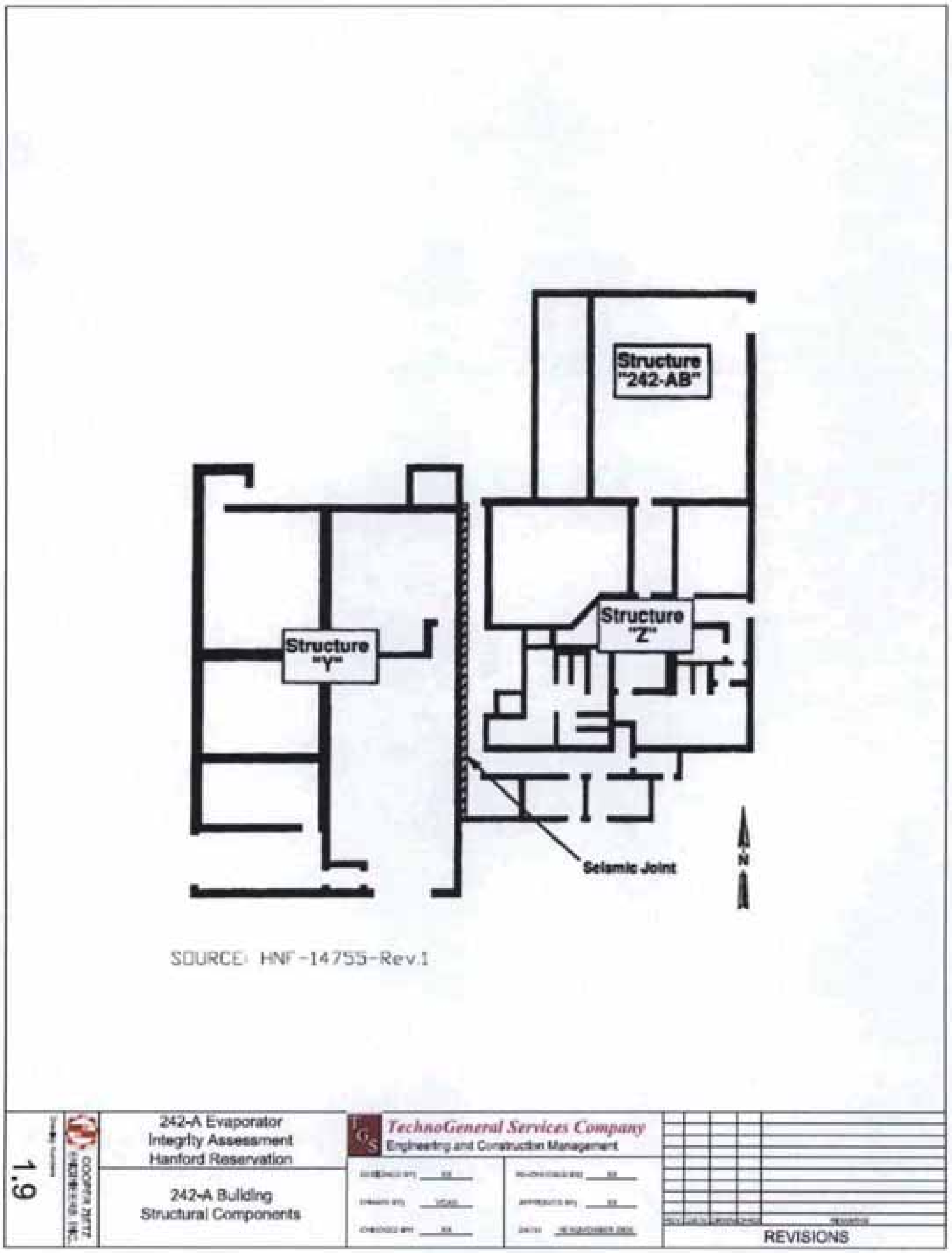
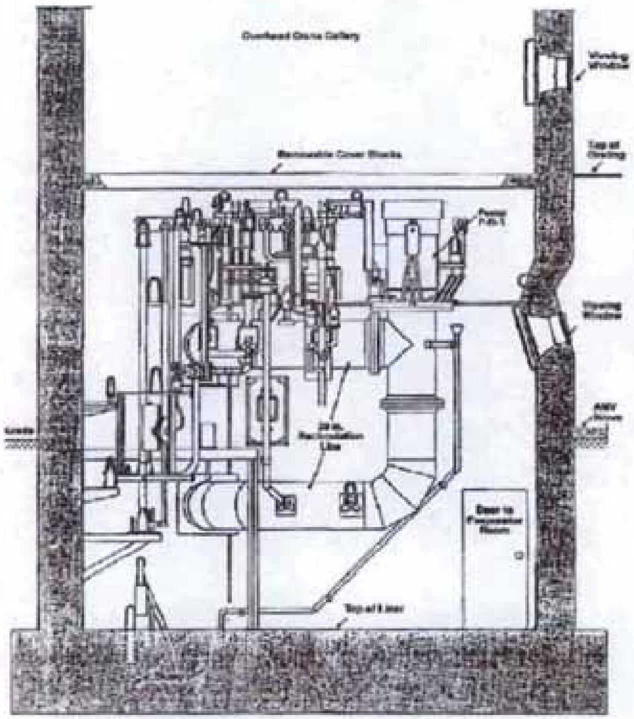


Figure 1.9 242-A Building Structural Components



Sectional drawing – not all equipment and piping shown.

SOURCE: HNF-14755-Rev.1

1.10	COOPER ZIETZ ENGINEERS, INC.	242-A Evaporator Integrity Assessment Hanford Reservation Pump Room	TechnoGeneral Services Company Engineering and Construction Management
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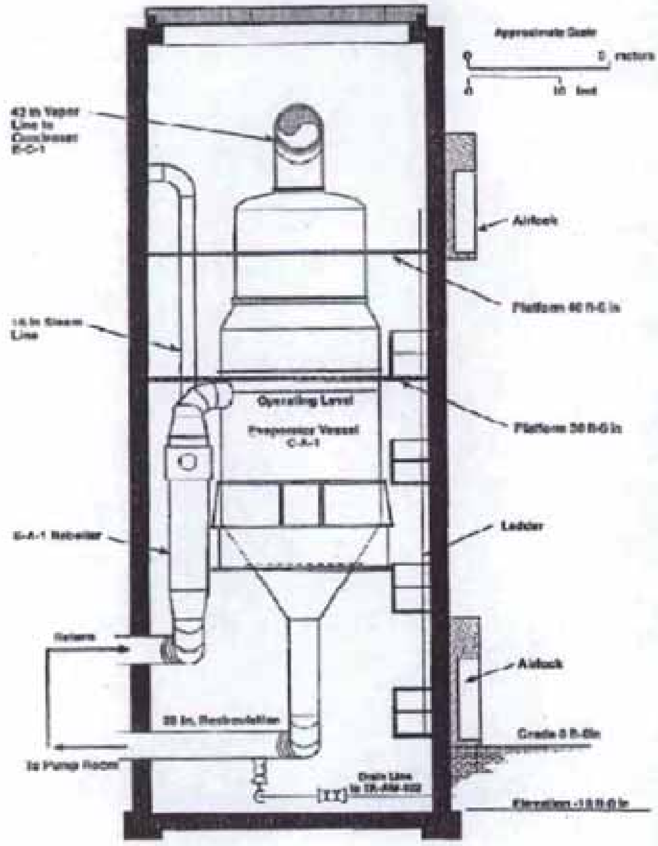
Figure 1.10 Pump Room



SOURCE: HNF-14755-Rev.1

1.11

COOPER ZIETZ ENGINEERS, INC.

242-A Evaporator
Integrity Assessment
Hanford Reservation

Evaporator Room

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Figure 1.11 Evaporator Room

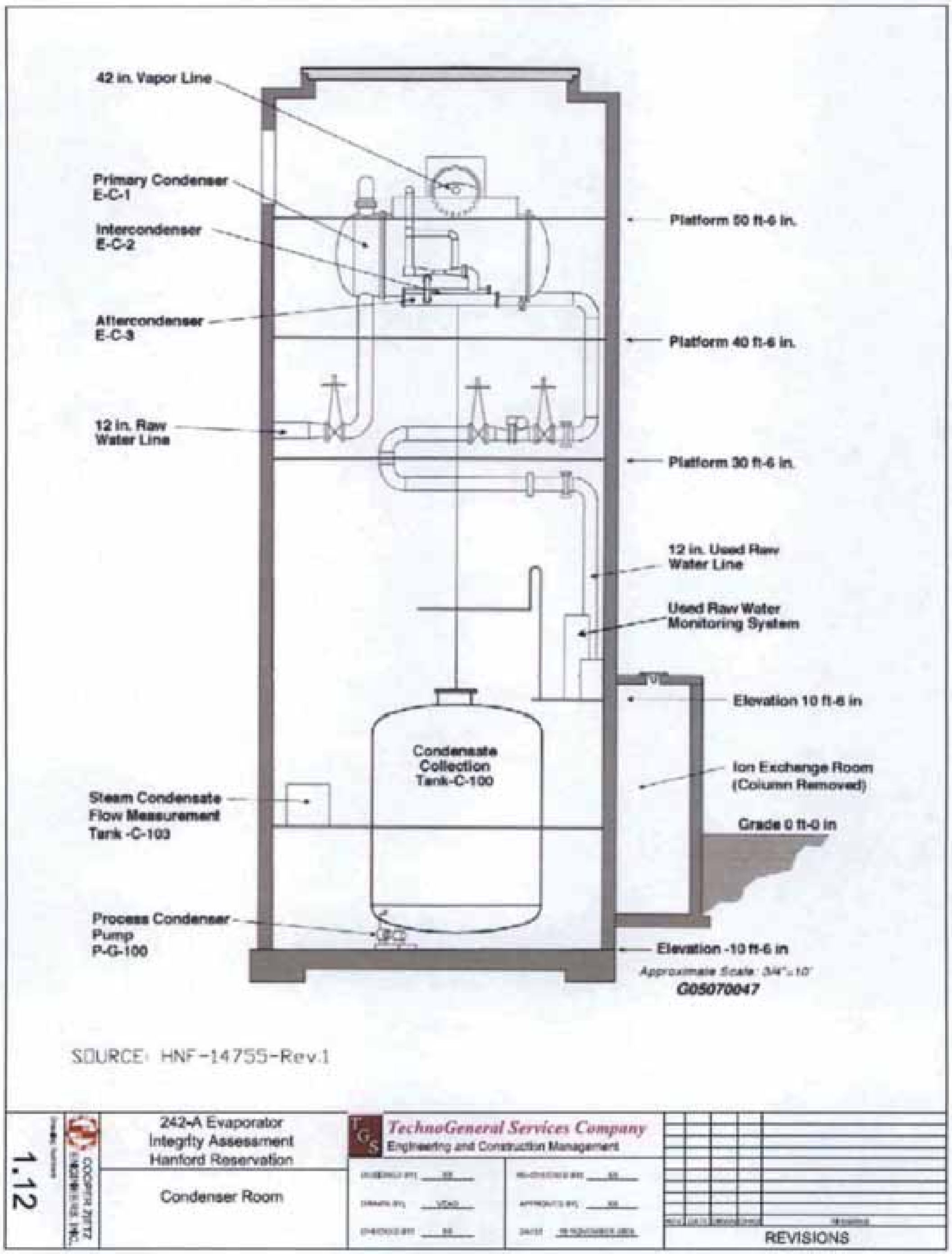


Figure 1.12 Condenser Room

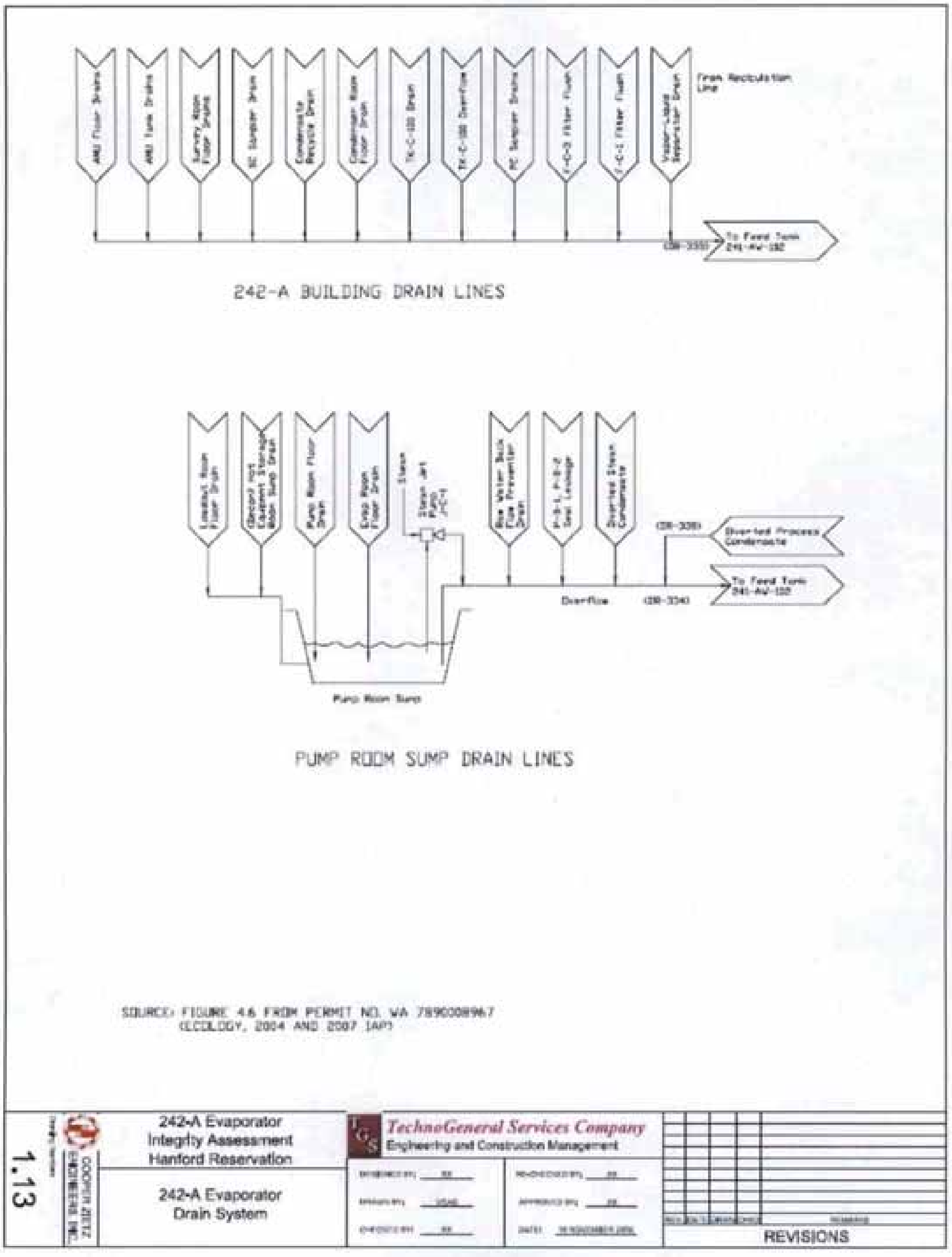


Figure 1.13 242-A Evaporator Drain System

2.0 INTEGRITY ASSESSMENT

State dangerous waste regulations require the integrity of existing tank systems storing dangerous waste to be assessed to "determine that the tank system is adequately designed and has sufficient structural strength and compatibility with the waste(s) to be stored or treated to ensure that it will not collapse, rupture or fail" (WAC 173-303-640(2)(c)). The integrity of 242-A Evaporator unit system described in Section 1.4 was assessed for the purposes of compiling this report by reviewing numerous references, including the following items:

- Codes, design standards, and regulations
- Available design plans, as-built drawings, and construction specifications
- Test reports for leak testing and ultrasonic testing
- Campaign process control plans and post run documents
- Waste characterization data
- Inspection records
- Records of previous integrity assessments
- Life extension studies and implementation documents for unit upgrade and replacement-in-kind projects
- RCRA Permit documents

The following sections describe the specific considerations made by the IQRPE to complete the IA of the 242-A Evaporator unit in accordance with the requirements of WAC 173-303-640 (2).

2.1 Codes, Standards, and Regulations

An evaluation of the codes, standards, and regulations applicable to the 242-A Evaporator unit was completed as part of the integrity assessment. The codes, standards, and regulations used are referenced as necessary throughout this report.

An in depth review of the applicable codes and standards was performed for the 1993 IAR (WHC 1993). The 1998 IAR (LMHC 1998) did not include a review of applicable codes and standards. Instead, the report stated that the review and evaluation of the codes and standards performed for the 1993 IAR was sufficient (LMHC 1998). Subsequent to the 1998 IAR, a review of the codes and standards was performed as part of the DSA (HNF-14755 Rev 1).

A summary of the review and evaluation of the codes and standards performed for the 1993 IAR and 2004 DSA is presented in the following sections. These summaries cover structural specifications, structural analysis evaluations, design drawings evaluations, design standards evaluations, and guidance document reviews. Conclusions based on the evaluation of these codes, standards, and regulations for the 242-A Evaporator unit are presented at the end of this subsection.

2.1.1 Structural Specifications

Structural specifications for the 242-A and 242-AB buildings were defined during the original design and construction of the 242-A Evaporator unit using the latest editions of codes and standards in effect at the time of design. These structural specifications are divided into the following categories:

- Earthwork
- Concrete
- Masonry
- Structural steel
- Roofing

A detailed description of these structural specifications taken from HNF-14755 Rev 1 is provided in Attachment 2 to this IAR. Additional design correspondence is included as Attachment 9. No additional specifications have been prepared since the completion of the DSA because the 242-A Evaporator unit has not undergone any significant structural modifications since the completion of the1993 IAR. The 1993 structural analysis is therefore considered sufficient for this IAR.

2.1.2 Structural Analysis Evaluation

The 1993 IAR (WHC 1993) included an evaluation of the structural analyses that could be located for each component of the 242-A Evaporator unit. A summary of the structural analyses evaluated in the 1993 IAR is provided in Table 2.1.1. A structural analysis was not performed as part of the 1998 IAR or this IAR because the systems at the unit which handle dangerous waste have not undergone any significant modifications since the completion of the 1993 IAR. The 1993 structural evaluation is considered sufficient for this IAR.

2.1.3 Design Drawing Evaluation

Available design drawings and as-built drawings of the tank and piping systems for the 242-A Evaporator unit were reviewed (Table 2.1.2). The drawings were reviewed for materials of construction, design specifications, and code requirements for tanks and pressure vessels at the time of installation. This information was used to determine whether the tanks were suitable to contain dangerous wastes at the time of installation, and to evaluate any conditions which may have contributed to deterioration of a tank's structural integrity over time.

As-built, dimensioned drawings for some detailed areas of the condensate collection subsystem are not available because these drawings have not been recently updated. Specifically, dimensioned drawings are not available for the condensate filters or the condensate recirculation line. Supplemental information regarding these components was gathered from the systems engineer and via visual inspections conducted as part of the IA. With the aforementioned exceptions noted, a complete collection of as-built and P&ID drawings depicting the Vapor Liquid Separator and Condensate Collection subsystems were available for review by the IQRPE. These drawings are summarized in Table 2.1.2.

Table 2.1.1 Structural Analysis Performed for the 242-A Evaporator Unit

Component	Structural Analysis (SA) Performed	Comments/Recommendations	Reference
242-A Evaporator Facility	Review performed by Blume and Scott.	Meets or exceeds the current natural phenomena hazards criteria for a Safety Class 2 Moderate Hazard Facility	SD-WM-DP-019 (WHC 1993)
Evaporator, C-A-1	Performed by Struthers for 242-S Evaporator vessel; no separate analysis performed for 242-A Evaporator vessel. Vitro approved for establishing evaporator material thickness only. Struthers report limited to the vessel support rings.	Vitro recommended a more comprehensive stress report; a seismic analysis to enhance confidence in the structural integrity of the evaporator during an earthquake event.	SD-WM-DP-019 (WHC 1993)
Reboiler, E-A-1	No SA was located; however, certified by code data report to be in accordance with the ASME code.	Testifies that appropriate design parameters were considered and that the authorized code inspector verified that applicable calculations were completed and on file at the manufacturer's plant at the time of Data Report signed.	SD-WM-DP-019 (WHC 1993)
E-C-1, Primary Condenser	No SA located for the original condenser; replaced condenser was certified by code data report; stress analysis conducted during a water hammer event in 1992 showed that condenser heads, flow dividers, and head bolts may have exceeded ASME Section VIII, Division I, code stress allowable.	Recommended additional inspections and tests to assure the system integrity.	SD-WM-DP-019 (WHC 1993)
E-C-2, Inter Condenser	No SA located	Constructed in accordance with ASME VIII, Division I, criteria; certified by code data report.	SD-WM-DP-019 (WHC 1993)

Table 2.1.1 Structural Analysis Performed for the 242-A Evaporator Unit

Component	Structural Analysis (SA) Performed	Comments/Recommendations	Reference
E-C-3, Inter Condenser	No SA located.	Constructed in accordance with ASME VIII, Division I, criteria; certified by code data report.	SD-WM-DP-019 (WHC 1993)
TK-C-100, Condensate Collection Tank	No SA located	Fabricated, inspected and tested in accordance with ASME VIII, Division 1 criteria; not certified by code data report; wall thickness inspections meet or exceed the minimum wall thickness of 0.16 inch.	SD-WM-DP-019 (WHC 1993)
TK-C-103, Condensate Measurement Tank	No SA located	Constructed in accordance with ASME VIII, Division 1 criteria.	SD-WM-DP-019 (WHC 1993)
Seal Pot Liquid Seal	No SA located	Constructed in accordance with ASME VIII, Division 1 criteria.	SD-WM-DP-019 (WHC 1993)
Recirculation Pump (P-B-1)	No SA located	New pump installed by B-534 project; flow sizing, nozzle loading, and lifting yoke analysis performed; no documentation to qualify the pump in accordance with the seismic requirements of the UBC-85.	SD-WM-DP-019 (WHC 1993)
Bottoms Pump (P-B-2)	No SA located	New pump installed by B-534 project; flow sizing, lifting attachment loading analysis performed.	SD-WM-DP-019 (WHC 1993)
Condensate Pump (P-C-100)	No SA located	New pump installed byB-534 project; flow sizing analysis performed.	SD-WM-DP-019 (WHC 1993)
Recirculation Piping	Performed SA by Struthers, but no detailed analysis report located; Only summary report by RHO was located; summary report addresses the thermal flexibility of the recirculation system with various piping configurations; performed insulation sizing calculations;	Summary report recommended for support modifications and recirculation pump nozzle loading resulting from thermal loading conditions; no other loading conditions discussed.	SD-WM-DP-019 (WHC 1993)

Table 2.1.1 Cont' Structural Analysis Performed for the 242-A Evaporator Unit

Component	Structural Analysis (SA) Performed	Comments/Recommendations	Reference
Other 242-A Evaporator Piping	Piping stress analysis performed by Kaiser Engineering as part of B-534 project listed below: Evaporator discharge piping Jumper 38 to P-B-1 Jumper (P-B-2) C to 4&5 Jumper P-B-2 At nozzle "C" on 28" recirculation loop Jumpers C to 13 & (P-B-2) A to (P-B-2) B	No additional piping stress analysis were found for the remaining evaporator piping. This is a very small portion of the piping system.	SD-WM-DP-019 (WHC 1993)
Other 242-A Evaporator Piping (Continued)	Hydrostatic pressure distribution for evaporator system piping Jumper modification analysis E-C-1 safety relief valve discharge flow analysis Lifting bail analysis for jumper P-B-2C to 4 & 5 inch Hoop & Longitudinal stress of 2" & 3" P-B-2 jumper piping due to hydrostatic over pressurization Jumper J to 13A stress analysis Jumper D to 13A stress analysis P-B-2 relief valve over pressure device sizing P-B-2 discharge line analysis Thrust block for 14' RW line Static pressure calculations, vessel vent system	No additional piping stress analysis were found for the remaining evaporator piping. This is a very small portion of the piping system.	SD-WM-DP-019 (WHC 1993)
Miscellaneous B-534 Upgrades & Modifications	Pressure transducer to vessel wall reinforcement (Reboiler E-A-1) Lifting structure for E-C-1 condenser E-C-1 safety relief valve piping Removable beam for E-C-1 end bell lifting device Qualification of existing reinforced concrete floor for pipe support load.		SD-WM-DP-019 (WHC 1993)

Table 2.1.2 Design Drawings Reviewed

Number	Sheet	Rev	Date[(1)]	Drawing Title	Notes
H-14-020802	6 of 10	6	10/11/2006	Waste Transfer System (WT) O&M System P&ID	
H-2-69328	1of 1	1	12/1/1976	Process Hydraulic Diagram	Note[(2)]
H-2-69328	1 of 1	1	12/1/1976	Process Hydraulic Diagram	Note[(2)]
H-2-69335	1of 1	1	2/14/1977	Piping Arrangement Plans Above El 722'-0" Condenser Room	Note[(2)]
H-2-69337	1 of 1	4	7/22/1977	Piping Arrangement Pump Room & Hot Equipment Storage Plan	Note[(3)]
H-2-69338	1of 1	4	7/22/1977	Piping Arrangement Pump Room & Hot Equipment Storage Sections	Note[(3)]
H-2-69339	1of 1	2	12/1/1976	Piping Arrangement Evaporator Room Plans	Note[(2)]
H-2-69340	1 of 1	3	7/1/1977	Piping Arrangement Evaporator Room Sections	Note[(3)]
H-2-69342	1of 1	4	10/4/1977	Piping Arrangement Condensate Room Section	Note[(3)]
H-2-69343	1of 1	5	11/14/1988	Piping Arrangement Condenser Room Section	Note[(3)]
H-2-69344	1 of 1	2	7/1/1977	Piping Arrangement Condenser Room Section & Details	Note[(3)]
H-2-69351	1of 1	1	12/9/1976	Jumper Arrangement Pump Room Elevation	Note[(2)]
H-2-69357	1of 1	2	12/9/1976	Condensate Tank TK-C-100 Assembly and Details	Note[(2)]
H-2-69369	1of 1	1	12/9/1976	Pump Room Sump Assembly and Details	Note[(2)]
H-2-69370	1of 1	1	12/9/1976	Flow Measurement Tank TK-C-103 Assembly and Details	Note[(2)]
H-2-69374	1 of 2	3	5/16/1984	Jumper Arrangement Pump Room	Note[(2)]
H-2-69374	2 of 2	0	5/21/1984	Jumper Arrangement Pump Room	
H-2-79590	1 of 1	3	6/20/1990	Civil Plan, Sections and Details Cell Basin Bottom Liner	
H-2-79591	1 of 1	3	6/20/1990	Civil Plan, Sections and Details Cell Basin Top Liner	
H-2-79592	1 of 3	3	6/20/1990	Civil Sections & Details Cell Basin	
H-2-79593	1 of 2	4	6/20/1990	Civil Plan Sections & Det Catch Basin	
H-2-79601	1 of 4	3	9/17/1998	P&ID 242-A Evaporator Legend	
H-2-79601	2 of 4	4	9/1/2000	P&ID Evaporator BLDG & XCY Piping	Note[(4)]
H-2-79601	3 of 4	5	9/1/2000	P&ID 242-A Evap Retention Basins	Note[(4)]
H-2-79602	2 of 3	4	9/1/2000	P&ID 242-A Evap Retention Basins	Note[(4)]
H-2-79604	1 of 1	3	7/22/1998	Piping Plot & Key Plans 242-A Evap Cond Stream	
H-2-79605	1 of 1	3	9/17/1998	Piping Plan Sect & Det 242-A Evap Cond Stream	
H-2-79608	1 of 1	3	9/17/1998	Piping Plan Sect & Det 242-A Evap Cond Stream	
H-2-79609	1 of 1	3	6/17/1998	Piping Plans 242-A Evap Cond Stream	
H-2-79610	1 of 1	3	6/17/1998	Piping Plan Retention Basins	
H-2-79611	1 of 1	2	6/17/1994	Piping Plan Sections and Isometric 242-A Evap Stream	
H-2-79614	1 of 1	4	4/6/1998	Piping Plan Catch Basin	
H-2-79616	1 of 1	2	6/21/1994	Piping Sections Catch Basins 242AL-42-43-44	
H-2-79617	1 of 1	3	7/23/1998	Piping Sections Catch Basins 242AL-42-43-44	
H-2-79618	1 of 1	3	7/29/1998	Piping Details Catch Basins 242AL-42-43-44	
H-2-79619	1 of 2	4	6/29/1998	Piping, Portable Manifold Assembly Plans, Sect & Det	
H-2-79620	1 of 3	5	11/10/2003	Piping Elev Sections & Dets Leachate Pump Assembly	
H-2-79623	1 of 1	2	1/3/1994	Piping Profile 242-A Evap Cond Stream	
H-2-88766	1 of 5	10	7/27/2005	P&ID LERF Basin & ETF Influent Evaporator	
H-2-88766	2 of 5	12	7/22/2006	P&ID LERF Basin & ETF Influent Evaporator	

Table 2.1.2 Cont' Design Drawings Reviewed

Number	Sheet	Rev	Date[1]	Drawing Title	Notes
H-2-88766	3 of 5	13	7/22/2006	P&ID LERF Basin & ETF Influent Evaporator	
H-2-88766	4 of 5	15	7/22/2006	P&ID LERF Basin & ETF Influent Evaporator	
H-2-88766	5 of 5	1	11/1/2001	P&ID LERF Basin & ETF Influent Evaporator	
H-2-98970	1 of 5	1	7/20/1991	Drawing List Area Map	Note[5]
H-2-98970	2 of 5	1	7/20/1991	Drawing List	
H-2-98970	3 of 5	2	2/6/1992	Drawing List	
H-2-98970	4 of 5	1	7/20/1991	Drawing List Area Map	Note[5]
H-2-98970	5 of 5	1	7/20/1991	Drawing List Area Map	Note[5]
H-2-98988	1 of 2	9	9/5/2006	P&ID Evap Recirc System	
H-2-98988	2 of 2	9	9/5/2006	P&ID Evap Recirc System	
H-2-98989	1 of 1	16	9/5/2006	P&ID Slurry System	
H-2-98990	1 of 2	13	7/21/2006	P&ID Process Condensate System	
H-2-98990	2 of 2	6	7/5/2005	P&ID Process Condensate System	
H-2-98993	1 of 1	20	7/5/2005	P&ID Steam Condensate System	
H-2-98994	1 of 1	16	7/5/2005	P&ID Used Raw Water System	
H-2-98995	1 of 2	13	7/23/2003	P&ID Drain System	
H-2-98995	2 of 2	8	7/5/2005	P&ID Drain System	
H-2-98996	1 of 1	5	5/19/1996	P&ID Decontamination System	
H-2-98998	1 of 1	12	7/5/2005	P&ID Vessel Vent System	
H-2-98999	1 of 1	14	7/5/2005	P&ID Vacuum Condenser System	
H-2-99002	1 of 1	8	1/4/2006	P&ID Jet Gang Valve System	
H-2-99003	1 of 1	16	1/5/2006	P&ID Filtered Raw Water System	
H-2-99009	1 of 1	2	7/19/1991	Piping Jumper Arrangement Pump Room	Note[6]
H-2-99029	1 of 1	2	2/5/1992	Piping Evaporator / Pump Room Plans & Section	Note[6]
H-2-99030	1 of 4	2	2/6/1992	Piping Evaporator / Pump Room Sections & Details	Note[6]
H-2-99030	2 of 4	2	11/11/1996	Piping Evaporator / Pump Room Sections & Details	Note[6]
H-2-99030	3 of 4	1	7/18/1991	Piping Evaporator / Pump Room Sections & Details	Note[6]
H-2-99030	4 of 4	1	2/7/1992	Piping Evaporator / Pump Room Sections & Details	Note[6]
H-2-99031	1 of 3	2	3/1/1997	Piping Condenser, AMU, & HVAC Room - Plans	Note[6]
H-2-99031	2 of 3	2	3/1/1997	Piping Condenser, AMU, & HVAC Room Sections and Details	Note[6]
H-2-99031	3 of 3	2	3/1/1997	Piping Condenser, AMU, & HVAC Room Sections and Details	Note[6]
H-2-99032	2 of 3	4	11/20/1996	Piping Condenser Room Sections & Details	Note[6]
H-2-99032	3 of 3	0	7/25/1991	Piping Condenser Room Plans & Sections	Note[6]
H-2-99033	1 of 3	4	3/9/1990	Piping Condenser, AMU, HVAC Room Section & Details	Note[6]
H-2-99033	2 of 3	2	3/22/1990	Piping Condenser Room Sections & Details	Note[6]
H-2-99033	3 of 3	0	7/25/1991	Piping Condenser Room Sections & Details	
H-2-99034	1 of 1	2	7/18/1991	Piping Pump and Condenser Room Site Preparation	Note[6]
H-2-99038	1 of 1	1	7/22/1991	Piping Jumper Arrangement Pump Room	Note[6]

Table notes on next page.

Table 2.1.2 Cont' Design Drawings Reviewed

Notes:

(1) Date stamped or most recent date found in title block

(2) Checked for as-built

(3) As-Built Record Dwg. Not For Fabrication

(4) VOID - See H-2-88766

(5) B-534 Package No. 1 242-A Evaporator Crystallizer Upgrade (KEH 1992)

(6) 242-A Evaporator Crystallizer Upgrade / Project B-534 (KEH 1992)

2.1.4 Design Standards Evaluation

This section provides a design standards evaluation for the 242-A Evaporator unit in support of the integrity assessment report required by WAC 173-303-640(2).

2.1.4.1 Design Standards Evaluation in the 1993 IAR

The 1993 IAR included a design standards evaluation of the 242-A Evaporator unit based on a review of the design standards to which the unit was constructed.

The design standards evaluation was performed on all associated piping, drains, valves sumps, secondary containment and tanks that receive, store, accumulate, transfer, or treat Washington State dangerous waste within the 242-A Evaporator Unit. A detailed list of equipment and components evaluated in 1993 is provided in the 1993 IAR (Appendix B, Table 1, WHC 1993). These systems were evaluated up to, but not including, the last valve or flange connection inside the 242-A Evaporator unit perimeter.

Table 2.1.3 is a complete list of the design standards and design criteria included in the original specifications for each of the unit components. Table 2.1.4 is a description of the specific "M" piping codes used for construction of the process piping lines within the 242-A Evaporator unit.

2.1.4.2 Design Standards Evaluation in the 1998 IAR

A detailed design standards evaluation was not performed as part of the 1998 IA because the systems at the unit which handle dangerous waste had not undergone any significant modifications or revisions since the 1993 IAR. The 1998 IAR concluded that the review and evaluation of the design standards performed for the 1993 IAR was sufficient for the 1998 IAR.

2.1.4.3 Design Standards Evaluation in the Documented Safety Analysis

Subsequent to the 1998 IAR, a detailed design standards evaluation was performed as part of the DSA (HNF-14755 Rev1). A detailed evaluation of structural and mechanical design criteria is provided in the DSA (Section 2.4.2.1, HNF-14755 Rev 1). The DSA also includes an evaluation of various operational issues encountered during campaigns between 1994 and 2001. This evaluation is included as Attachment 11. The 242-A Evaporator was originally designed and constructed (Project B- 100) in 1977 in accordance with Hanford Plant Standard Design Criteria (SDC) 4.1, Revision 6, *Design Loads for Facilities* (DOE/RL 1975), which established the design loads and acceptance criteria for all permanent Hanford Site facilities constructed at that time (HNF-14755 Rev 1). The standard was revised in September 1989 (SDC-4.1, Revision 11; *Standard Architectural - Civil Design Criteria: Design Loads for Facilities* [DOE-RL 1989]). A comparison of the original 242-A Evaporator design criteria to the criteria defined in SDC-4.1, Revision 11 is provided in Table 2.1.5.

The 242-A Evaporator unit was designed to withstand a 0.25g earthquake, a 100 mi/h high wind/tornado, and wind-generated missiles. These criteria exceed those required by SDC-4.1, Revision 11 for moderate hazard facilities and for Hazard Category 2 facilities. The 242-A Evaporator structure is qualified to PC-3 criteria.

Table 2.1.3 Equipment Design Standards and Design Criteria

COMPONENTS	DESIGN CRITERIA		COMMENTS
C-A-1 Evaporator	Standard(s):	ASME Section VIII Div. 1, HPS 230W & 220W	Designed by Struthers Nuclear and Process Co.
	Temperature:	200° F	
	Pressure:	Full Vacuum	
	Materials:	ASTM SA 240 304L (Shell)	
	Reference:	Construction Spec. B-100-P1, SD-WM-TI-003	
E-A-1 Reboiler	Standard(s):	ASME Section VIII Div. 1, HPS 230W & 220W	ASTM SA 312 304 (Nozzles)
	Temperature:	350°F (Shell), 250°F (Tubes)	
	Pressure:	100 psig (Shell), Full Vacuum (Tubes)	
	Materials:	ASTM SA 240 304L (Shell)	
	Reference:	Construction Spec. B-100-P1, SD-WM-TI-003	
P-B-1 Recirculation Pump	Standard(s):	Not Specified	New Installation per Project B-534
	Temperature:	200°F	
	Pressure:	Not Specified	
	Materials:	ASTM A296 Gr CF-8 and GrGF-8	
	Reference:	Procurement Spec. B-534-P4	
	Capacity:	14,000 GPM	
P-B-2 Bottoms Pump	Standard(s):	Not Specified	New Installation per Project B-534
	Temperature:	Not Specified	
	Pressure:	Not Specified	
	Materials:	Stainless Steel	
	Reference:	Procurement Spec. B-534-P11	

Table 2.1.3 –Cont' Equipment Design Standards and Design Criteria

COMPONENTS	DESIGN CRITERIA	COMMENTS
E-C-1 Primary Condenser	Standard(s): ASME Section VIII Div. 1, HPS 220W Temperature: 150°F (Shell and Tubes) Pressure: Full Vacuum (Shell), 100 psig (Tubes) Materials: SA285 GrC (Shell Heads, Internal Supports) Reference: Construction Spec. B-100-P1	A spare E-C-1 is in storage and has not yet been replaced
E-C-2 Intermediate Condenser	Standard(s): ASME Section VIII Div. 1, TEMAC Temperature: 350°F (Shell and Tube) Pressure: 100 psig to Full Vacuum (Shell), 100 psig (Tube) Materials: Carbon Steel Reference: Shutte and Koerting Co. Spec. Sheet 72-T-018-J-1	Replaced in 2004 ECN-721480-RO WP-EE-03-00085W
E-C-3 Final Condenser	Standard(s): ASME Section VIII Div.1, TEMAC Temperature: 350°F Pressure: 100 psig to Full Vacuum (Shell), 100 psig (Tube) Materials: Carbon Steel Reference: Shutte and Koerting Co. Spec. Sheet 72-T-018-J-1	Replaced in 2004 ECN-721480-RO WP-EE-03-00085W
TK-C-100 Condensate Catch Tank	Standard(s): ASME Section VIII Div. 1 & HWS 4311, Rev.2 Temperature: Not Available Pressure: 5 psig Materials: 347 SS Reference: H-2-69357 & H-2-40704	Modified in 1977 per ASME Sec. VIII Div. 2 New material ASTM A312 Type 304. 1124 gallon capacity

Table 2.1.3 Cont' Equipment Design Standards and Design Criteria

COMPONENTS	DESIGN CRITERIA		COMMENTS
TK-C-103 Condensate Measurement Tank	Standard(s): Temperature: Pressure: Materials: Reference:	ASME Section VIII Div. 1 Not Available Atmospheric ASTM A36 (Wier Plate ASTM A240 304L) H-2-69370	500 Gallon tank
Seal Pot, Liquid Seal	Standard(s): Temperature: Pressure: Materials: Reference:	ASME Section VIII Div. 1 Not Available Atmospheric ASTM A36 CS H-2-69368	27 Gallon tank
Building/Structure	Standard(s): Temperature: Pressure: Materials: Reference:	UBC, 1972 N/A N/A Poured in-place concrete Structural Dwgs. H-2-69276 thru 85 and H-2-69269 thru 75 and H-2-90739 thru 41	Seismic Design Loads: Horizontal, 0.25g DBE/0.125g OBE, Vertical, 2/3 horizontal. Coated with Carboline 305 chemically resistant coating.

Table 2.1.4 Pipe Materials and Codes

SYSTEM DESIGNATOR	MATERIAL
M1	ASTM A53, TYPE E OR S, GR A OR B, OR ASTM A106, GR A OR B
M2	ASTM A53, TYPE E OR S, GR A OR B, OR ASTM A106, GR A OR B
M5	ASTM A53, TYPE E OR S, GR A OR B, OR ASTM A106, GR A OR B
M7	ASTM A53, TYPE E OR S, GR A OR B, OR ASTM A106, GR A OR B
M8	ASTM A312, TP304L
M9	≤12" (30.5 cm): ASTM A312, GRTP304L, ≥14" (36 cm): ASTM A240, GRTP304L
M21	SS 304L, PER HPS-124-M
M24	ASTM A53, TYPE S, GR B, OR ASTM A106, GR B
M25	ASTM A53, TYPE S, GR B, OR ASTM A106, GR B
M27	SS ASTM A312, TYPE 304L
M31 (TUBING)	.035" (9 mm) WALL THK, ASTM A269, GR TP304
M32 (TUBING)	POLYETHYLENE, SINGLE LINE OR BUNDLED & SHEATHED IN PVC
M33 (TUBING)	COPPER ASTM B68
M42	ASTM A53, TYPE E OR S, GR A OR B, OR ASTM A106, GR A OR B

Table 2.1.5

Summary Comparison of the 242-A Evaporator to

Hanford Plant Standard Requirements for Severe Natural Phenomenon

Severe Natural Phenomenon	Original Design Criteria	Hanford Plant Standard SDC-4.1	Compliance
Wind			
242-A Building Processing Areas	113 km/h (70 mi/h)	129 km/h (80 mi/h)	Yes[a]
242-A Building Nonprocessing Areas	113 km/h (70 mi/h)	113 km/h (70 mi/h)	Yes
242-AB Building	113 km/h (70 mi/h)	113 km/h (70 mi/h)	Yes
Tornado	None	Not applicable	Yes
Flood	None	Not applicable	Yes
Seismic			
242-A Building Processing Areas	0.25 g	0.12 g	Yes
242-A Building Nonprocessing Areas[c]	0.25 g	0.12 g	Yes[b]

Notes:

[a] As a result of design requirements for seismic loads and radiation shielding, this portion of the facility can withstand winds in excess of 193 km/h (120 mi/h).

[b] Although the functional design criteria specified design for a 0.25 g seismic event, the K1 Ventilation System has not been formally evaluated.

[c] Nonprocessing areas are included as part of the IA because the 242-A Evaporator unit control room housing and MCS (e.g. interlock controls).

The original design criteria in DOE 6430.1A, Section 0111 (HNF-14755 Rev 1) established unit structural design requirements. It required that structures be protected against dynamic effects that could result from severe natural phenomenon, accidents at nearby facilities, and equipment failures. The specific severe natural phenomenon events to be considered were straight winds, tornados, floods, and earthquakes.

DOE 6430.1A referenced UCRL-15910, *Design and Evaluation Guidelines for Department of Energy Facilities Subjected to Natural Phenomenon Hazards* (HNF-14755 Rev 1), as guidance for selecting the magnitude of severe natural phenomenon that could impact a unit. UCRL-15910 suggested four usage categories for designing and evaluating DOE facilities:

- General Use - facilities that have a nonmission-dependent purpose
- Important or Low-Hazard - facilities that have mission-oriented use
- Moderate-Hazard - facilities where confinement of contents is necessary for public or employee protection
- High-Hazard - facilities where confinement of contents and public and environmental protection are of paramount importance. Facilities in this category represent hazards with potential long-term and widespread effects

Annual performance goals and criteria for exceeding these goals were established for each category. The magnitude of severe natural phenomenon could then be selected from hazard curves (return period versus magnitude) as a function of the unit-use category. Based on a hazard classification analysis performed for the unit as part of the DSA (HNF-14755 Rev 1) and the safety classification of systems and structures in use at the time, the 242-A Evaporator unit was categorized as a moderate-hazard structure.

The guidance provided in UCRL-15910 was incorporated into DOE-RL (1989). DOE-RL (1989) established the design loads and acceptance criteria for all new facilities and new additions to, or modifications of, existing facilities at the Hanford Site.

The functional design criteria for Project B-534 specified compliance with the minimum requirements of DOE-RL (1989). However, the majority of the 242-A Evaporator structures, systems, or components were designed and constructed before DOE 6430.1A, UCRL-15910, and DOE-RL (1989) were issued. Table 2.1.6 provides a summary of the compliance of the 242-A Evaporator with UCRL-15910 as implemented through DOE-RL (1989).

A review of the seismic design of the 242-A Building was performed as part of Project B-534 (References McCallum 1990a and 1990b in HNF-14755 Rev 1). This review concluded that the previous analysis (Reference JABE-VITRO-03 in HNF-14755 Rev 1) demonstrated the structural integrity of the unit to be adequate for a 0.25 g seismic event with the exception of underground utilities. In addition, although the previous analysis did not provide sufficient detail to predict a leak-tight structure following a 0.25 g seismic event, the review concluded that the potential for through-wall cracking was small. Thus, in the event of 0.12 g seismic event (the current standard), because the unit structure is designed for a 0.25g seismic event this can be credited as a barrier for liquid confinement (Table 2.1.5).

An additional evaluation (WHC-SD-WM-ER-102, 1992) of the 242-A Evaporator's seismic design basis was performed as part of the 1993 IAR. This evaluation concluded that the 242-A Evaporator exceeds the natural phenomena hazards criteria in DOE-RL (1989) for a moderate hazard unit-use category structure, and that the original seismic analyses performed by JABE compared favorably to the current criteria in WHC-SD-WM-ER-102 and UCRL-15910.

The 1993 IAR also included minimum allowable wall thickness calculations for the TK-C-100 Condensate Collection Tank to ensure that the wall thicknesses measured by UT were within allowable tolerances (WHC 1993). The DSA (HNF-14755 Rev 1) also includes a seismic analyses reviewed to ensure that the 242-A building structure could withstand a design basis earthquake.

Finally, the equipment anchorage design at the time of construction met the Uniform Building Code (UBC 1988). Therefore, the DOE 6430.1A requirements for compliance with UBC 1988 seismic anchorage requirements were met. The DSA (HNF-14755 Rev 1) determined that any differences between the 1988 and current codes were negligible.

Table 2.1.6 Summary of Compliance Assessment

DOE Order	Total Criteria	Applicable Criteria	Compliance	
			Yes	No
5400.5, Radiation Protection of the Public and Environment	11	0	N/A	N/A
5480.11, Radiation Protection for Occupational Workers	9	7	7	0
5480.5, Safety of Nuclear Facilities	7	0	N/A	N/A
435.1, Radioactive Waste Management	31	11	9	2
5480.7,FireProtection	26	19	17	2
6430.1A, General Design Criteria	676	231[a]	163	37
Totals	760	268	196	41

Notes:

[a] Includes 31 indeterminate criteria.

Source:
WHC-SC-WM-CR-042, 1991, Comparative Evaluation of the 242-A Evaporator Department of Energy Design Criteria, Westinghouse Hanford Company, Richland, Washington in reference HNF-14755 Rev1.

A seismic analysis for the pump room sump stainless steel liner has not been conducted. This liner simplifies sump decontamination and provides a leak-tight container for spills in the pump room. The concrete walls and floor support the liner. As the concrete foundation supporting the liner will withstand a 0.25 g safe shutdown earthquake, it is expected that the liner will also retain its integrity during an event of this magnitude.

2.1.5 Guidance Documents

The following design codes, standards, regulations, and U.S. Department of Energy (DOE) orders were reviewed and compared the current operational configuration of the 242-A Evaporator to design criteria established in the DOE orders in the DSA (HNF-14755 Rev 1):

- 10 CFR 830, "Nuclear Safety Management"
- 10 CFR 835, "Occupational Radiation Protection"
- DOE O 435.1, *Radioactive Waste Management*
- DOE O 5400.5, *Radiation Protection of the Public and the Environment*
- DOE O 5480.11, *Radiation Protection for Occupational Workers*
- DOE O 5480.28, *Natural Phenomena Hazards Mitigation*
- DOE O 6430. 1A, *General Design Criteria*
- DOE O 414. 1A, *Quality Assurance*
- DOE O 420.1, *Facility Safety*
- DOE-STD- 1020-94, *Natural Phenomena Hazards Design and Evaluation Criteria for Department of Energy Facilities*
- DOE-STD- 1021-93, *Natural Phenomena Hazards Performance Categorization Guidelines for Structures, Systems, and Components*
- DOE-STD- 1022-94, *Natural Phenomena Hazards Characterization Criteria*
- DOE-STD- 1023-95, *Natural Phenomena Hazards Assessment Criteria.*

The 242-A Evaporator unit was designed and constructed in accordance with the functional and safety requirements documented in project functional design criteria, specifications, and drawings (WHC-SD-TWR-RPT-002, 1998), *Structural Integrity and Potential Failure Modes of the Hanford High-Level Waste Tanks* before current design requirements were issued.

Compliance with specific design requirements are documented in the DSA (HNF-14755 Rev 1). Because the unit has not undergone any significant modifications since the completion of the DSA, a separate comparison of the listed documents was not completed as part of this report.

2.1.6 IQRPE Concurrence

The IQRPE concurs with the use of the codes, standards, and regulations that have been designated in the technical specifications for the design and construction of the 242-A Evaporator unit. The systems that handle dangerous waste have not undergone any significant modifications since the 1993 IAR. The review and evaluation of the codes and standards performed for the 1993 IAR, 1998 IAR, and 2004 DSA (WHC 1993, LMHC 1998, and HNF-14755 Rev 1, respectively) is, therefore, sufficient for this IAR.

2.2 Waste Characteristics

The 242-A Evaporator receives mixed waste (i.e., waste containing both radioactive and hazardous components) as feed. Other wastes include the pumpable liquid fraction of the waste stored in underground single shell tanks (SSTs) as a part of interim stabilization, and laboratory waste. Waste from the sources identified above has historically been segregated into four categories for storage in DSTs. The four categories were:

- Aging Waste - first cycle waste from Plutonium and Uranium Recovery by Extraction (PUREX) that has not cooled or been processed to permit storage in a nonaging waste DST. Aging waste has not been processed through the 242-A Evaporator unit.
- Complexed Waste - waste that typically has a total organic carbon (TOC) concentration above 10 grams/Liter (g/L) when evaporated to double-shell slurry feed (DSSF) product composition, or that exhibits rapid viscosity increase upon crystallization.
- Phosphate Waste - waste resulting from decontamination operations previously conducted at the N Reactor
- Noncomplexed Waste - waste consisting of dilute waste solutions that originate from PUREX and other sources planned to be treated by the 242-A Evaporator unit, as well as more concentrated waste that has been treated previously by the 242-A Evaporator unit.

Waste to be treated, or candidate waste, is pumped from various DSTs and staged in a selected DST for sampling and analysis. If the candidate waste is acceptable for processing, it is transferred to feed tank 241-AW-102, which serves as the feed tank for the 242-A Evaporator unit. Feed tank 241-AW-102 is a 3.8×10^6 Liter (1×10^6 gallon) underground DST located south of the 242-A Evaporator unit in the 241-AW Tank Farm. Process control limits are established for each 242-A Evaporator unit campaign based on pre-campaign characterization data. Waste fed to the 242-A Evaporator unit is supernate taken from the DST System in accordance with the RCRA Permit Waste Analysis Plan (Ecology 2005); the sludge is not processed through the 242-A Evaporator unit.

Waste processing at the 242-A Evaporator requires laboratory characterization to identify the concentration process end point. Laboratory characterization includes bench-scale evaporation (boil down) of feed samples simulating the 242-A Evaporator unit boiling point temperature, vacuum, and density. Determining the end point characteristics assists engineering and operations staff in establishing 242-A Evaporator unit operating parameters prior to the start of each campaign.

The Evaporator generates two liquid streams: a concentrated slurry stream and a process condensate stream. The slurry is an aqueous solution containing the same components as the feed stream with increased concentrations. Most of the volatile constituents are evaporated and transferred to the process condensate. These waste streams are Washington State dangerous waste (categorized as "Extremely Hazardous Waste" by the Part A permit application, Ecology 1998).

The steam condensate, cooling water, and used raw water (back flush water) generated by the evaporator process are not listed as dangerous wastes by Washington State. These wastes are not discussed in this report because these streams are not dangerous waste per WAC 173-303.

The following sections describe the waste characteristics of the evaporator feed, concentrated slurry, and process condensate streams.

2.2.1 Evaporator Feed Composition

The 242-A Evaporator receives a mixed blend of feed from tanks throughout the double-shell tank systems via the Evaporator feed tank, 241-AW-102. The feed in the past has contained the following liquid wastes:

- Wastes originated from B Plant and aging waste condensate
- Pre-campaign cold runs
- Waste water from terminal cleanout of the PUREX facility
- Single shell tank salt well liquor and dilution water
- Salt well pumping solutions from tank farms
- Previously evaporated wastes (double-shell slurry feed)
- Heel water from maintenance upgrades
- Heel water from previous campaigns
- Pot dumps
- Catch tank water
- Pump seal water
- Post-campaign flush water and water addition during campaign start-up

The physical and chemical characteristics of the 242-A Evaporator feed vary from one campaign to the next. In general, the feed is a highly-alkaline liquid (approximately pH 13) with a specific gravity up to 1.4. The temperature of the feed pumped from feed tank 241-AW-102 is approximately 25°C (77°F). The primary chemical constituents are sodium hydroxide, sodium nitrate, sodium nitrite, sodium carbonate, sodium aluminate, and sodium sulfate. Small quantities of organic chemicals are also present. Tables 2.2.1 and 2.2.2 present inorganic and organic constituent concentrations of the feed. These values were derived during development of the process flow sheet for the DSA (HNF-14755 Rev 1).

Table 2.2.1 Inorganic Constituents

Inorganic Constituent	Concentration (mg/L)		
	Evaporator Feed	Concentrated Slurry	Process Condensate
pH (unit less)[1]	13.00	13.00	10.00
Sp.G (uni less)[1]	1.30	1.40	1.00
Temperature[1]	109.4^0 F (43^0 C)	125.6^0 F (52^0 C)	82.4^0 F (28^0 C)
TOC[1]	3.30E+03	4.60E+03	2.60E+02
TDS[1]	0.00	0.00	3.40E-01
Alpha (µCi/ML)[1]	0.00E+00	2.90E-11	5.70E-11
Beta (µCi/ML)[1]	0.00E+00	3.50E-10	6.80E-13
Aluminate	2.20E+04	3.20E+04	4.1 E+01
Ammonium	9.3 E+02	1.3 E+02	2.3 E+03
Barium	9.8 E+00	1.4 E+01	3.0 E-02
Boron	1.2 E+01	1.7 E+01	3.5 E-02
Calcium	5.1 E+01	7.3 E+01	1.9 E+00
Cadmium	1.1 E+01	1.60E+01	3.1 E-02
Carbonate	8.7 E+03	1.2 E+04	2.4 E+01
Chloride	4.5 E+03	6.4 E+03	2.4 E+01
Chromium	4.2 E+02	6.0 E+02	3.4 E-02
Copper	4.8 E+00	6.9 E+00	1.5 E-02
Cyanide	3.4 E+01	4.8 E+01	9.5 E-02
Fluoride	2.7 E+02	3.9 E+02	4.3 E-02
Iron	2.8 E+01	3.9 E+01	8.5 E-02
Hydroxide	4.9 E+04	7.0 E+04	1.4 E+02
Lead	5.1 E+01	7.0E+01	4.60E+00
Magnesium	2.0 E+01	2.9 E+01	4.6 E-01
Manganese	2.0 E+01	2.9 E+01	5.8 E-02
Mercury	5.60E+00	8.0E+00	1.60E-02
Molybdenum	4.20E+01	6.0E+01	1.20E-01
Nickel	2.8 E+01	4.0 E+01	7.9 E-02
Nitrate	1.2 E+05	1.8 E+05	6.1 E+02
Nitrite	6.0 E+04	8.6 E+04	7.0 E+01
Phosphate	3.7 E+03	5.3 E+03	1.0 E+01
Phosphorus	3.4 E+03	4.9 E+03	9.6 E+00
Potassium	1.3 E+04	1.8 E+04	1.0 E+01
Silicon	1.3 E+02	1.9 E+02	5.9 E-01
Sodium	1.70E+05	2.40E+05	1.60E+01
Sulfate	2.0 E+03	2.9 E+03	5.0 E+00
Tungsten	1.5 E+02	2.1 E+02	4.1 E-01
Uranium	5.3 E+01	7.5 E+01	1.5 E-01
Zinc	3.4 E+01	4.8 E+01	9.6 E-02

Note: [1] Values are from Table 2B-1, Appendix 2B of HNF-14755, Rev.1; All other values are from Table 2.8, Chapter 2 of HNF-14755, Rev.1

Table 2.2.2 Organic Constituents

Organic Constituent	Concentration (mg/L)		
	Evaporator Feed	Concentrated Slurry	Process Condensate
Acetone	4.5 E-01	1.2 E-02	1.0 E+02
Alkyl, hydroxy-methyl benzene	1.3 E+00	1.8 E+00	1.1 E-01
Butanedioic acid	3.0 E+02	4.2 E+02	3.6 E+01
C3-Alkylbenzene	3.9 E+02	3.2 E+02	4.5 E+02
Chioroethyl, 2-hydroxymethyl, BA	1.3 E+01	1.3 E+01	1.1 E+01
2-Chloromethylhydroxymethyl-benzene	1.4 E+01	1.2 E+01	1.6 E+01
2-Chloromethyl-o-xylene	1.5 E+01	6.6 E+00	2.9 E+01
Citric acid	2.8 E+01	3.4 E+01	1.3 E+01
Diethylphthalates	4.6 E+00	6.6 E+00	4.4 E-02
Dimethyltoluidine	1.0 E+01	1.2 E+01	4.7 E+00
Dioctylphthalate	9.0 E+00	1.3 E+01	7.7 E-02
Dodecane	2.2 E+00	2.9 E+00	5.5 E-01
Dodecanoic acid	6.6 E-01	9.5 E-01	2.6 E-03
Ethanedioic acid	2.9 E+03	4.2 E+03	3.5 E+01
Ethyl, 2-methyl-hydroxymethyl-benzenes	3.3 E+01	4.6 E+01	1.3 E+00
Ethylbenzaldahyde	5.2 E+02	6.9 E+02	9.6 E+01
ED3A	8.0E+00	1.1 E+01	1.40E-03
EDTA	2.40E+01	3.40E+01	4.0E-03
Ethylxylene	2.7 E-01	3.2 E-01	1.4 E-01
Heptadecanoic acid	1.7 E+00	2.4 E+00	1.8 E-02
Heptanedioic acid	1.9 E+01	2.7 E+01	2.8 E-01
Hexadecanoic acid	5.9 E-01	8.3 E-01	9.4 E-03
Hexanedioic acid	2.5 E+01	3.6 E+01	7.5 E-03
Hexanoic acid	3.0 E+01	4.3 E+01	3.9 E-01
Hydroxyacetic acid	6.8 E+01	4.6 E+01	1.0 E+02
2-Hydroxymethylbenzoic acid	2.0 E+01	2.7 E+01	2.4 E+00
Methylbenzaldahyde	5.0 E+02	6.9 E+02	6.3 E+01
2-Methylbenzoic acid	1.4 E+01	1.8 E+01	3.0 E+00
2-Methyl, hydroxymethylbenzene	2.6 E+02	3.5 E+02	5.8 E+01
Methyltoluidine	2.5 E+00	3.5 E+00	1.8 E-01
n-C22H46-C40H46	1.8 E+01	1.8 E+01	3.6 E-02
HEDTA	1.50E+01	2.10E+01	1.70E+00
MAIDA	4.10E+02	5.80E+02	1.0E+01

Table 2.2.2 Cont' Organic Constituents

Organic Constituent	Concentration (mg/L)		
	Evaporator Feed	Concentrated Slurry	Process Condensate
MICEDA	2.1 E+01	3.0 E+01	5.40E-01
Nitrilotriacetic acid	4.2 E+00	6.0 E+00	1.1 E-01
Octodecanoic acid	2.9 E-01	4.1 E-01	3.2 E-03
Pentadecane	1.6 E+00	2.2 E+00	4.8 E-02
Pentadecanoic acid	2.5 E+01	3.5 E+01	6.0 E-01
Pentanedioic acid	4.9 E+01	7.0 E+01	7.8 E-03
Propylbenzene	2.4 E+00	1.8 E+00	3.2 E+00
Tetradecane	5.9 E+00	8.2 E+00	3.8 E-01
Tributyiphosphate	1.6 E+01	2.2 E+01	1.1 E+00
Tri-n-butyl-(di-ol)-phosphate	7.7 E+00	1.1 E+01	5.4 E-01
Tridecane	1.1 E+01	1.5 E+01	1.8 E+00
1,3,5-Trimethylbenzene	1.2 E+02	7.8 E+01	1.9 E+02
Undecane	1.6 E+00	1.9 E+00	8.3 E-01
Unknown phthalates	9.2 E+00	1.3 E+01	8.8 E-02

Source: All values are from Table 2.9, Chapter 2 of HNF-14755 Rev 1.

MICEDA - N-(Methylim inocarboxy) ethylenediam inc-N-acetic acid.

The flow sheet contains average sample values from three campaigns during the 1980s that produced a DSSF product. The flow sheet models a 30 percent waste volume reduction factor for feed near the upper limit for processing current feed stock. Actual candidate feed tanks contain a wide range of feed compositions, including trace quantities of constituents not presented in Tables 2.2.1 and 2.2.2.

The 242-A Evaporator feed is designated as mixed waste containing trace amounts of organic solvents (primarily non-halogenated but some halogenated) and heavy metals. It is corrosive; and may exceed the Washington State criteria for toxicity and persistence based on the known or suspected chemical constituents. Detailed information regarding the waste designation of the feed can be found in the RCRA Permit (Ecology 2003).

The principal radionuclides in the feed are ^{90}Sr and ^{37}Cs. Low concentrations of ^{3}H, ^{14}C, ^{79}Se, ^{99}Tc and other fission products and trace quantities of uranium, ^{239}Pu, and ^{241}Am are also present. Table 2.2.3 presents the concentrations of radionuclides in 242-A Evaporator unit feed derived from the process flow sheet (HNF-14755 Rev 1). Note that this table is included as part of the evaluation of the chemical composition of the evaporator feed, and does not constitute an evaluation of the radiological composition of the evaporator feed.

Table 2.2.4 presents the chemical composition of evaporator feed compiled from the PCPs prepared for the campaign years 1994 to 2007. Table 2.2.5 presents the chemical composition of concentrated slurry compiled from the post run reports for the campaign years 1994 to 2001 (post run reports are not available after 2001). Sampling and analysis of the evaporator feed and concentrated slurry are documented in data package for each of the evaporator campaigns. The data presented in Tables 2.2.4 and 2.2.5 show that the chemical composition of the evaporator feed varies from campaign to campaign.

2.2.1.1 Feed Specifications

Feed specifications are established to:

- Ensure operating requirements for criticality, exothermic chemical reactions, and other safety and process requirements are not exceeded
- Ensure the process condensate meets LERF acceptance limits
- Ensure the waste meets waste acceptance requirements in the 242-A Evaporator portion of the Hanford Site RCRA Permit (Ecology 2003)

The feed specifications are provided in HNF-SD-WM-DQO-014, *242-A Evaporator Data Quality Objectives* (DQO) (Banning 2005).

The 242-A Evaporator unit portion of the Hanford Site RCRA Permit (Ecology 2003) includes a waste analysis plan (WAP) that established feed limits on uncontrolled chemical reaction, chemical compatibility, and organic concentrations. The limits in the waste analysis plan are also provided in Banning (2005). The feed concentration limits to ensure compliance with LERF waste acceptance criteria are also described in Banning (2005).

Table 2.2.3 Concentrations of Radionuclides in Evaporator Feed, Concentrated Slurry, and Process Condensate

Radionuclide	Concentration (µCi/mL)		
	Evaporator Feed	Concentrated Slurry	Process Condensate
^{3}H	1.8 E-02	1.0 E-02	3.0 E-02
^{14}C	9.7E-04	1.4E-03	2.7E-06
^{60}CO	2.3 E-02	3.3 E-02	6.4 E-05
^{79}Se	1.0 E-02	1.5 E-02	2.9 E-05
^{90}Sr	7.6E+00	1.1 E+01	4.6E-06
^{94}Nb	1.7 E-02	2.5 E-02	4.8 E-05
^{99}Tc	8.5 E-02	1.2 E-01	2.4 E-04
^{106}Ru	7.0 E+00	1.0 E+01	2.5 E-05
^{129}I	2.7 E-04	2.8 E-04	2.0 E-04
^{134}Cs	2.0 E+00	2.9 E+00	8.0 E-05
^{137}Cs	3.5 E+02	5.1 E+02	5.4 E-07
^{234}U	2.6 E-05	3.6 E-05	7.2 E-08
^{235}U	1.3 E-06	1.8 E-06	3.5 E-09
^{238}U	9.3 E-06	1.3 E-05	2.6 E-08
^{237}Np	4.4 E-05	6.3 E-05	1.2 E-07
^{238}Pu	5.1 E-04	7.3 E-04	3.9 E-10
^{239}Pu	1.1 E-03	1.5 E-03	8.0 E-10
^{241}Am	1.5 E-03	2.2 E-03	3.0 E-09
^{244}Cm	1.7 E-04	2.4 E-04	4.8 E-07

Note:
*Based on the 242-A Evaporator Process Flowsheet, Section 2.5.5 of HNF-14755 Rev 1.

Table 2.2.4

Chemical Composition of Pre-Run Evaporator Feed

Compound	94-01 Feed	94-02 Feed	95-01Feed	97-01Feed	97-02 Feed	99-01 Feed	2000-01 Feed	2001-01 Feed
OH (M)	1.84E-01	4.27E-02	3.20E-01	1.92E+00	2.57E-01	4.39E-01	6.39E-01	9.27E-02
Al (M)	1.96E-02	5.46E-04	1.49E-02	6.18E-01	1.08E-01	5.04E-02	3.44E-01	5.41E-03
NO_3 (M)	1.96E-01	2.22E-02	1.69E-01	1.58E+00	8.98E-01	2.84E-01	1.52E+00	1.87E-01
NO_2 (M)	6.32E-02	2.75E-01	8.69E-02	9.90E-01	8.64E-01	1.51E-01	6.38E-01	4.79E-02
CO_3 (M)	NA	NA	7.01E-02	1.65E-01	5.21E-01	1.58E-01	1.86E-01	4.88E-02
PO_4 (M)	2.40E-03	4.01E-04	<0.00484	1.41E-02	1.56E-02	8.27E-03	3.96E-02	1 .40E-03
SO_4 (M)	1.57E-02	1.17E-03	<8.34E-03	2.35E-02	6.01E-02	1.27E-02	2.40E-02	1 .83E-03
F (M)	1.26E-01	3.54E-03	1.43E-01	1.61E-02	6.66E-02	7.95E-02	4.01E-02	1.41E-03
Na (M)	6.06E-01	9.22E-02	6.27E-01	4.80E+00	2.98	1.23E+00	3.59E+00	3.51 E-01
TIC (g/L)	1.41E-02	5.28E-03	NA	1.47E+00	NA	NA	2.23E+00	5.85E-01
TOC (g/L)	3.70E-01	5.58E-02	4.81-E01	NA	2.62	5.82E-01	9.89E-01	8.08E-01
TC (g/L)	NA	NA	NA	4.68E+00	NA	2.33E+00	3.27E+00	9.35E-01
U (g/L)	NA	NA	NA	NA	NA	1.31E-02	1.16E-02	5.13E-03
Fe (G/L)	NA	NA	NA	NA	NA	NA	1.01E-02	1 .0SE-02
Mn (g/L)	NA	NA	NA	NA	NA	NA	2.01E-03	2.01 E-04
Ni (g/L)	NA	NA	NA	NA	NA	NA	4.02E-03	4.20E-02
Cr (g/l)	NA	NA	NA	NA	NA	NA	6.98E-01	2.19E-03
NH_4 (ppm)	<86.4	9.13E+02	4.00E+02	6.20E+01	NA	NA	NA	NA
SpG	NA	9.92E-01	NA	1.22	1.15	1.06	1.21	1.02
pH	NA	NA	NA	NA	> 9.35	NA	NA	NA

1 - The slurry concentration = feed concentration / (1 - WVR).
2 - U indicates all sample results for the analysis were under the detection limit. In these cases, the minimum detection limit is specified as the feed concentration. The minimum detection limit / (1 - WVR) is used as the slurry concentration
3 - Sample results were ammonium ion. This was converted to ammonia by using the MWs of ammonia (17) and ammonium (18).
4 - Assumes 10% of the ammonia stays in the slurry stream (per Letter, T.A. Campbell to R.J. Nicklas, "Correlation of 242-A Feed Ammonia Content to Ammonia Release During Campaign 94-2", Appendix K of 242-A Campaign 94-2 Post Run Document WHC-SD-WM-PE-054. For ammonia, slurry concentration = (0.10 x feed concentration) / (1 - WVR).

5 – An average for pH is not strictly appropriate (logarithmic value) and should be considered approximate
6 - SpG value for slurry selected based on laboratory boildown.

Table 2.2.4 Cont'

Chemical Composition of Pre-Run Evaporator Feed

Compound	Unit	2002-02	2003-03	2004-01	2005-01	2006-01	2007-01[1,2,5,6]	2007-02[1,2,5,6]
OH	µg/mL	1.51E+04	2.56E+04	4.22E+04	1.83E+04	1.48E+04	2.92E+03	1.96E+04
Al	µg/mL	1.55E+04	2.17E+04	2.07E+04	1.40E+04	1.13E+04	1.94E+03	1.67E+04
NO_3	µg/mL	1.34E+05	1.15E+05	1.47E+05	1.13E+05	9.15E+04	1.60E+04	1.00E+05
NO_2	µg/mL	5.67E+04	7.06E+04	6.75E+04	5.17E+04	4.19E+04	1.51E+04	6.37E+04
CO_3	µg/mL	NA	NA	NA	NA	NA	NA	NA
PO_4	µg/mL	3.93E+03	3.35E+03	5.66E+02	2.73E+03	2.21E+03	2.53E+03	3.76E+03
SO_4	µg/mL	2.30E+03	2.72E+03	2.55E+03	3.53E+03	2.86E+03	1.04E+03	2.12E+03
F	µg/mL	1.25E+03	2.56E+02	1.16E+03	8.09E+01	6.55E+01	2.88E+02	3.06E+02
Na	µg/mL	1.30E+05	1.36E+05	1.68E+05	1.23E+05	9.96E+04	3.76E+04	1.28E+05
Cl	µg/mL	3.87E+03	4.39E+03	3.27E+03	3.67E+03	2.97E+03	5.92E+02	5.19E+03
TIC	µg/mL	2.17E+03	2.14E+03	4.22E+03	3.42E+03	2.77E+03	3.29E+03	3.45E+03
TOC	µg/mL	4.00E+03	2.57E+03	3.02E+03	2.47E+03	2.00E+03	1.90E+03	4.14E+03
TC	µg/mL	6.19E+03	4.16E+03	6.39E+03	5.23E+03	4.24E+03	5.55E+03	7.29E+03
U-total	µg/mL	4.23E+00	1.50E+00	2.44E+01	1.90E+00	1.54E+00	3.39E+01	1.18E+01
Fe	µg/mL	2.01E+01	1.25E+01	1.10E+01	6.02E+00	4.88E+00	2.00E+00	5.02E+00
Mn	µg/mL	4.01E+00	2.50E+00	1.25E+00	8.38E-01	6.79E-01	2.00E+00	1.01E+00
Ni	µg/mL	4.38E+01	1.05E+01	1.18E+01	1.17E+01	9.48E+00	8.31E+00	4.59E+01
Cr	µg/mL	4.70E+02	4.53E+02	5.20E+02	6.44E+02	5.22E+02	4.02E+01	4.99E+02
NH_4[(3,4)]	µg/mL	8.06E+02	4.72E+02	3.91E+02	1.19E+02	9.64E+01	5.63E+01	1.00E+03
SpG	NA	1.24	1.31	1.36	1.28	1.23	1.07	1.28
pH	NA	>13.5	13.60	NA	>13.5	>13.5	13.3	13.5

See notes on previous page.

Table 2.2.5

Post Run Concentrated Slurry Composition

Compound	Unit	1994-2 Post Run	1995 Post Run	1996 Post Run	1997 Post Run	1999 Post Run	2000 Post Run	2001 Post Run
Gross Alpha	uCi/mL	NA	NA	NA	9.31E-03	NA	NA	NA
Gross Beta	uCi/mL	NA	NA	NA	8.97E-01	NA	NA	NA
U-total	ug/mL	NA	NA	NA	2.00E+02	NA	NA	NA
Al	M	2.18E-02	9.48E-02	NA	NA	NA	NA	NA
Al	ug/mL	NA	NA	3.12E+02	1.53E+04	NA	NA	NA
NH_3	M	4.56E-02	3.25E-02	8.66E+01	NA	NA	NA	NA
NH_3	uglmL	NA	NA	NA	NA	NA	NA	NA
CO_3	ug/mL	NA	NA	NA	NA	NA	NA	NA
Cl	ug/mL	NA	NA	NA	2.37E+03	NA	NA	NA
Cr	ug/mL	NA	NA	NA	1.98E+02	NA	NA	NA
F	M	1.37E-01	3.75E-01	NA	NA	NA	NA	NA
F	ug/mL	NA	NA	7.04E+03	1.20E+03	NA	NA	NA
OH	M	1.30E-01	1.05E+00	NA	NA	NA	NA	NA
OH	ug/mL	NA	NA	1.56E+04	2.62E+04	NA	NA	1.58E+03
Fe	ug/mL	NA	NA	NA	2.01E+01	NA	NA	NA
Mn	ug/mL	NA	NA	NA	4.01E+00	NA	NA	NA
Ni	ug/mL	NA	NA	NA	8.02E+00	NA	NA	NA
NO_3	M	3.56E-01	7.43E-01	NA	NA	NA	NA	NA
NO_3	ug/mL	NA	NA	7.37E+04	1.01E+05	NA	NA	1.16E+04
NO_2	M	2.23E-01	4.41E-01	NA	NA	NA	NA	NA
NO_2	ug/mL	NA	NA	1.35E+04	4.41E+04	NA	NA	2.20E+03
PO_4	M	3.81E-03	1.28E-02	NA	NA	NA	NA	NA
PO_4	ug/mL	NA	NA	3.50E+03	1.17E+03	NA	NA	NA
Na	M	8.96E-01	2.85E+00	NA	NA	NA	NA	NA
Na	ug/mL	NA	NA	8.30E+04	1.06E+05	NA	NA	NA
SO_4	M	1.60E-02	2.57E-01	NA	NA	NA	NA	NA
SO_4	ug/mL	NA	NA	<6.93E+03	2.06E+03	NA	NA	NA
TIC	M	1.73E-01	4.14E-01	NA	NA	NA	NA	NA
TIC	ug/mL	NA	NA	5.88E+03	2.43E+03	NA	NA	NA
TOC	g/L	8.52E-01	1.67E+00	NA	NA	NA	NA	NA
TOC	ug/mL	NA	NA	9.10E+02	1.98E+03	NA	NA	NA
TC	g/L	NA	6.52E+00	NA	NA	NA	NA	NA
TC	ug/mL	NA	NA	1.02E+04	NA	NA	NA	NA
SpG	Sp.G	1.03	1.104	1.152	1.27	1.09	1.163	NA
pH	NA	12.69	13.66	13.57	NA	NA	NA	NA

M = Molarity

The 242-A Evaporator unit WAP requires that no exothermic reactions occur below 168 °C and that the ratio of exotherm-to-endotherm energy be less than 1. The second criterion is also a requirement of 242-A Evaporator unit DSA Technical Safety Requirement (TSR) 5.6.1.6 (Campbell 2003). Results of differential scanning calorimeter tests of the evaporator feed have not indicated any exothermic reactions in the past.

TSR 5.6.1.6.a requires that prior to operating the evaporator, the absence of separable organics in the feed will be determined by a visual examination of the surface sample and laboratory analysis. Per the DQOs, a separable organic layer is present if: (1) it can be visually detected in the surface sample or (2) a TOC analysis of the surface sample exceeds 2600 milligrams/L (mg/L) and is greater than the 95 percent confidence level calculated using the mean, standard deviation, and number of samples of tank supernatant. The DQOs also establish a process control limit to prevent the transfer of any separable organic phase in the feed tank to the 242-A Evaporator unit. If a separable organic phase is present, the feed tank level must be maintained above 100 inches during evaporator operations. In accordance with criteria established in the DQOs, no separable organic layer has been observed or measured during past campaigns.

The 242-A Evaporator unit DSA (HNF-14755 Rev 1) and associated TSRs (Campbell 2003 and 2004) have an administrative control requirement that the plutonium-equivalent concentration in the feed be less than or equal to 0.005 g/L. Plutonium-equivalent (fissile material) is defined as Pu-239 and U-233. U-235 is included if the uranium exceeds 0.72 weight percent (wt%) enrichment. The Tank Farm compatibility program (Fowler 2007) also uses an estimate of the slurry fissile material concentration and total fissile material transferred to feed tanks. If the total is greater than 50 grams, Tank Farms must assess the quantity of neutron absorbers (iron, manganese, nickel, and chromium) in the waste. The total fissile material going to the feed tanks has been less than the mass limit during past campaigns.

In June 2004, the U.S. Environmental Protection Agency (EPA) issued approval of the Toxic Substance Control Act Risk-based Disposal Approval Application for Management of Polychlorinated Biphenyl (PCB) Remediation Waste at the 200 Area Liquid Waste Processing Facilities (EPA 2004, Szelmeczka 2002). This approval allows for the treatment of PCB remediation waste with up to a maximum total Aroclor concentration of 6000 micrograms per Liter (µg/L) at the 242-A Evaporator unit. Conditions of this approval include additional vessel vent monitoring and slurry and process condensate sampling for PCBs, but only if the feed PCB concentration is greater than or equal to 600 µg/L. No detectable PCBs have been reported in the feed samples from past campaigns.

2.2.2 Concentrated Slurry Composition

The 242-A Evaporator unit can produce three slurry products: (1) double-shell slurry (DSS), (2) double shell slurry feed (DSSF), and (3) dilute double shell slurry feed (DDSSF) if the ending slurry concentration is limited to the dilute form. These products, collectively referred to as 'slurry', are defined by their relationship to the sodium-aluminate boundary (Figure 2.1). When the concentration is above the phase change line in Figure 2.1, aluminum solids (specifically sodium-aluminate crystals) precipitate out of solution and form DSS, the most concentrated product the 242-A Evaporator unit can produce. Although sodium-aluminate crystals represent only a small percentage of the solids in DSS, they greatly increase the viscosity of the slurry (up to 100 centipoise

[cP]) and make it more difficult to pump from DSTs. Although DSS was produced prior to 1989, there are no plans to produce DSS.

DSSF is defined as a slurry with a chemical composition that is below the sodium-aluminate boundary but that could be concentrated past the sodium-aluminate boundary with a single additional pass through the 242-A Evaporator unit. In contrast to DSS, the viscosity of DSSF typically ranges from 20 to 40 cP.

Dilute DSSF is more than one 242-A Evaporator unit pass away from DSS.

Due to tank farm requirements imposed prior to the 1998 IA, the sodium-aluminate boundary is no longer the controlling factor for target slurry concentrations, but is typically driven by formation of solids and specific gravity (SpG) limits. Therefore, the terms DDSSF, DSSF, and DSS have not been used since the 1998 IA (LMHC 1998). Instead, the slurry product produced by the 242-A Evaporator unit is referred to as "concentrated slurry".

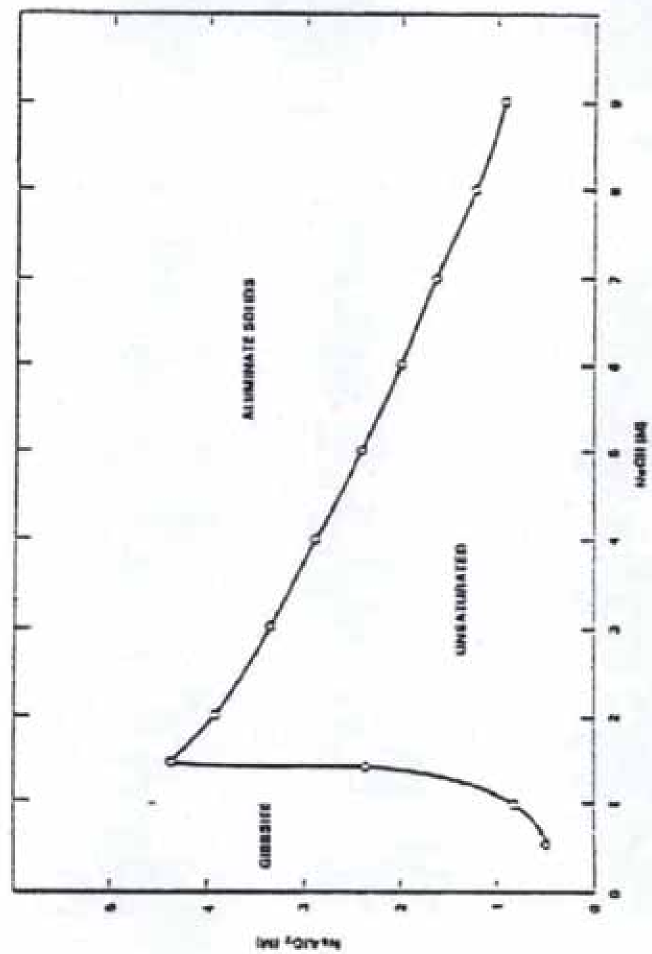
The physical and chemical characteristics of the concentrated slurry vary from one 242-A Evaporator unit campaign to the next based on changing characteristics of the evaporator feed. In general, the slurry is a highly alkaline liquid (approximately pH 13), with a specific gravity of about 1.5 (Tables 2.2.1, 2.2.2, and 2.2.3). The temperature of the discharged slurry is approximately 130 °F (54 °C).

Tables 2.2.6 and 2.2.7 present the chemical composition of concentrated slurry projected from evaporator feed composition data compiled from the PCPs and post run reports prepared for the campaign years 1994 to 2006. Results of evaporator feed sampling and analysis activities are documented in a data package for each of the evaporator campaigns. The data in Tables 2.2.6 and 2.2.7 show that the chemical composition of the concentrated slurry varies from campaign to campaign.

The 242-A Evaporator TSR document (Campbell 2003) has an administrative control requirement that the radionuclide concentrations in the concentrated slurry not exceed the bounding source strength limits in Table 5.6-1 of the TSRs. The projected concentrations in the concentrated slurry for past campaigns were compared to the bounding source strength; all radionuclides were found to be present at levels less than their bounding limits.

Knight (2003) and Fowler (2007) specifies that certain parameters be taken into consideration, including the SpG and phosphate and aluminum concentrations. This includes the evaluation of concentrated slurries with a SpG greater than 1.35 to demonstrate that the slurry may be safely pumped without the risk of precipitation or gelling in the transfer line. Solids formation has been minimal during past campaigns by maintaining the SpG within its limit. Because the evaporator raises the temperature of the concentrated slurry, the solubility of phosphates, carbonates, and aluminates in the slurry are such that precipitation of these solids are not anticipated at campaign conditions. Laboratory analysis and boildown studies from past campaigns indicate that precipitation or gelling of solids has not been an issue during past campaigns.

A review of concentrated slurry data produced by the 242-A Evaporator unit during past campaigns indicates that it has also met tank farm waste specifications summarized in HNF-SD-WM-OCD-015, *Tank Farm Waste Transfer Compatibility Program* (HNF-14755 Rev 1), for corrosion control, criticality control, flammable gas control, and waste segregation.



SOURCE: HNF-14755-Rev.1

Drawing Number 2.1	COOPER ZIETZ ENGINEERS, INC.	242-A Evaporator Integrity Assessment Hanford Reservation	TechnoGeneral Services Company Engineering and Construction Management
		Sodium-Aluminate Boundary	DESIGNED BY: XX / DRAWN BY: VCAD / CHECKED BY: XX / RECHECKED BY: XX / APPROVED BY: XX / DATE: 19 NOVEMBER 2000

REV	DATE	DRWN	CHKD	REMARKS
REVISIONS				

Figure 2.1 **Sodium-Aluminate Boundary**

Table 2.2.6 Pre-Run Slurry Composition

Compound	2002-02 Feed µg/mL	2003-01 Feed µg/mL	2004-01 Feed µg/mL	2005-01 Feed µg/mL	2006-01 Feed µg/mL
Al	2.46E+04	3.74E+04	2.58E+04	2.05E+04	2.05E+04
B	6.03E+01	5.50E+01	2.43E+01	4.20E+01	4.20E+01
Ba	3.19E+01	2.16E+01	1.45E+01	9.28E+00	9.28E+00
Be	3.19E+00	2.16E+00	9.18E-01	5.88E-01	5.88E-01
Ca	8.54E+01	4.31E+01	1.48E+01	3.32E+01	3.32E+0l
Cd	8.21E+00	2.16E+00	2.69E+00	1.01E+00	1.01E+00
Cl	6.14E+03	7.57E+03	4.09E+03	5.39E+03	5.39E+03
Cr	7.46E+02	7.81E+02	6.50E+02	9.48E+02	9.48E+02
F	1.98E+03	4.41E+02	1.45E+03	1.19E+02	1.19E+02
Fe	3.19E+01	2.16E+01	1.38E+01	8.85E+00	8.85E+00
K	2.56E+03	4.64E+03	1.54E+04	2.69E+03	2.69E+03
La	NA	2.16E+01	3.78E+00	2.43E+00	2.43E-01
Mn	6.37E+00	4.31E+00	1.56E+00	1.23E+00	l.23E+00
Mo	7.67E+01	9.97E+01	5.23E+01	6.77E+01	6.77E+01
Na	2.06E+05	2.34E-05	2.10E+05	1.81E+05	l.81E+05
Ni	6.95E+01	1.81E+01	1.48E+01	1.72E+01	l.72E+01
Pb	6.37E+01	4.90E+01	3.84E+01	2.87E+01	2.87E+01
Si	7.87E+01	3.07E+01	6.02E+01	1.43E+01	l.43E+01
Se	NA	NA	NA	NA	2.41E+01
U-total	6.71E+00	2.59E+00	3.05E+01	2.79E+00	2.79E+00
^{235}U	7.32E-02	2.10E-02	2.93E-01	3.65E-02	3.65E-02
^{238}U	3.86E+00	2.93E+00	3.94E+01	4.97E+00	4.97E+00
Zr	6.37E+00	4.31E+00	3.00E+00	1.04E+00	1.04E+00
NH_3	1.28E+02	8.14E+01	4.89E+01	1.75E+01	l.85E+01
NO_3	2.13E+08	1.98E+05	1.84E+05	1.66E+05	l.66E+05
NO_2	9.00E+04	1.22E+05	8.44E+04	7.61E+04	7.61E+04
OH	2.40E+04	4.41E+04	5.27E+04	2.69E+04	2.69E+04
$P0_4$	6.24E+03	5.78E+03	7.05E+02	4.02E+03	4.02E+03
$S0_4$	3.65E+03	4.69E+03	3.15E+03	5.19E+03	5.19E+03
TC	9.83E+03	7.17E+03	7.99E+03	7.69E+03	7.69E+03
TIC	3.44E+03	3.69E+03	5.28E+03	5.03E+03	5.03E+03
TOC	6.35E+03	4.43E+03	3.78E+03	3.63E+03	3.63E+03
pH (Unitless)	>13.5	>13.6	NA	> 13.5	> 13.5
SpG (Unitless)	1.38	1.44	1.46	1.42	1.42

Table 2.2.6 Cont'
Pre-Run Slurry Composition

Compound	94-01 Feed[1]	94-02 Feed[2]	95- 01 Feed[3]	97-01 Feed[4]	97-02 Feed[5]	99-01 Feed[6]	2000-01 Feed[7]	2001-01 Feed[8]
OH (M)	7.01E+00	8.00E+00	7.97E+00	8.00E+00	7.72E+00	7.11E+00	8.00E+00	6.18E-01
Al (M)	7.47E-01	3.76E-01	3.65E-01	2.35E+00	3.24E+00	8.18E-01	2.89E+00	3.61E-02
NO_3 (M)	4.64E+00	3.93E+00	3.03E+00	3.90E+00	5.50E+00	4.33E+00	5.49E+00	1.25E+00
NO_2 (M)	2.41E+00	8.94E+00	2.13E+00	3.76E+00	6.63E+00	2.30E+00	4.67E+00	3.19E-01
CO_3 (M)	3.63E-01	3.28E-01	9.43E-01	3.24E-01	4.91E-01	1.01E+00	6.72E-01	3.25E-01
PO_4 (M)	5.00E-03	1.00E-03	1.00E-02	2.80E-02	0.00E+00	1.70E-02	7.90E-02	9.33E-03
SO_4 (M)	5.98E-01	3.10E-01	2.04E-01	9.80E-02	3.22E-01	2.06E-01	8.70E-02	1.22E-02
F (M)	6.92E-01	1.93E-01	5.57E-01	6.10E-02	8.90E-02	3.17E-01	1.45E-01	9.40E-03
Na (M)	NA	NA	NA	NA	NA	NA	NA	2.34E+00
TIC (g/L)	NA	NA	NA	NA	NA	NA	NA	3.90E+00
TOC (g/L)	NA	NA	NA	NA	NA	NA	NA	5.39E+00
TC (g/L)	NA	NA	NA	NA	NA	NA	NA	6.23E+00
U (g/L)	NA	NA	NA	NA	NA	NA	NA	3.42E-02
Fe (g/L)	NA	NA	NA	NA	NA	NA	NA	7.00E-02
Mn (g/L)	NA	NA	NA	NA	NA	NA	NA	1.34E-03
Ni (g/L)	NA	NA	NA	NA	NA	NA	NA	2.80E-01
Cr (g/l)	NA	NA	NA	NA	NA	NA	NA	1.46E-02
NH_4 (ppm)	NA	NA	NA	NA	NA	NA	NA	NA
SpG(Unitless)	NA	NA	NA	NA	NA	NA	NA	1.32E+00
pH(Unitless)	NA	NA	NA	NA	NA	NA	NA	NA
Organic (g/L)	1.41E+01	1.26E+01	1.19E+01	6.13E+00	7.87E+01	9.43E+00	12.382	NA

Note:
1. Maximum of composite predict run from 6 passes.
2. Maximum of composite predict run from 8 passes.
3. Maximum of composite predict run from 5 passes.
4. Maximum of composite predict run from 3 passes.
5. Maximum of composite predict run from 3 passes.
6. Maximum of composite predict run from 5 passes.
7. Maximum of composite predict run from 4 passes.
8. Slurry values are conservatively calculated at WVRF of 85%
9. NA - Data not available for this compound from this campaign.

Table 2.2.7 Post Run Slurry Composition

Compound	Unit	1994-2	1995	1996	1997	1999	2000	2001	
		Post Run	Post Run	Post Run	Post Run	Post Run	Post Run	Pre Run[1]	Post Run[2]
Gross Alpha	uCi/mL	NA	NA	NA	NA	4.49E-03	3.79E-03	1.28E-03	2.01E-02
Gross Beta	uCi/mL	NA	NA	NA	NA	1.95E+02	2.22E+02	3.41E+01	1.01E+02
U Total	Ug/mL	NA	NA	NA	NA	NA	NA	3.42E+01	4.16E+01
Aluminium	Ug/mL	5.09E-02(M)	0.196 (M)	4.54E+03	2.737 (M)	8.28E+03	2.04E+04	9.75E-02	2.46E+04
Ammonium	Ug/mL	7.76E-04(M)	0.000173(M)	5.00E+00	NA	NA	NA	2.04E+02	3.74E+03
Carbonate	Ug/mL	NA	NA	NA	0.372 (M)	NA	NA	1.95E+04	7.46E+03
Chloride	Ug/mL	NA	NA	NA	NA	2.39E+03	5.27E+03	5.27E+03	7.66E+02
Chromium	Ug/mL	NA	NA	NA	NA	2.25E+02	1.50E+03	1.46E+01	1.29E+03
Fluoride	Ug/mL	2.51E-01(M)	0.144 (M)	8.89E+03	0.231 (M)	1.46E+03	1.22E+03	1.79E+02	1.60E+03
Hydroxide	Ug/mL	3.45E-01(M)	1.85 (M)	2.84E+04	8.006 (M)	4.20E+04	1.13E+04	1.05E+04	3.82E+04
Iron	Ug/mL	NA	NA	NA	NA	2.01E+01	3.01E+01	7.00E+01	1.17E+02
Manganese	Ug/mL	NA	NA	NA	NA	4.01E+00	6.01E+00	1.34E+00	6.01E+00
Nickel	Ug/mL	NA	NA	NA	NA	8.02E+00	1.20E+01	2.80E+02	1.20E+01
Nitrate	Ug/mL	5.19E-01(M)	1.54 (M)	1.89E+05	6.125 (M)	1.15E+05	1.96E+05	7.75E+04	9.50E+04
Nitrite	Ug/mL	3.34E-01(M)	0.881(M)	3.75E+04	4.878 (M)	4.32E+04	6.29E+04	1.47E+04	3.51E+04
Phosphate	Ug/mL	1.06E-02(M)	0.012(M)	1.20E+04	0.075 (M)	1.51E+03	6.18E+02	8.86E+02	3.36E+03
Potassium	Ug/mL	NA	NA	NA	NA	1.91E+04	5.24E+03	1.14E+04	1.33E+04
Sodium	Ug/mL	1.86E+00(M)	5.2(M)	1.69E+05	NA	1.60E+05	1.78E+05	5.38E+04	3.00E+05
Sulfate	Ug/mL	2.78E-02(M)	0.0602 (M)	1.38E+04	0.080 (M)	5.18E+03	5.00E+03	1.17E+03	3.81E+03
SpG	NA	1.097	1.34	1.238	NA	1.347	1.377	1.32	NA
pH	NA	12.93	13.5	13.46	NA	13.51	12.98	NA	NA

Table notes on next page.

M = Molarity

1. Estimated slurry
2. Calculated slurry

Slurry sample analysis done on non representative sample due to poor/inadequate slurry sample
Maximum value out of three samples analyzed

2.2.3 Process Condensate Waste Stream

The 242-A Evaporator unit produces one waste stream, process condensate, which requires further processing before discharge. It is considered a byproduct because it is derived directly from the 242-A Evaporator feed. (Note: this should not be confused with other specialized applications of the term 'byproduct'). Process condensate consists primarily of the condensed vapors from the 242-A Evaporator process. It is initially collected and filtered within the 242-A Evaporator unit, then discharged through the PC-5000 transfer line to the LERF for storage prior to treatment at the Effluent Transfer Facility (ETF).

Process condensate is a dilute aqueous solution with ammonia, volatile organics, and trace quantities of radionuclides and inorganic constituents. Process condensate is classified as a mixed waste because it contains radioactive components and is a listed waste (Ecology 2005). Process condensate is a listed waste because it is derived from a listed waste.

Table 2.2.8 lists the dangerous waste codes assigned to the process condensate. Process condensate is designated as F001 through F005 because it is derived from the treatment of DST System waste assigned these codes.

The physical and chemical characteristics of the process condensate reported in the DSA (HNF-14755, Rev 1) are presented in Tables 2.2.1, 2.2.2, and 2.2.3. The organic and inorganic constituents measured in process condensate samples collected during 242-A Evaporator unit campaigns are presented in Attachment 3. The data in Attachment 3 indicate that the chemical composition of the process condensate varies from one 242-A Evaporator unit campaign to the next similar to the evaporator feed and concentrated slurry. A review of the data presented in Attachment 3 also indicate that the process condensate met acceptance criteria established for the LERF (HNF-SD-WM-S AD-040), *Liquid Effluent Retention Facility Final Hazard Category Determination* and the LERF/ETF portion of the Hanford Site RCRA Permit (Ecology 1998).

Table 2.2.8 Waste Designation for Process Condensate

Waste Code	Characteristic/Source	Basis for Designation
F001	Spent halogenated solvents	Derived from F001 waste
F002	Spent halogenated solvents	Derived from F002 waste
F003	Spent non-halogenated solvents	Derived from F003 waste
F004	Spent non-halogenated solvents	Derived from F004 waste
F005	Spent non-halogenated solvents	Derived from F005 waste
F039	Multi-source leachate from waste disposal operations	Future receipt of waste with the F039 number, derived from F001 through F005.

2.2.4 IQRPE Concurrence

The IQRPE has evaluated the 242-A Evaporator unit feed, concentrated slurry, and process condensate. The characteristics of these streams meet the waste acceptance requirements in the 242-A Evaporator portion of the Hanford Site RCRA Permit (Ecology 1998) and the feed specifications as provided in HNF-SD-WM-DQO-014, *242-A Evaporator Data Quality Objectives.*

2.3 Waste Compatibility Assessment

According to the WAC (WAC 173-303-640(2)(c)(ii)), existing tank systems must be assessed for the dangerous characteristics of the waste being stored or treated at the 242-A Evaporator unit. The waste should be compatible with the materials used for the tank and ancillary equipment. This section presents:

- Review of the dangerous wastes or treatment reagents that may be placed into the 242-A Evaporator unit to ensure that they can be processed without causing the tank system to rupture, leak, corrode, or otherwise fail per the requirements of WAC 173-303-640(5)(a)
- Review of the materials of construction and their current condition for the tank systems to ensure that they are compatible with the wastes to be stored or treated per the requirements of WAC 173-303-640(3)(a)

The waste fed to the 242-A Evaporator unit is regulated as a mixed waste with the same waste constituents as the waste in the DST System. The concentrated slurry is a characteristic waste (D001, D002, and D003), toxic waste (D004 through D011, D018, D019, D022, D028 through D030, D033 through D036, D038 through D041, and D043), nonspecific source waste (F001 through F005 and F039), and state-only characteristic waste (WT01, WT02, WP01, WP02). Multi-source leachate (F039) is included as a waste derived from nonspecific source waste F001 through F005. These codes are based on the RCRA Permit (WA7890008967) Part A application and may not be applied to every waste stream.

All waste to be processed at the 242-A Evaporator unit must be sampled to determine if the waste is compatible with the materials of construction at the 242-A Evaporator. Before each campaign, candidate feed tanks are sampled per the requirements of the WAP (Ecology 2005). Based on the results, three possible options are implemented:

- The waste is acceptable for processing without further actions
- The waste is unacceptable for processing as a single batch, but is acceptable if blended with other waste that is going to be processed
- The waste is unacceptable for processing

Prior to operations, laboratory boildown studies are performed on a composite sampling of the campaign feed tank to substantiate the chemical or physical characteristics of the waste. In addition, the boildown studies provide reasonable assurance that campaign wastes will be processed safely in the 242-A Evaporator unit. The projected concentrated slurry product composition is also evaluated against the compatibility criteria in order to ensure that no additional waste categories or tank safety concerns will be created as a result of transferring concentrated slurry to tank farms.

A variety of compatibility assessments are also completed based on the chemical and physical characteristics of the evaporator feed, concentrated slurry, and process condensate. These assessments, described in the following subsections, ensure that proper process control can be maintained during each campaign. A corrosion assessment to evaluate waste compatibility with respect to the materials of construction for the tanks, piping systems, and ancillary components of the 242-A Evaporator unit is included in Section 2.7 of this IAR. Procedures used to control the operations of the 242-A Evaporator unit are included in Attachments 13 and 14. These documents were reviewed to determine whether the appropriate controls on waste compatibility are in place. Attachment 12 includes a summary of off-normal events recorded between 1993 and 2007. These events were reviewed as part of the IA to determine whether they impacted the integrity of the system or represented problems with the waste compatibility procedures identified in Attachments 13 and 14 and described in this section.

2.3.1 Watch List Tanks

Waste contained in a Watch List Tank in the Double-Shell Tank (DST) systems was isolated to prevent inadvertent commingling with other wastes. The Watch List Tanks were deleted in 2001. The Watch List Tanks were tanks with significant amounts of solids. A review of the historical campaign data indicate that no watch list tanks were used for feed to the 242-A Evaporator unit (HNF-14755 Rev 1).

2.3.2 New Waste Streams

Waste streams sent to the tank farms from new or significantly modified chemical processes implemented at a unit are accepted only after issuing an approved tank farm flow sheet. No new waste types are generated within the DST systems or by the 242-A Evaporator unit during the campaigns.

2.3.3 Energetics/Uncontrolled Chemical Reaction

WAC 173-303-395 requires waste handling be conducted to prevent an uncontrolled reaction that could damage the tank system structural integrity or threaten human health or the environment. The 242-A Evaporator unit WAP (Ecology 2005) requires that no exothermic reactions occur below 168 °C and the ratio of exotherm-to-endotherm energy be less than 1. A review of the historical campaign data indicate that no exothermic reactions have been identified in any of the feed samples collected during the past campaigns.

2.3.4 Mixing and Compatibility Studies

To verify there will be no adverse affects because of mixing the contents of different waste tanks in the feed tank and evaporator vessel, the 242-A Evaporator unit WAP (Ecology 2005) requires a mixing and compatibility study when staging multiple tanks for feed to the evaporator. A study is not required for one-tank campaigns. A mixing and compatibility study is performed on composite samples collected during the campaigns to ensure the waste compatibility and provide data to establish process controls. As samples from each of the planned waste sources are mixed, observations are made to note any changes in color, temperature, clarity, or any other visually determinable characteristics. This would indicate an unexpected chemical reaction that might have an impact on 242-A Evaporator unit operations. If such visible changes are observed when mixing samples, the wastes are not processed in the 242-A Evaporator unit.

A review of the mixing and compatibility studies performed during past campaigns indicates no appearance of stratification, gas evolution, heat generation, precipitation, dissolution of solids, color change, clarity change, or any other visually determinable characteristics. This indicates that the waste processed at the 242-A Evaporator unit was compatible with the unit operations without an unexpected chemical reaction.

2.3.5 Corrosivity

Prior to each campaign, the Tank Farm DQOs (Mulkey 1999) require an evaluation to ensure that the concentrated slurry characteristics will inhibit uniform corrosion, pitting corrosion, and stress corrosion in the slurry tank (Mulkey 1999). The nitrate, nitrite, and hydroxide concentrations are limited in order to reduce the deterioration rate of the primary carbon steel of the receiving slurry tank.

Waste that does not meet tank corrosivity limits can not be transferred to the DSTs. Although these corrosion limits are strictly a Tank Farm requirement, they are significant because they are based on minimizing the corrosion of carbon steel. As shown in Tables 1.6, and sections 2.1.3, and 2.1.4 and the corrosion assessment in Section 2.7 of this IAR, the components of the 242-A Evaporator unit that contact concentrated slurry are stainless steel.

The predicted nitrate, nitrite and hydroxide concentrations of the concentrated slurry are compared to the DST waste corrosion specifications prior to each campaign. An evaluation of the predicted concentrations to the DQOs from past campaigns indicates that waste processed at the 242-A Evaporator met the Tank Farm DQOs.

2.3.6 High Phosphate Waste

Evaporator feed can not be concentrated above 8 Molar (M) sodium and 0.1 M phosphate concentrations in concentrated slurry in order to prevent the formation of needle-shaped crystals of $Na_3PO_4 \cdot 12H_20$ (VonBargen 1998). Waste containing high phosphate concentrations increase the viscosity of the waste and can cause the formation of a gel-like matrix (Fowler 2005). Although these limits are strictly a Tank Farm requirement, they are significant because they minimize the solids content and viscosity of the waste handled in the 242-A Evaporator unit.

An evaluation of the phosphate and sodium concentrations during the past campaigns indicate that these requirements have been met. Pre-campaign boildown results did not indicate crystal formation, indicating that high viscosity, gel-like slurries have not been produced in the past.

2.3.7 Organic Complexants

Historically, waste feeds that contain organic complexants were segregated to avoid processing problems. Feed wastes that contain organic complexants concentrated beyond the nitrate/nitrite saturation level increase the potential for hydrogen or flammable gas accumulation. Tanks that contain greater than three weight percent TOC on a dry weight basis were historically classified as complexed waste. The waste in 242-A Evaporator unit campaign feed tanks and concentrated slurry have not exceeded the 3 weight percent TOC level.

2.3.8 Transfer Line Plugging

An evaluation of flow velocity to avoid solids deposition is required prior to each campaign in order to prevent potential slurry transfer line plugging (Fowler 2005). The critical velocity in the slurry transfer line is estimated to be 0.45 meters per second (m/s) (1.5 feet per second [ft/s]). Although transfer line plugging is not an issue for the 242-A Evaporator unit (these limits are strictly a Tank Farm requirement) they are significant because they minimize the solids content and viscosity of the waste handled in the 242-A Evaporator unit.

Transfer line plugging can be prevented if the transfer velocity is maintained above the critical velocity, which is defined as the minimum velocity to keep solids suspended in the solution. Past operational experience indicates that the transfer velocity is maintained above the critical velocity for the feed and slurry solutions.

Alternatively an evaluation of transfer line plugging was made using Reynolds number (N_{Re}) and percent volume solids for feed and slurry solutions between 1994 and 1999. To prevent potential transfer line plugging, waste having a N_{Re} of less than 20,000 or greater than 30 percent volume solids should not be transferred without a technical evaluation. A review of the N_{Re} and percent solids analysis on campaign feed and slurry indicates that the values for N_{Re} and percent solids were within these limits.

2.3.9 Heat Generation

To prevent internal boiling in the evaporator feed and concentrated slurry receiver tanks during and after the end of the campaign, evaporator feed cannot be over-concentrated to produce a slurry product such that total heat generation in the receiving tank is greater than 58,000 British Thermal Units per hour (Btu/hr). Historically, the heat generation had been 70,000 Btu/hr but was changed to 58,000 Btu/hr based on the findings of the DSA (HNF-14755 Rev 1). A review of past campaign data indicates that the heat generation of the concentrated slurry produced during past campaign runs has been well below the heat load limit of 58,000 Btu/hr.

2.3.10 Separable Organic Layers

A separable organic phase can accumulate in Condensate Collection Tank (TK-C-100) during evaporator operations if separable organics are contained in the evaporator feed. In addition, the presence of an immiscible organic layer in the process condensate would cause operational difficulties if transferred to the ETF. Therefore, controls are implemented to prevent separable organics from being introduced into the 242-A Evaporator unit. Detection of a surface organic layer restricts the operational minimum level in feed tank 241-AW-102 to 100 inches to prevent the possible transfer of the organic layer to the evaporator.

Based on an evaluation of past campaign data, no surface organic layer has been found to be present in the evaporator feed.

2.3.11 IQRPE Concurrence

The IQRPE concurs with the waste compatibility assessment described herein that the evaporator feed, concentrated slurry, and process condensate produced at the 242-A Evaporator unit met the requirements of WAC 173-303-640(5)(a). The dangerous wastes or treatment reagents placed into and processed in the 242-A evaporator unit were controlled such that it did not cause the tank system to rupture, leak, corrode, or otherwise fail.

2.4 Results of Visual Inspection

External visual inspection of the 242-A Evaporator unit was performed to identify and evaluate external indications of potential deficiencies. These indications include the following:

- (i) rust, pitting and other visual evidence of corrosion on the exterior of metal tanks, piping systems, and ancillary components
- (ii) evidence of deterioration of exterior coatings such as rust spots and blisters on the secondary containment system walls and floors
- (iii) damage or deterioration of insulation
- (iv) discolorations and staining of coatings around the tank or ancillary equipment

The following subsections describe the visual inspection activities conducted for the Vapor Liquid Separator subsystem, Condensate Collection subsystem, Secondary Containment Subsystem, Load-Out and Hot Equipment Room, and IX Room.

2.4.1 Visual Inspection of Vapor Liquid Separator Subsystem

Visual inspection, video tapes, and digital film were used in the evaporator room to identify visible cracks, potential leak sites, and other physical impairments. The inspections were completed by trained and certified technicians and reviewed by the IQRPE. Visual examination of the Vapor Liquid Separator Subsystem, including the 242-A Evaporator and its components were conducted prior to and after the leak test activities described in Section 2.5 of this IAR. The information used to complete the visual inspection of the Vapor Liquid Separator Subsystem is presented in Attachments 7A, 7B, and 7D. Highlights of the evaluation of this information by the IQRPE is presented below.

Rust was noted over some areas of tank and ancillary equipment (Attachment 7A, 7B, and 7D). Water stains due to condensation and wash downs on tank shell and supports were evident but no liquid was observed. There were water or oil stains on some tank supports but no source was attributed in the visual examination films. Because of the presence of insulation over many of the major subsystem components and as low as reasonably achievable (ALARA) concerns, the external areas of C-A-1 evaporator were only partially examined.

Video taken at the 732' 6" level of the Evaporator Room shows the upper support ring of the evaporator vessel (C-A-1) and its attachment to the building structural framing. The upper rings are attached to the building framing with guide pins, washers, and cotter pins. One of the guide pins does not show both ends of the top cotter pin. CH2M HILL Hanford Inc. (CH2M HILL) reviewed this situation using pertinent drawings and calculations (CH2M-PER-2007-0975 [CH2M HILL 2007]). This evaluation determined that the design purpose for the guide pin is satisfied as long as the top remains above the bottom of the upper guide ring (about a 1" drop from the original installed elevation). The photo shows about a 1/4" drop (assuming it was installed as shown on the design drawings). This indicates that the current configuration is acceptable and that after 30 years of service the guide pin is still restrained. Because the seismic restraint calculations only take credit for two of the four pins when determining response to a seismic event, this pin could be completely removed without impacting the structural integrity of the unit.

Visual inspection during leak testing activities (Section 2.5) and the examination of digital films and video tapes collected before and after leak testing activities found no indications of a leak from the tank shell and its associated ancillary components (that is pumps, piping systems, flanges, and valves) except for an apparent leak from Nozzle E on the 28" recirculation line. An apparent leak from Nozzle E was identified during operator rounds on September 1, 2007 (TF-OR-A02, 2007). The leak may have occurred due to a waste "plug" in the line dissolving following the four hour deep flush and the protracted (24 hour) leak test, thus allowing it to leak through.

It was identified as a small mound of brown material on the pump room floor underneath Nozzle E and a small amount of material on the base of the instrument attached to Nozzle E. No liquid was observed. Solid waste material was removed from floor. The repairs will be completed within work package WFO-WO-07-2340 early in 2008. The IQRPE has reviewed and concurs with the work package and recommends that it be implemented before the beginning of the next campaign.

Recommendations based on the visual observations tabulated in Attachments 7A, 7B, and 7D are summarized below. All of these recommendations are related to insignificant deterioration in the system components and/or non-dangerous waste components. These recommendations do not impact the integrity of the 242-A Evaporator unit dangerous waste vessels, piping systems, or ancillary components or its ability to contain a release of dangerous waste. Corrective actions have already been completed to implement some of these recommendations related to piping hangers and supports. All items are listed below for completeness.

2.4.1.1 Evaporator Pump Room

- Dark fluid in sump; scaling, white stain on floor; minor surface corrosion on floor; hairline crack on western wall and in wall above door, chipped wall coating above jumper 38. Clean floor surface to remove surface staining and corrosion; repair coating over crack
- Minor surface corrosion P-B-1 pump CS flange bolts. Monitor; replace CS flange bolts with SS when servicing
- Minor dark staining on P-B-2 pump mounts and under pump. Determine cause of staining and remove stains
- Paint chipped on P-B-1 support, crack in wall/wall coating. Recoat supports

2.4.1.2 Evaporator Room Basement

- Minor surface rust on valve actuator linkage. Identify valve actuator shown; remove rust, recoat valve actuator linkage
- Pipe hanger and bolts show surface corrosion; bolt pulled free from wall; nut loose; U-bracket corroded. Identify line, reanchor conduit hanger to wall, remove corrosion from hanger and replace bolts, replace U-bracket, ensure anchor nuts are tight
- Surface corrosion on valve actuator to CA1-7 and supports. Remove corrosion and recoat
- Actuator linkage to CA1-7 is supported by pipe stand and restrained by U-hanger and loose pad underneath, creating groove in actuator linkage; support appears adequate (no stresses evident at base). Another restraint or means to prevent grooving the actuator linkage should be considered
- White staining on flange (upstream of Location 15, Line 6"DR-335-M9). Identify source of staining and remove staining
- Surface corrosion on actuator linkage and linkage support (valve ZS-CAI-9-2). Remove corrosion and recoat
- Multiple chips in floor coating (approx 1"X1"). Repair coating over chips
- SS pressure line sensor not attached to unistrut hanger; line is open ended. Attach line to hanger or if abandoned, remove line

2.4.1.3 Evaporator Room Ground Floor

- Anchor bolt pulled out of wall. Identify line, reanchor conduit hanger to wall, remove corrosion from hanger, and replace bolts
- Loose U-anchor. Replace U-bracket, ensure anchor nuts are tight
- Missing bolts; two bolts in four bolt flange, 3/4 SS line connection. Install any and all missing bolts
- Unistrut hanger for 3/4 SS line pulling away from wall. Secure hanger to wall

2.4.1.4 Evaporator Room First Floor

- Support nuts and bolts show surface corrosion. Monitor; replace when support is serviced
- 2" SS Water line anchor bolt pulled out of wall. Identify line, re-anchor conduit hanger to wall, remove corrosion from hanger, and replace bolts
- Concrete spalling and anchor possibly pulled away from wall, 2"SS Water line. Identify line, inspect concrete and anchor to determine if anchor is firmly attached; repair if needed
- 3/4" Line unistrut anchor pulled away from north wall. Identify line, reattach unistrut anchor

2.4.1.5 Evaporator Room Third Floor

- Bent hanger/anchor bolt pulled away from wall, 2"SS line (east wall). Identify line, replace/re-anchor SS line
- Nut on U-bolt appears to have pulled through 2"SS line anchor due to missing washers, U-bolt corroded. Anchor has pulled away from wall (east wall). Place washers behind nuts, replace U-bolt, secure anchor to wall

2.4.1.6 Evaporator Room Fourth Floor

- Pipeline appears to span two or more floors vertically with no anchoring (NW corner). Verify adequate anchoring, support (anchor) vertical piping at every floor if necessary
- Inner line sitting on anchor strut without bracket. Secure line to anchor strut; identify line shown (appears to be a 1/2" FRW)
- Vertical structural support missing bolt. Replace bolt

2.4.2 Visual Inspection of Condensate Collection Subsystem

Visual inspection, video tapes, and digital film were used in the condenser room to identify visible cracks, potential leak sites, and other physical impairments. The inspections were completed by trained and certified technicians and reviewed by the IQRPE. Visual examination of the Condensate Collection Subsystem, including the Condensate Collection Tank and its components were conducted prior to and after the leak test activities described in Section 2.5 of this IAR. The information used to complete the visual inspection of the Condensate Collection Subsystem is presented in Attachment 7C. Highlights of the evaluation of this information by the IQRPE are presented below.

Rust was noted on some areas of tank and ancillary equipment (Attachment 7C). Some areas where condensation (room condensation or tank condensation) and wash down fluids had collected on the tank shell and tank supports were observed, however no liquid was noted. There were water or oil stains on some surface areas of the tank but no source was identified.

Visual examination of digital films and visual inspection before, during, and after leak testing found no indications of leaks from the tank, piping systems, and ancillary components such as pumps, flanges, and valves.

Recommendations based on the visual observations tabulated in Attachment 7C are summarized below. All of these recommendations are related to insignificant deterioration in the system components and/or non-dangerous waste components. These recommendations do not impact the integrity of the 242-A Evaporator unit dangerous waste vessels, piping systems, or ancillary components.

- Minor surface contamination/staining, possible scaling on the tank skirt of TK-C-100 condensate collection tank. Recommended to clean the surface, monitor, and reassess the surface
- Surface corrosion on cast iron (CS) flange bolts; rust on vent and drain lines; housing of F-C-1 is chipped. Replace CS flange bolts with stainless steel (SS) when servicing; monitor and reassess; recoat chipped and corroded surface
- Surface corrosion on CS flange bolts on foreground flange cover. Replace CS flange bolts with SS when flange serviced; monitor flange connections for bolt breakage or flange leak
- Tool marks on foreground bolts. Repaint bolts

- Flange bolts on top flange on the 6" vapor line are corroded. Replace bolts when flanges or lines are serviced/monitor flange connections for bolt breakage or flange leak
- Appearance of missing and chipped paint on and near upper elbow, 6" vapor line. Clean surface and repair coating
- Damage to coating on the First Floor North Wall of condenser room. Recoat
- Staining on bottom 6" support wall on the First Floor West Wall. Clean and recoat
- Surface staining near drain and tank walls. Clean and recoat
- Lube oil leak below pump and motor. Needs monitoring and maintenance
- Staining below E-C-2. Needs cleaning and paining if necessary
- Staining and rust inside the tray at F-C-3. Clean or replace tray
- Surface staining on tank wall at several walls. Needs cleaning and painting if necessary
- Surface staining on support walls for P-C-100 and P-C-106. Needs cleaning and painting if necessary
- Rust on seal pot bottom flange bolts. Needs monitoring and maintenance
- Lube oil leak below motor at TK-C-100 agitator flange. Needs monitoring and maintenance
- Surface staining on TK-C-100 tank top at flanges E, F, and H. Needs monitoring and maintenance
- White powder spots on valve #2-33. Needs cleaning and maintenance

2.4.3 Visual Inspection of Secondary Containment Subsystem

Visual inspection, video tapes, and digital film were used to identify visible cracks, potential leak sites, and other physical impairments to the Secondary Containment Subsystem. The inspections were completed by trained and certified technicians and reviewed by the IQRPE. Visual examination of the Secondary Containment Subsystem were conducted prior to and after the leak test activities described in Section 2.5 of this IAR. The information used to complete the visual inspection of the Secondary Containment Subsystem is presented in Attachments 7A, 7B, and 7C. Highlights of the evaluation of this information by the IQRPE is presented below.

Attachment 7B provides the observations viewed from the DVDs taken at the Evaporator room prior to leak testing of the evaporator. Most of the areas on the secondary containment walls and flooring at the evaporator room are clean and have protective coating. There are no indications of deteriorated joint sealant, moisture accumulation in the joints, or concrete deterioration around the joints.

Chipped wall coatings were only found in areas that do not serve as secondary containment. The DVD of the Evaporator Pump Room shows hairline cracks in the western wall. These are above the coating on the walls and would not impact the integrity of the secondary containment subsystem. The cracks do not appear below where the wall coating begins.

There are several small chips in the floor of the Evaporator Basement that could potentially impact to the integrity of the secondary containment subsystem in the future if not addressed. Chips of various sizes were observed; the larger chips measuring from 1" by 1" to 1" by 2". There is no visual evidence of staining or infiltration associated with the chips.

Recommendations based on the visual observations tabulated in Attachments 7A, 7B, and 7C are summarized below. All of these recommendations are related to minor deterioration in the secondary containment subsystem. These recommendations do not impact the integrity of the 242-A Evaporator unit secondary containment subsystem.

The locations identified in Attachment 7B are, in the judgment of the IQRPE, the minimum repairs needed. The flooring immediately surrounding the drums and the area for storing scaffolding should be examined for chips due to items dropped from scaffolding. If additional similar chips are subsequently identified during future repair activities, they should be repaired as well. Shielding blankets on the floor may remain in place since they have been there for several years and have likely protected the original floor coating. Drums for storing scaffolding and other metal parts may also be left in place.

Concurrence on the final results of repaired areas would be established by providing a follow up visual inspection of the repaired areas by a qualified observer, documented by still or video photography to ensure that the coating has been repaired. CH2M HILL is in the process of planning and estimating the coating repair.

2.4.4 Visual of Inspection of Loadout and Hot Equipment Storage Room

Digital films were used in the condenser room for observations of rust spots, pitting, loss of metal, corrosion, blisters, discoloration of coatings, damage to insulation, bolts and welds, joint cracks, loss of weld integrity, and evidences of leaks by trained and certified technicians and reviewed by the IQRPE. The results of visual examination of the films are presented in Attachment 7F.

Based on the review digital films no observations or potential deficiencies were identified and no recommendations are presented.

2.4.5 Visual of Inspection of IX Room

Digital films were used in the condenser room for observations of rust spots, pitting, loss of metal, corrosion, blisters, discoloration of coatings, damage to insulation, bolts and welds, joint cracks, loss of weld integrity, and evidences of leaks by trained and certified technicians and reviewed by the IQRPE. The results of visual examination of the films are presented in Attachment 7E.

Based on the review digital films no observations or potential deficiencies were identified and no recommendations are presented.

2.5 Results of Leak Testing

Level draw down leak tests were performed for the Vapor Liquid Separator Subsystem and Condensate Collection Tank in accordance with the procedures outlined in the IAP (TGS 2007a). The results of both leak tests met the requirements of the testing procedures.

The following sections discuss the leak testing results

2.5.1 Condensate Collection Subsystem Leak Test

This leak test was conducted on July 2, 2007 in accordance with the IAP (TGS 2007a). The work instructions for completing the test are included as Attachment 4A. Liquid levels in the Condensate Collection Tank (TK-C-100) were recorded hourly by observing the weight factor from the level indicator (WFIC-C100). Visual inspection of the shell of TK-C-100 and the associated connections were performed every 4 hours during the test.

Leak test data is tabulated in Attachment 4B (Table 4B.1). Weight factors were converted to gallons for IQRPE analysis. Analysis of the tabulated data indicate that the tank volume increased from an initial value of 11,730.412 gallons at 0950 on July 2, 2007 and reached a maximum value of approximately 11,756.8 gallons at 0050 on July 3, 2007 before dropping back to and ending value of 11,753.2 gallons at 0950 on July 3, 2007. The observed increase of approximately 23 gallons over the duration of the test was anticipated as part of the test due to temperature and ventilation influences. These factors are described in detail in Attachments 4 and 5. The acceptance criteria for the test was less than 1 percent decrease (about 117 gallons). The observed increase was not significant enough to mask a leak that would have resulted in an unacceptable test.

Leak test results and visual inspection data sheets indicate no detectable leak from the Condensate Collection Tank (TK-C-100).

2.5.2 Vapor Liquid Separator Subsystem Leak Test

The leak test for the Vapor Liquid Separator Subsystem was conducted on September 1 and 2, 2007 in accordance with the IAP (TGS 2007a). The work instructions for completing the test are included in Attachment 5A. Liquid levels in the Evaporator vessel (C-A-1) were recorded hourly over a 24 hour period by observing the level indicator (LIC-CA1-2). Visual inspections were performed every 4 hours during the hold test through the pump room window. In accordance with IAP, no entry was made into the evaporator or pump room during the test due to safety issues. No detectable liquid leaks were observed. Results of the leak test are included in Attachment 5A.

A visual inspection was also planned after the level test on the same day, however, the pump room could not be accessed due to radiation concerns. This inspection was performed immediately after the conclusion of the hold test on September 4, 2007 (Attachment 5C) once C-A-1 was drained and radiation issues were resolved. No detectable leaks were observed.

Leak test data is tabulated in Table 5B. A volume fluctuation (15 gallons) of similar form and magnitude to a volume fluctuation that was observed in 1998 (17 gallons) was observed. This fluctuation is most likely attributable to diurnal temperature fluctuations. A comprehensive analysis of the fluctuation is included in Attachment 5B. In contrast, if the system had been subjected to a leak, a steady decline would have been observed.

Leak test results and visual inspection data sheets indicate no detectable leak from the Condensate Collection Tank (TK-C-100).

2.5.3 IQRPE Concurrence

The IQRPE concurs with the leak test results and evaluation described herein. The unit components subjected to level drawdown leak test did not indicate a measurable leak or deterioration of the system integrity. The test met the requirements of WAC 173-303-640(2)(c) "...that the tank system is adequately designed and has sufficient structural strength and compatibility with the waste(s) to be stored or treated to ensure that it will not collapse, rupture or fail."

2.6 Results of Ultrasonic Testing

Ultrasonic tests of the Vapor Liquid Separator Subsystem and Condensate Collection Subsystem were completed in accordance with the IAP (TGS 2007a). Wall thickness measurements made in 1993, 1998, and 2007 show little variability. UT data are included in Attachments 6A and 6B. Certifications for the UT technicians are included in Attachment 8.

A total 2,042 UT test data points were collected at 18 locations. Statistical evaluation of the UT results show that there has been no measurable deterioration of tank system integrity. The UT evaluation suggests that the vessels tested remain structurally sound and are not corroding due to thinning, cracking, or pitting to any appreciable extent. Potential extreme values or outliers occurred in some data sets, possibly indicating either minor errors in measurement, data recording, or minor localized pitting. Analysis of the UT results demonstrate that the observed variations in the measured wall thicknesses are within the margin of error of the testing equipment. Statistical analysis of UT results also indicate that the data typically followed uniform distributions indicative of ordinary corrosion. Data was found in all cases to be above the allowable thickness and, in many cases above the nominal thickness specified for the original construction of each vessel. Evaluation of the minimum thickness measurements and statistical mean values also demonstrate little or no loss in material thickness since previous measurements were made.

Table 2.6.1 summarizes the measured values and estimated corrosion rates based on the UT data. The following subsections present a detailed summary of the UT data analysis included in Attachments 6A and 6B.

2.6.1 General Comments Concerning the UT Data

The materials of construction, system design, and protective coatings for the 242-A Evaporator unit provide adequate corrosion protection and compatibility with the wastes processed and generated by the unit. The wall thicknesses of the equipment and piping remain above the "T-nom" thickness minus the mill tolerance which is the minimum thickness expected during original construction (see Table 2.6.1). This is consistent with the results of the 1993 and 1998 IARs (WHC 1993 and LMHC 1998, respectively).

The 242-A Evaporator unit corrosion protection program consists of materials, methods of construction, and control of the process chemistry for the liquid waste environments. The unit components and piping are constructed primarily of austenitic stainless steels and low alloy carbon steels. Gaskets at component and piping connections are chemically resistant non-metallics. Each subsystem was designed for the operating parameters and material/environment compatibilities characteristic of past campaigns and the RCRA Permit limits.

Based on the UT analysis, is the IQRPE recommends that all accessible equipment and grid points that were tested in this (2007) integrity assessment be tested during the next integrity assessment. These points were selected based on accessibility to certain locations and data sets at each test location that could be statistically evaluated (see Attachment 6A for narratives regarding the selection of ultrasonic test points). Conducting future testing at these locations will establish a baseline for future testing to that can be used to calculate corrosion rates and remaining equipment life.

UT thickness testing locations were selected to repeat test locations so that corrosion rates and equipment life could be calculated. It was determined that the number of test points could be reduced and still satisfy statistical analysis requirements (Attachment 6A). In cases where only a portion of the UT points from the 1993 IA were tested due to ALARA concerns (usually alternating columns within a test grid), the IQRPE recommends that the next IA collect data from the points not tested in 2007 (that is, collect data from the columns that were last tested in 1993) in order to allow statistical analysis of the measurements at these points over time.

2.6.2 Statistical Analysis of UT Data

UT thickness data was analyzed statistically in accordance with American Society for Testing Materials (ASTM) 2004, ASTM 2005, and HSE 2002 procedures. UT analysis included the determination of maximum, minimum, and mean of thickness data in order to calculate corrosion rates and equipment life (Attachments 6B and 6C). This information is summarized in Table 2.6.1. ASTM (2004) and HSE (2002) recommend performing statistical analysis to determine the presence of random measurement errors, to estimate confidence limits, identify potential data outliers, and extrapolate minimum area thickness values by estimating and evaluating the underlying data distribution. These tests determine the behavior of the corrosion and the probability that actual thicknesses fall below the range of the measured data. Probability analysis is sensitive to both the number of data points and the variability of data within the data set.

Statistical analysis of UT thickness data collected for the 242-A Evaporator unit indicate that the data typically followed uniform distributions indicative of ordinary corrosion. Potential extreme values or outliers occurred in some data sets, possibly indicating either minor errors in measurement or data recording or minor localized pitting. However, the data was found in all cases to be above allowable thicknesses. In many cases, the measured values were above the nominal thickness allowed by codes governing the original fabrication of the vessels.

Location 3 in particular offered a unique opportunity for statistical analysis. Because the UT location tested in 1993 and again in 1998 was both subject to unit ALARA concerns and inaccessible without erecting scaffolding, a different side of the Evaporator was tested in 2007 (Attachments 6A and 6B). Testing at Location 3 in 2007 was subdivided into two sub-locations (3-All and 3 Additional Grid) to obtain the total number of UT points required for statistical analysis by the IQRPE. This was because of the presence of supports and the proximity of the vessel to the evaporator building wall. 1998 IAR UT data was from rows A-L and columns 1-8 were also calculated. Similar statistical analysis of mean Evaporator thickness and minimum thicknesses were performed for data collected in 1993 and 1998 and compared to 2007 where available (Attachment 6C). A comparison of these readings, indicate little variation between comparative areas (that is, areas of similar geometry). Further, analysis of the data indicates that there is little to no change in material thickness when comparing the areas inspected. Calculating the life of the evaporator vessel (C-A-1) based on the different readings all yield calculations exceeding 20 years (see Table 2.6.1).

For Location 18, the initial UT data collected at subarea Data T yielded two data points near and slightly below allowable thickness (0.202 and 0.206 inches). Statistical analysis indicated that the lowest of the two points from data set were possible outliers since they were significantly smaller than the remainder of the set of five smallest data points collected at this location (0.202, 0.206, 0.237, 0.252, and 0.257 inches). Retesting was conducted at Location 18 at the direction of the IQRPE to determine if these readings were anomalous. Initial and re-test data at Location 18 were collected by the same examiner. Retest data show no anomalous readings. All readings are above allowable thickness. The NDE examiner believes that the discrepancy was due to the procedure used to collect the data. During testing activities, the NDE examiner had another UT qualified person with him as the data recorder, leaving both hands free to make the actual measurement. Because of the radiation intensity in that area, the scribe was required to be about 15 feet away from the examiner. During the original testing, the values were shouted between the examiner and the scribe, both of whom were wearing full-face respirators. During the retesting activities, the data collection and recording procedure required the examiner to measure thickness at one to two locations at a time and then walk to the scribe and speak the values for her to write down. The NDE examiner believes that there was a miscommunication of the values during the original testing attributable to miscommunication of readings caused by working conditions (ambient noise and speaking through a respirator) that was avoided in retesting under the aforementioned procedures. Because Location 18 represents an new UT location for this IAR, no equipment life predictions can be made from the data collected in 2007. Minimum thickness values collected at this location are similar to or greater than the minimum thickness values obtained at other test locations (4, 5, and 7) on the same vessel that have a predicted life exceeding twenty years (see Table 2.6.1).

Area extrapolation for minimum thickness estimation by evaluating the underlying distribution is conducted by first making use of reliability analysis as follows:

$$F(x) = \int_{\infty}^{x} f(t)dt$$

And

$$R(t) = \int_{t}^{\infty} f(u)du = 1 - F(t)$$

Where:

F(x) = the cumulative distribution function of x

f(t) = the probability density function

R(t) = the survivor function (or reliability function)

f(u) = the cumulative probability density function

The measurements selected of interest are allowable thickness, minimum measured thickness, and nominal thickness. The minimum measured thickness, used to predict corrosion rates and the life of each component, was in all cases larger than the allowable thickness and was therefore used to bound the probability range.

An evaluation of UT measurement checks against a measurement standard (calibration step wedges) prior to and following each test event at each test location demonstrated that measurement errors ranged between -0.003 to 0.001 inches (Attachment 6B). If this measurement range error is considered in statistical analyses, it does not directly impact statistical means rather, it introduces uncertainty in measurement (such as an error bar). Whether a unique error for each measurement location is applied (i.e. Locations 1 through 22) or the maximum error range of 0.001 to -0.003 inches is applied uniformly to all measurements, if these small variations are applied, the statistically predicted life times are not affected. For instance, if an uncertainty of 0.001 to -0.003 inches is applied to minimum thickness measurement of 0.506 inches at Location 9, the life prediction for this component, based on material loss since 1998 (when it was measured to be 0.504 inches) becomes 90.9 +2.5 / -7.5 years. The overall prediction of lifetime for this component remains >20 years.

Table 2.6.1

Thickness and Corrosion Rate

					Mean Thicknesses			Total Loss			Corrosion Rate			Minimum Thicknesse			Min Remaining Life		
			Nominal	Allowable	1993	1998	2007	93-98	98-07	93-07	93-98	98-07	93-07	1993 Min	1998 Min	2007 Min	93-98	98-07	93-07
Location	Equipment	Mat'l	inch	inch	inch	inch	inch	inch	inch	inch	MPY	MPY	MPY	inch	inch	inch	Years	Years	Years
1	42-inch vapor line[1]	SS	0.3125	0.2675	0.317	NA	0.319	NA	NA	0.0E+00	NA	NA	0.0E+00	0.308	NA	0.303	NA	NA	>20
2	42-inch vapor line[2]	SS	0.3125	0.2675	0.319	NA	0.320	NA	NA	0.0E+00	NA	NA	0.0E+00	0.290	NA	0.290	NA	NA	>20
3	C-A-1 All[3]	SS	0.375	0.32	0.375	NA	0.381	0.0E+00	NA	0.0E+00	0.0E+00	NA	0.0E+00	0.348	NA	0.343	>20	NA	>20
3	C-A-1 A-L, 1-8[3]	SS	0.375	0.32	0.380	0.384	0.383	0.0E+00	3.6E-04	0.0E+00	0.0E+00	4.0E-02	0.0E+00	0.377	0.381	0.380	>20	1520.3	>20
3	C-A-1, Additional Grid[3],[4]	SS	0.375	0.32	NA	NA	0.383	NA	NA	NA	NA	NA	NA	NA	NA	0.343	NA	NA	NA
4	28-inch Recirc Line[5]	SS	0.25	0.205	0.263	NA	0.265	NA	NA	0.0E+00	NA	NA	0.0E+00	0.252	NA	0.261	NA	NA	>20
5	28-inch Recirc Line	SS	0.25	0.205	0.263	0.264	0.265	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.244	0.252	0.242	>20	>20	>20
6	E-A-1	SS	0.25	0.205	0.249	NA	0.253	NA	NA	0.0E+00	NA	NA	0.0E+00	0.245	NA	0.248	NA	NA	>20
7	28-inch Recirc Line	SS	0.25	0.205	0.249	0.251	0.249	0.0E+00	2.2E-03	6.0E-04	0.0E+00	2.4E-01	4.3E-02	0.229	0.239	0.233	>20	139.2	656.0
9	E-C-1	CS	0.5	0.47	0.521	0.515	0.515	5.7E-03	0.0E+00	5.5E-03	1.1E+00	0.0E+00	4.0E-01	0.489	0.504	0.506	16.7	>20	90.9
11	TK-C-100	SS	0.3125	0.161	0.318	0.320	0.319	0.0E+00	9.1E-04	0.0E+00	0.0E+00	1.0E-01	0.0E+00	0.309	0.310	0.190	>20	1477.8	>20
12	E-C-2[6]	CS	0.3125	0.273	0.333	0.326	0.313	7.0E-03	1.3E-02	NA[6]	1.4E+00	NA[6]	NA[6]	0.314	0.310	0.307	29.4	NA	NA
13	E-C-3[6]	CS	0.322	0.282	0.345	0.341	0.322	4.5E-03	1.9E-02	NA[6]	9.1E-01	NA[6]	NA[6]	0.334	0.328	0.308	57.3	NA	NA
15	Slurry Drain Line (6" DR-335-M9)	SS	0.134	0.117	0.137	0.137	0.137	7.7E-05	0.0E+00	0.0E+00	1.5E-02	0.0E+00	0.0E+00	0.135	0.135	0.136	1170.0	>20	>20
16	C-100 Tank Condensate Line (3" DR-359-M42)	CS	0.216	0.189	0.212	0.225	0.218	0.0E+00	7.2E-03	0.0E+00	0.0E+00	8.1E-01	0.0E+00	0.208	0.211	0.215	>20	27.3	>20
17	E-C-1 / E-C-2 Line (6" VAC-1500-M42)	CS	0.280	0.245	0.306	0.313	0.304	0.0E+00	9.3E-03	2.3E-03	0.0E+00	1.0E+00	1.7E-01	0.298	0.299	0.296	>20	52.1	306.0
18	28-inch Recirc Line[7]	SS	0.25	0.205	NA	NA	0.280	NA	NA	NA	NA	NA	NA	NA	NA	0.238	NA	NA	NA
19	F-C-1[8]	WS	0.120	NA	NA	NA	0.135	NA	NA	NA	NA	NA	NA	NA	NA	0.133	NA	NA	NA
21	F-C-3[9]	CI	0.438	NA	NA	NA	0.605	NA	NA	NA	NA	NA	NA	NA	NA	0.490	NA	NA	NA
22	2" PC-554-M42[10]	CS	0.154	NA	NA	NA	0.182	NA	NA	NA	NA	NA	NA	NA	NA	0.175	NA	NA	NA

Notes:

CI	Cast iron
CS	Carbon steel
NA	Not applicable
Pend	Data pending
SS	Stainless steel
WS	Welded steel

[1] No 1998 data, rates calculated from 1993 to 2007; Columns A&D data only for 2007, compared to Columns A&D data from 1993.

[2] No 1998 data, rates calculated from 1993 to 2007; Columns ADG data only for 2007, compared to Columns ADG data from 1993.

[3] Using Rows 1-8, Columns A-L for 1993 to 1998 and 1998 to 2007 life prediction; using complete data sets for 1993 to 2007 life prediction.

[4] Additional UT points were collected in this area at Location 3 in 2007.

[5] No 1998 data, rates calculated from 1993 to 2007; Column A data only for 2007, compared to Column A data from 1993.

[6] E-C-2 and E-C-3 were replaced in 2004. No life predictions can be made for these components based on previous UT data.

[7] New location. Data and results shown are for retesting performed on November 28, 2007+A13.A29

[8] New Location, specifications not available to the IQRPE. Assume equivalent of 4", schedule 10 pipe to provide nominal thickness (0.120 inch).

[9] New Location, specifications not available to the IQRPE. Assume equivalent of 4", schedule 120 pipe to provide nominal thickness (0.438 inch).

[10] New Location, specifications not available to the IQRPE. Pipe is 2", schedule 40 pipe, which provides the nominal thickness (.154 inch).

2.6.3 Reliability Analysis of UT Test Data

Reliability analysis was used to determine the probability that measurements within the test area are at a given thickness (see Table 2.6.2 for a summary of statistical reliability analyses). For example, at Location 1, based on measurements collected for the 2007 IA, the probability that a measurement will be greater than the allowable thickness (0.2675 inch) is 100% within the area tested at Location 1. Similarly, the probability that a measurement will be greater than the minimum thickness measured at Location 1 in 2007 (0.303 inch) within the area tested at Location 1 is 99.23%. The probability that a measurement will be greater than the nominal thickness (0.3125 inch) within the area tested at Location 1 is 97.56% (see Table 2.6.2). Generally, the results of reliability function statistical analysis predicted probabilities of wall thicknesses greater than the allowable thicknesses at 100% for nearly all areas tested (see Table 2.6.2).

Area extrapolation analysis was also performed by raising the reliability function to the power of the ratio of the test area to the total area. Area ratio values for each test area are presented in Table 2.6.3. This method is used to estimate the probability that a point located elsewhere on a given unit will be found below a the measured data. The measurements of interest are allowable thickness, smallest measured thickness, and nominal thickness. At Location 1, the probability that a measurement will be above the allowable thickness (0.2675 inch) is 100% elsewhere on the 28-inch line. Similarly, the probability that a measurement will be above the minimum thickness measured at Location 1 in 2007 (0.303 inch) elsewhere on the 28-inch line is 66.27% and the probability that a measurement will be above the nominal thickness (0.3125 inch) elsewhere on the 28-inch line is 51.84% based on measurements collected in 2007 (see Table 2.6.4).

In calculating reliability, the cumulative distribution is dependent upon the number of readings up to a thickness divided by the total number of readings. If there are few data points, then the probability at each data point is assigned a much greater value. If there is little uniformity in the data (i.e. a large number of readings up to a given data point) probability has a very narrow distribution. This has an effect on reliability calculations and this effect is further magnified in the area distribution extrapolation analysis since the area ratio power is applied. In the case of this data set, the effect can become a prediction of no values below allowable and no values above nominal for some test areas (see Tables 2.6.2 and 2.6.4).

Table 2.6.2

Reliability Analysis Summary

Year	Location	Equipment	Mat'l	Allowable	Reliability	Minimum	Reliability	Nominal	Reliability
2007	1	42-inch vapor line	SS	0.2675	100.00%	0.303	99.23%	0.3125	97.56%
1993	1	42-inch vapor line	SS	0.2675	100.00%	0.308	99.23%	0.3125	96.92%
2007	2	42-inch vapor line	SS	0.2675	100.00%	0.29	99.05%	0.3125	99.25%
1993	2	42-inch vapor line	SS	0.2675	100.00%	0.29	96.19%	0.3125	87.01%
2007	3	CA1	SS	0.32	100.00%	0.381	80.56%	0.375	100.00%
1998	3	CA1	SS	0.32	100.00%	0.381	80.56%	0.375	100.00%
1993	3	CA1	SS	0.32	100.00%	0.348	99.78%	0.375	51.10%
2007	4	28-inch Recirc Line	SS	0.205	100.00%	0.261	96.43%	0.25	100.00%
1993	4	28-inch Recirc Line	SS	0.205	100.00%	0.252	96.43%	0.25	100.00%
2007	5	28-inch Recirc Line	SS	0.205	100.00%	0.242	98.08%	0.25	100.00%
1998	5	28-inch Recirc Line	SS	0.205	100.00%	0.252	98.08%	0.25	100.00%
1993	5	28-inch Recirc Line	SS	0.205	100.00%	0.244	98.08%	0.25	96.79%
2007	6	E-A-1	SS	0.205	100.00%	0.248	98.21%	0.25	55.36%
1993	6	E-A-1	SS	0.205	100.00%	0.245	98.21%	0.25	21.43%
2007	7	28-inch Recirc Line	SS	0.205	100.00%	0.233	98.08%	0.25	23.08%
1998	7	28-inch Recirc Line	SS	0.205	100.00%	0.239	97.92%	0.25	56.25%
1993	7	28-inch Recirc Line	SS	0.205	100.00%	0.229	98.21%	0.25	78.57%
2007	9	E-C-1	CS	0.47	100.00%	0.506	99.79%	0.5	100.00%
1998	9	E-C-1	CS	0.47	100.00%	0.504	99.83%	0.5	100.00%
1993	9	E-C-1	CS	0.47	100.00%	0.489	99.83%	0.5	99.73%
2007	11	TK-C-100	SS	0.161	100.00%	0.19	99.77%	0.3125	93.29%
1998	11	TK-C-100	SS	0.161	100.00%	0.31	99.77%	0.3125	96.99%
1993	11	TK-C-100	SS	0.161	100.00%	0.309	99.07%	0.3125	85.53%
2007	12	E-C-2	CS	0.273	100.00%	0.307	98.67%	0.3125	42.00%
1998	12	E-C-2	CS	0.273	100.00%	0.31	97.33%	0.3125	92.67%
1993	12	E-C-2	CS	0.273	100.00%	0.314	31.40%	0.3125	0.00%
2007	13	E-C-3	CS	0.282	100.00%	0.308	97.44%	0.322	100.00%
1998	13	E-C-3	CS	0.282	100.00%	0.328	94.87%	0.322	100.00%
1993	13	E-C-3	CS	0.282	100.00%	0.334	97.44%	0.322	100.00%
2007	15	Slurry Drain Line (6" DR-335-M9)	SS	0.117	100.00%	0.136	75.00%	0.134	100.00%
1998	15	Slurry Drain Line (6" DR-335-M9)	SS	0.117	100.00%	0.135	84.62%	0.134	100.00%
1993	15	Slurry Drain Line (6" DR-335-M9)	SS	0.117	100.00%	0.135	92.31%	0.134	100.00%
2007	16	C-100 Tank Condensate Line (3" DR-359-M42)	CS	0.189	100.00%	0.215	66.67%	0.216	41.67%
1998	16	C-100 Tank Condensate Line (3" DR-359-M42)	CS	0.189	100.00%	0.211	91.67%	0.216	45.83%
1993	16	C-100 Tank Condensate Line (3" DR-359-M42)	CS	0.189	100.00%	0.208	66.67%	0.216	16.67%
2007	17	E-C-1 / E-C-2 Line (6" VAC-1500-M42)	CS	0.245	100.00%	0.296	91.67%	0.28	100.00%
1998	17	E-C-1 / E-C-2 Line (6" VAC-1500-M42)	CS	0.245	100.00%	0.299	91.67%	0.28	100.00%
1993	17	E-C-1 / E-C-2 Line (6" VAC-1500-M42)	CS	0.245	100.00%	0.298	91.67%	0.28	100.00%
2007	18	28-inch Recirc Line	SS	0.205	100.00%	0.238	96.15%	0.25	92.86%
2007	19	F-C-1(1)	WS	NA	NA	0.133	96.00%	0.120	100.00%
2007	21	F-C-3(2)	CI	NA	NA	0.49	93.75%	0.438	100.00%
2007	22	2" PC-554-M42(3)	CS	NA	NA	0.175	91.67%	0.154	100.00%

Notes:

(1) New Location, specifications not available to the IQRPE. Assume equivalent of 4", schedule 10 pipe to provide nominal thickness (0.120 inch).

(2) New Location, specifications not available to the IQRPE. Assume equivalent of 4", schedule 120 pipe to provide nominal thickness (0.438 inch).

(3) New Location, specifications not available to the IQRPE. Pipe is 2", schedule 40 pipe, which provides the nominal thickness (.154 inch).

Table 2.6.3

Area Ratio

Test Location	DWG No.	Description	Location	UT Points 1993	UT Points 1998	UT Points 2007	Test Area (in^2) 1993	Test Area (in^2) 1998	Test Area (in^2) 2007	Surface Area (in^2)	Reliability Power Ratio 1993	Reliability Power Ratio 1998	Reliability Power Ratio 2007	Comments
1	6.3	42" Vapor Line	Evaporator Room	260	NA[2]	130	1040	NA[2]	520	27,709.00	26.64	NA[2]	53.29	Length inside Evaporator Room
2	6.4	42" Vapor Line	Evaporator Room	245	NA[2]	105	980	NA[2]	420	27,709.00	26.27	NA[2]	65.97	Length inside Evaporator Room
3	6.5	C-A-1 Evaporator Shell	Evaporator Room	456	72	422	1824	288	1688	259,671.00	142.36	901.64	153.83	Outside shell (from 1993 IAR)
4	6.19	28" Recirculation Line	Evaporator Room	112	NA[2]	28	448	NA[2]	112	105,556.00	235.62	NA[2]	942.46	From 1993 IAR
5	6.6	28" Recirculation Line	Evaporator Room	52	52	52	208	208	208	105,556.00	507.49	507.49	507.49	From 1993 IAR
6	6.20	Reboiler	Evaporator Room	56	NA[2]	56	224	NA[2]	224	47,124.00	210.38	NA[2]	210.38	From 1993 IAR
7	6.7	28" Recirculation Line	Evaporator Room	112	48	52	448	192	208	105,556.00	235.62	549.78	507.49	From 1993 IAR
8	NA[1][2][3]	E-C-1 (old)	Evaporator Room	5	NA[1][2]	NA[1][3]	20	NA[1][2]	NA[1][3]	70,403.09	3,520.15	NA[1][2]	NA[1][3]	Removed
8A	NA[1][2][3]	E-C-1 (old)	Evaporator Room	18	NA[1][2]	NA[1][3]	72	NA[1][2]	NA[1][3]	70,403.09	977.82	NA[1][2]	NA[1][3]	Removed
9/9AABB	6.8	E-C-1	Condenser Room	286	286	198	1144	1144	792	70,403.09	61.54	61.54	88.89	Approximated as cylinder 7.5W by 17L
9A	6.8	E-C-1	Condenser Room	187	143	143	748	572	572	70,403.09	94.12	123.08	123.08	Approximated as cylinder 7.5W by 17L
9B	6.8	E-C-1	Condenser Room	130	143	143	520	572	572	70,403.09	135.39	123.08	123.08	Approximated as cylinder 7.5W by 17L
9	6.8	E-C-1	Condenser Room	603	572	484	2412	2288	1936	70,403.09	29.19	30.77	36.37	Survivor*Area Ratio should be based on total surface area tested
10	NA[2][3]	Reboiler Condensate Line (4" SC-500-M9)	Evaporator Room	13	NA[2]	NA[3]	52	NA[2]	NA[3]	1,130.98	21.75	NA[2]	NA[3]	Total length unknown, est approx 30 feet long (H-2-69328)
11	6.9	C-100 Tank	Condenser Room	432	432	432	1728	1728	1728	70,842.91	41.00	41.00	41.00	Approximated from H-2-69357
12	6.10	E-C-2	Condenser Room	72	75	75	288	300	300	6,263.16	21.75	20.88	20.88	Approximated from H-2-99034
13	6.11	E-C-3	Condenser Room	39	39	39	156	156	156	6,263.16	40.15	40.15	40.15	Approximated from H-2-99034
14	NA[1][2][3]	Ion Exchange Column	Condenser Room	124	NA[1][2]	NA[1][3]	496	NA[1][2]	NA[1][3]	NA[1][2][3]	NA[1][2][3]	NA[1][2][3]	NA[1][2][3]	Removed
15	6.12	Slurry Drain Line (6" DR-335-M9)	Evaporator Room	13	13	12	52	52	48	565.49	10.87	10.87	11.78	Total length unknown, approx 15 feet inside Evaporator Room (H-2-69340)
16	6.13	C-100 Tank Condensate Line (3" DR-359-M42)	Condenser Room	12	12	12	48	48	48	1,130.98	23.56	23.56	23.56	Total length unknown, est 10 feet long (H-2-69328)
17	6.14	E-C-1 / E-C-2 Line (6" VAC-1500-M42)	Condenser Room	12	12	12	48	48	48	4,873.81	101.54	101.54	101.54	Approximated from H-2-69343
18	NA[2][3][4]	Evaporator Feed (3" SN-251-M9)	Evaporator Room	NA[4]	NA[2][4]	NA[3][4]	NA[4]	NA[2][4]	NA[3][4]	1,696.46	NA[4]	NA[2][4]	NA[3][4]	Total length unknown, est 15 feet long (H-2-69328)
18	6.15	28" Recirculation Line (near HV-CA1-7)	Evaporator Room	NA[5]	NA[5]	26	NA[5]	NA[5]	104	105,556.00	NA[5]	NA[5]	1,014.98	From 1993 IAR
19	6.16	F-C-1	Condenser Room	NA[5]	NA[5]	12	NA[5]	NA[5]	48	3,562.57	NA[5]	NA[5]	74.22	Approximated from H-2-69343 and H-2-99031
21A	6.17	F-C-3	Condenser Room	NA[5]	NA[5]	8	NA[5]	NA[5]	32	1,884.96	NA[5]	NA[5]	58.90	Estimated from photos
21B	6.17	F-C-3	Condenser Room	NA[5]	NA[5]	8	NA[5]	NA[5]	32	1,884.96	NA[5]	NA[5]	58.90	Estimated from photos
21	6.17	F-C-3	Condenser Room	NA[5]	NA[5]	16	NA[5]	NA[5]	64	3,769.91	NA[5]	NA[5]	58.90	NA
22	6.18	Condensate Recirculation Line (2" PC-554)	Condenser Room	NA[5]	NA[5]	12	NA[5]	NA[5]	48	6,786.86	NA[5]	NA[5]	141.37	Total length unknown, est 60 feet long (H-2-69328)

Notes:
(1) Equipment replaced/removed.
(2) Testing not performed in 1998.
(3) Testing not performed in 2007.
(4) Testing location proposed for 1993 test but line not installed (no data collected).
(5) Testing not performed in 1993 or 1998 (added in 2007)

Table 2.6.4

Area Power Analysis

Year	Location	Equipment	Mat'l	Allowable	Reliability^Area Ratio	Minimum	Reliability^Area Ratio	Nominal	Reliability^Area Ratio
2007	1	42-inch vapor line	SS	0.2675	100.00%	0.303	86.27%	0.3125	51.84%
1993	1	42-inch vapor line	SS	0.2675	100.00%	0.308	86.27%	0.3125	43.49%
2007	2	42-inch vapor line	SS	0.2675	100.00%	0.29	53.19%	0.3125	10.95%
1993	2	42-inch vapor line[(1)]	SS	0.2675	100.00%	0.299	77.60%	0.3125	0.01%
2007	3	CA1	SS	0.32	100.00%	0.343	89.42%	0.375	0.00%
1998	3	CA1	SS	0.32	100.00%	0.381	0.00%	0.375	100.00%
1993	3	CA1	SS	0.32	100.00%	0.348	73.16%	0.375	0.00%
2007	4	28-inch Recirc Line	SS	0.205	100.00%	0.261	0.00%	0.25	100.00%
1993	4	28-inch Recirc Line	SS	0.205	100.00%	0.252	0.00%	0.25	100.00%
2007	5	28-inch Recirc Line	SS	0.205	100.00%	0.242	0.01%	0.25	0.00%
1998	5	28-inch Recirc Line	SS	0.205	100.00%	0.252	0.00%	0.25	100.00%
1993	5	28-inch Recirc Line	SS	0.205	100.00%	0.244	0.01%	0.25	0.00%
2007	6	E-A-1	SS	0.205	100.00%	0.248	2.26%	0.25	0.00%
1993	6	E-A-1	SS	0.205	100.00%	0.245	2.26%	0.25	0.00%
2007	7	28-inch Recirc Line	SS	0.205	100.00%	0.233	0.01%	0.25	0.00%
1998	7	28-inch Recirc Line	SS	0.205	100.00%	0.239	0.00%	0.25	0.00%
1993	7	28-inch Recirc Line	SS	0.205	100.00%	0.229	0.02%	0.25	0.00%
2007	9	E-C-1	CS	0.47	100.00%	0.506	92.75%	0.5	100.00%
1998	9	E-C-1	CS	0.47	100.00%	0.504	95.02%	0.5	100.00%
1993	9	E-C-1	CS	0.47	100.00%	0.489	95.27%	0.5	77.74%
2007	11	TK-C-100	SS	0.161	100.00%	0.19	90.94%	0.3125	5.79%
1998	11	TK-C-100	SS	0.161	100.00%	0.31	90.94%	0.3125	28.57%
1993	11	TK-C-100	SS	0.161	100.00%	0.309	88.29%	0.3125	0.17%
2007	12	E-C-2	CS	0.273	100.00%	0.307	75.56%	0.3125	0.00%
1998	12	E-C-2	CS	0.273	100.00%	0.31	56.88%	0.3125	20.39%
1993	12	E-C-2	CS	0.273	100.00%	0.314	73.77%	0.3125	0.00%
2007	13	E-C-3	CS	0.282	100.00%	0.308	35.24%	0.322	0.00%
1998	13	E-C-3	CS	0.282	100.00%	0.328	12.08%	0.322	100.00%
1993	13	E-C-3	CS	0.282	100.00%	0.334	35.24%	0.322	100.00%
2007	15	Slurry Drain Line (6" DR-335-M9)	SS	0.117	100.00%	0.136	3.37%	0.134	100.00%
1998	15	Slurry Drain Line (6" DR-335-M9)	SS	0.117	100.00%	0.135	16.26%	0.134	100.00%
1993	15	Slurry Drain Line (6" DR-335-M9)	SS	0.117	100.00%	0.135	41.88%	0.134	100.00%
2007	16	C-100 Tank Condensate Line (3" DR-359-M42)	CS	0.189	100.00%	0.215	0.01%	0.216	0.00%
1998	16	C-100 Tank Condensate Line (3" DR-359-M42)	CS	0.189	100.00%	0.211	12.87%	0.216	0.00%
1993	16	C-100 Tank Condensate Line (3" DR-359-M42)	CS	0.189	100.00%	0.208	0.01%	0.216	0.00%
2007	17	E-C-1 / E-C-2 Line (6" VAC-1500-M42)	CS	0.245	100.00%	0.296	0.01%	0.28	100.00%
1998	17	E-C-1 / E-C-2 Line (6" VAC-1500-M42)	CS	0.245	100.00%	0.299	0.01%	0.28	100.00%
1993	17	E-C-1 / E-C-2 Line (6" VAC-1500-M42)	CS	0.245	100.00%	0.298	0.01%	0.28	100.00%
2007	18	28-inch Recirc Line	SS	0.205	100.00%	0.238	0.00%	0.25	0.00%
2007	19	F-C-1[(2)]	WS	NA	NA	0.133	4.83%	0.120	100.00%
2007	21	F-C-3[(3)]	CI	NA	NA	0.49	2.23%	0.438	100.00%
2007	22	2" PC-554-M42[(4)]	CS	NA	NA	0.175	0.00%	0.154	100.00%

Notes:

(1) Location specific "2T", see attachment 6C.

(2) New Location, specifications not available to the IQRPE. Assume equivalent of 4", schedule 10 pipe to provide nominal thickness (0.120 inch).

(3) New Location, specifications not available to the IQRPE. Assume equivalent of 4", schedule 120 pipe to provide nominal thickness (0.438 inch).

(4) New Location, specifications not available to the IQRPE. Pipe is 2", schedule 40 pipe, which provides the nominal thickness (.154 inch).

2.6.4 Steam Pressure Oscillation Evaluation

In accordance with the IAP, UT data were collected at Location 6 to assist in the evaluation of observed steam pressure oscillations in the reboiler. Attachment 10 includes the only written analysis of the steam pressure oscillation that has been prepared to date.

Performance monitoring conducted during the 2006 campaign noted problems with the 10 lb steam (RPP-RPT-25891 2006). During the 2006 cold run, while attempting to increase the 10 lb steam flow rate to its upper operational limit of 27,000 lb/hr, the steam flow rate and the steam pressure started to oscillate, once every two to three minutes. Again, during the 2006 hot run, the same oscillations were observed when the steam flow rate was increased to 21,000 lb/hr. Because of these oscillations, 242-A Evaporator unit personnel have not been able to operate the 10 lb steam above 21,000 lb/hr.

The unit engineering evaluation in Attachment 10 concluded that the oscillations are a form of water/steam hammer in the reboiler known as thermal shock and that thermal shock may be causing damage to the reboiler and adjacent piping. The evaluation identified the cause of the thermal shock is too much condensate in the reboiler; determined that the condensate return line is poorly designed; and that modifications may be required to improve condensate flow rate and therefore increase steam heating.

As part of the IA, UT data was collected from the upper and lower conical sections of the Reboiler (E-A-1) at Location 6. The UT data from Location 6 do not indicate any deterioration of the reboiler vessel. Because there is no indication that this issue has impacted the integrity of the Reboiler (E-A-1) or process condensate piping system, the IQRPE does not recommend any further action regarding this issue.

2.6.5 IQRPE Concurrence

The IQRPE concurs with the UT test results and evaluation described herein. The components tested by UT indicate no measurable or noticeable deterioration of the tank system's integrity. The evaluation meets the requirements of WAC 173-303-640(2)(c) "...that the tank system is adequately designed and has sufficient structural strength and compatibility with the waste(s) to be stored or treated to ensure that it will not collapse, rupture or fail."

2.7 Corrosion Assessment

This section discusses the corrosion evaluation performed to confirm the compatibility of the 242-A Evaporator unit materials of construction with the potential corrosive environments and makes conclusions based on this evaluation. Review of the materials of construction and their current condition for the 242-A Evaporator unit were evaluated to ensure that they are compatible with the wastes to be stored or treated per the requirements of WAC 173-303-640(3)(a). The following sections provide include an analysis of the potential corrosion mechanisms, corrosion environments, materials of construction, and corrosion controls in place to prevent corrosion of the tanks, vessels, piping systems, and ancillary equipment used to treat dangerous waste at the 242-A Evaporator unit.

2.7.1 Corrosion Mechanisms

Several corrosion mechanisms were identified in the 1993 IAR (WHC 1993). The IQRPE reviewed the analysis completed for the 1993 IAR and found it to be complete. The following subsections that could potentially affect the 242-A Evaporator unit subsystems are described below as a basis for the evaluations in Sections 2.7.2 through 2.7.4.

2.7.1.1 General (Uniform) Corrosion

General (uniform) corrosion is a function of the waste composition. When the waste composition is maintained within the technical specifications, the corrosion rate is expected to be minimal. The 242-A Evaporator unit feed, concentrated slurry, and process condensate have varied compositions, and under acidic conditions could be highly corrosive to the stainless steel components used to construct the 242-A Evaporator unit. However, each of these waste streams are highly alkaline (pH greater than 12).

Corrosion failures seldom occur due to uniform corrosion (general wall thinning).

2.7.1.1.1 Stress Corrosion Cracking

Austenitic stainless steels under tensile stress are susceptible to stress corrosion cracking (SCC) in the presence of chloride ions. The minimum temperature required for cracking to occur is 50 to 60°C (122 to 140°F). Other components can also lead to SCC in stainless steel (for example, caustic solutions, fluoride ions, and polythionic acids) but these require either higher temperature or fully sensitized microstructures which do not exist in the 242-A Evaporator unit waste streams.

Because average operating temperature for most components of the 242-A evaporator unit are below the 50 to 60°C (122 to 140°F) range, chloride and other ion concentrations are low, and the components are properly supported (reducing any tensile stress in the system) SCC does not represent a likely corrosion failure mode.

2.7.1.1.2 Pitting Corrosion

Austenitic stainless steels are subject to pitting in the presence of chloride ions at low pH. Under some conditions, chloride ions can initiate localized corrosion on passive surfaces and at these sites pits may form. Once formed, a pit may continue to grow or spontaneously passivate. For a pit to form and continue to grow, the electrochemical potential of the metal must be above some minimum value which becomes lower as the chloride concentration and temperature increase. In addition, the presence of the other anions in solution inhibits the pitting process.

When a pit develops, the base of the pit is the anode and the surrounding area is the cathode of the corrosion cell. The solution within the pit is significantly different from the bulk solution and has a lower pH than the bulk solution. An active pit usually deepens at an appreciable rate, leading to relatively rapid penetration of vessel walls.

The high pH, dynamic operation, and low chloride concentrations in the waste streams make growth of existing pits or formation of new ones an unlikely corrosion failure mode for the 242-A Evaporator unit.

2.7.1.1.3 Crevice Corrosion

Crevice corrosion may occur under deposits, between metal flanges, and in other confined regions where a small volume of solution cannot readily mix with the bulk solution. Crevice corrosion often starts as a differential cell, where corrosion processes consume the dissolved oxygen in the solution within the crevice and the potential of the metal in that region becomes more active than the surfaces outside of the crevice. Once initiated, pitting and crevice corrosion proceed by the same mechanism.

Crevice corrosion is very improbable in solutions with pH values of 13, but in only slightly alkaline or acidic solutions it represents a potential failure mode. Because of the high pH, crevice corrosion is an unlikely corrosion failure mode for the 242-A Evaporator unit.

2.7.1.1.4 Intergranular-Knife Line Attack

The tank systems at the 242-A Evaporator are constructed of type 304L SS. This SS alloy nominally contains 18% chromium and 8% nickel and exhibits good corrosion resistance in many environments, particularly oxidizing ones. The carbon content is a maximum of 0.03% in 304L SS. Because of its low carbon content, conventional inter-granular attack is not to be expected in 304L SS.

2.7.2 Environments

The corrosion evaluation compared the chemical resistance of the unit components with potentially corrosive environments found in the process. The environments evaluated included an evaluation of the evaporator feed, concentrated slurry, process condensate, and the various conditions at which these wastes are found in as a result of the evaporation process.

Operating Temperatures for the 242-A Evaporator/Crystallizer range from 22° C on the tube side (cooling water) of the E-C-1 Primary Condenser to 115° C in the shell side (steam) of the E-A-1 Reboiler (HNF-14755 Rev 1). Evaporator feed temperatures range between 18° C and 49° C (65° F to 120° F). Concentrated slurry temperatures range between 18° C and 66° C (65° F to 150° F). Process condensate temperatures range between 27° C and 43° C (80° F to 110° F).

There is no significant change in the corrosion resistance of the materials of construction of the 242-A Evaporator unit that handle dangerous waste over this temperature range.

2.7.3 Materials

Materials used for the 242-A Evaporator unit tanks, vessels, piping systems, and ancillary components include austenitic SS (primarily ASTM A240, Type 304L) and low alloy carbon steel (CS) (primarily ASTM A53 and A106) with polyamide or asbestos gaskets at flanged connections. The building structure and secondary containment foundation is ACI 301-72 Structural Concrete for Buildings. Floors and walls that are part of the secondary containment system are coated with a chemically resistant coating system. Attachment 18 includes a summary of the materials of construction for the major vessels, piping systems, and ancillary components at the 242-A Evaporator unit. Corrosion allowances for equipment in the 242-A Evaporator system are ≤ 25 micrometers per year (μm/yr) (0.001 inch/yr) unless specified otherwise on the individual equipment drawings.

A complete description of the materials of construction, pressure and temperature limits, and dimensions are found in the construction specifications (Vitro 1974). Modifications performed after the original construction were found to have been in accordance with applicable code requirements. The materials used at the 242-A Evaporator unit are highly resistant to corrosion mechanisms discussed in Section 2.7.1.

2.7.4 Corrosion Controls

Corrosion controls for the 242-A Evaporator unit include proper materials selection, design, the use of protective coatings, and operation of the unit in accordance with RCRA Permit requirements including the monitoring and control of the characteristics of the wastes treated and generated by the unit. A detailed evaluation of 242-A Evaporator unit corrosion protection system was provided in the 1993 IAR (WHC 1993). The original protective phenolic coating in the pump room and evaporator room was replaced by the B-534 upgrades using the same Carboline Phenoline 305 coating that was originally used for the construction of the 242-A Evaporator unit. The coating system uses an acrylic primer and topcoat to protect the structural concrete. Vendor specifications for the Carboline Phenoline 305 coating are included in Attachment 16. It should be noted that the 1998 IAR incorrectly indicated that the replacement coatings used for the B-534 upgrades were Carboline 3358 and 3359.

Based on a review of the corrosion controls provided in the 1993 IAR, an evaluation of past campaign data indicating control of the waste streams within the unit, and UT and visual inspection results that indicate that no degradation of the units components have occurred, the IQPRE concludes that the corrosion controls currently in place are sufficient to ensure that the systems handling dangerous waste will not collapse, rupture, or fail.

2.7.5 Compatibilities

The mechanism, materials, environments, and controls summarized in Sections 2.7.1 through 2.7.4 were analyzed to determine the likelihood that specific corrosion mechanisms are degrading the subsystems of the 242-A Evaporator unit. This evaluation is summarized in Attachment 18. The following subsections describe the corrosion compatibilities for each of the waste streams with the vessels, piping systems, and ancillary components of the 242-A Evaporator unit and the Secondary Containment Subsystems.

2.7.5.1 Evaporator Feed and Concentrated Slurry

Stress corrosion cracking, crevice corrosion (pumps, elbows, flange connections), and pitting are all common corrosion failure mechanisms for SS vessels and components. The chemistry in the evaporator feed and concentrated slurry and environment of the 242-A Evaporator unit do not contain the conditions necessary for initiation and propagation of these corrosion mechanisms. After 29 years and nearly 2,389 days of operation between 1977 and 2007 (based on the historical campaign data in Table 1.7), no evidence of degradation has been noted on the 242-A Evaporator unit components during this or previous IA activities.

2.7.5.2 Process Condensate

The most likely attack for the components servicing the process condensate solution is crevice corrosion in the C-A-1 Evaporator de-entrainment pads. The geometry of these pads lends itself to crevice corrosion, however, during operation these pads are continuously washed with new condensate and the process design does not allow solutions to stagnate.

2.7.5.3 Pump Room and Evaporator Room

There are no unmitigated corrosion concerns associated with the pump room and evaporator room environments. The warm humid environment created in the pump room & evaporator room during operation was evaluated for potentially corrosive effects on CS and SS surfaces that may be continuously wetted by condensation. Carbon steel components exposed to this environment are painted to prevent uniform corrosion and SS components are inherently corrosion resistant. The insulating blanket that covers the entire SS Vapor Liquid Separator Subsystem has been previously analyzed (WHC 1993) to ensure that the chloride concentration in the blanket material (10 to 18 mg/L) was below concerns for pitting and SCC. Visual inspection results (Attachments 7-A, 7-B, and 7-C) indicate surface staining on certain components in the pump room and evaporator room and degradation of carbon steel bolts due to the warm humid environment and condensation in the pump and evaporator rooms (see Section 2.4).

2.7.5.4 Hanford Soils

There are no corrosion or degradation concerns with the Hanford soils for those portions of the unit that are within the scope of this integrity assessment. Only the building structure is in direct contact with Hanford soils (WHC 1993). The underground drain lines have secondary containment piping that is connected to the DST cathodic protection system to prevent external corrosion from contact with the soil.

2.7.6 IQRPE Concurrence

The IQRPE concurs with the corrosion evaluation described herein that the unit components have been no measurable or noticeable deterioration of the tank system's integrity. The unit is adequately designed and the tank system has sufficient structural strength with the waste(s) being stored or treated, and corrosion protection to ensure that it will not collapse or fail. The evaluation met the requirements of WAC 173-303-640(2)(c) "...that the tank system is adequately designed and has sufficient structural strength and compatibility with the waste(s) to be stored or treated to ensure that it will not collapse, rupture or fail."

2.8 Tank System Age

The 242-A Evaporator unit is located in the 200 East Area of the Hanford Site. Construction of the 242-A Evaporator unit extended from 1974 to 1977 and the unit began operations in 1977. Portions of the 242-A Evaporator were expanded and upgraded in 1983.

The design life of the 242-A Evaporator as originally constructed was 10 years. A 1987 study by WHC determined that the 242-A Evaporator would be required through the year 2000. Engineering studies and design efforts were initiated in FY 1987 to upgrade the unit to extend the operating life by 10 years. A major construction outage to incorporate the design changes was scheduled for FY 1990. The 242-A Evaporator was placed in temporary shutdown in April 1989 that lasted for 5 years. Operations restarted in April 1994.

The current and future mission of the 242-A Evaporator is to support environmental restoration and remediation of the Hanford Site by optimizing the 200 East and West areas DST waste volumes in support of the tank farm and vitrification contractors. To support this mission, an additional life extension study (HNF-3327 1998) was prepared to identify the work scope needed to extend the unit life through 2016. This study was revisited in January 2001 (HNF-3327 2001) due to a need for the unit through 2019.

Currently, the expected life-cycle of the 242-A Evaporator unit is through 2034 (per ORP contract baseline). A PEP (RPP-8949 2002) was issued in May 2002 to provide guidance in execution of the life extension projects. This PEP was updated in 2007 (RPP-PLAN-33477 2007). As of July 2006, the following activities had been completed: replacement of the slurry jumper (FY 2003), which included a new P-B-2 discharge relief valve and Coriolis mass flow density meter (DI-CA1-3); replacement of several brass valves on the process condensate system (FY 2003); removal of the ion exchange columns (FY 2003); replacement of the IX column room and non-process area roofs (FY 2003); replacement of the E-C-2 and E-C-3 condensers and associated steam jets (FY 2004); and replacement of the electric compressors and installation of an associated closed loop cooling system (FY 2006). Progress and imminent work plans on other upgrade projects are tracked through the upgrades project schedule.

Several possible aging (degradation or corrosion) mechanisms were evaluated as part of this IAR (see Section 2.7). The estimated remaining service life of the 242-A Evaporator unit based on the results of UT analysis was evaluated in Section 2.6 and 2.7 through UT testing and corrosion evaluation. These results indicate that the 242-A Evaporator unit tanks, vessels, piping systems, ancillary components and secondary containment systems are fit for continued service. Based upon the findings of this IAR, it is recommended that the next unit integrity assessment be performed no later than 10 years after submittal of this IAR.

2.8.1 IQRPE Concurrence

The IQRPE concurs with the age of the tank system as estimated through UT testing and corrosion evaluation described above. The 242-A Evaporator unit are fit for continued service through the intended operation of the 242-A Evaporator. The evaluation met the requirements of WAC 173-303-640(2)(c) "...that the tank system is adequately designed and has sufficient structural strength and compatibility with the waste(s) to be stored or treated to ensure that it will not collapse, rupture or fail."

3.0 CONCLUSIONS AND RECOMMENDATIONS

The following are the conclusions and recommendations of the IQRPE based on the activities of completed as part of this IA.

Conclusions

- The unit complies with specifications, national codes, and national standards required by the design documents.
- Evaporator feed, concentrated slurry, and process condensate is monitored to ensure that it is compatible with materials used for construction of the 242-A Evaporator unit. The wastes handled at the 242-A Evaporator unit are compatible with the materials of construction.
- Control and monitoring of operating parameters during campaigns ensures that design basis criteria for the 242-A Evaporator are not exceeded.
- Visual examination found no indications of tank and ancillary system leaks and no deterioration or corrosion failure for 242-A Evaporator unit components that handle dangerous waste. Recommendations based on the visual observation of surface staining and miscellaneous maintenance needs are described below.
- Leak testing of the Vapor Liquid Separator and Condensate Collection Subsystems met the acceptance criteria for the tests. No liquid leaks were observed. These results are consistent with the 1993 and 1998 IAs.
- Ultrasonic testing results indicate that there has been no measurable deterioration of the vessel wall thicknesses for those components tested. These results are consistent with the 1993 and 1998 IAs.
- The corrosion assessment indicates that the materials of construction and operation of the 242-A Evaporator unit are compatible with the wastes treated and generated by the unit. The evaporator feed and concentrated slurry compositions are controlled during campaigns to inhibit the most likely corrosion mechanisms. The materials of construction, system design, and protective coatings provide adequate corrosion protection.

Recommendations

The IQRPE provides the following recommendations in order to ensure that the 242-A Evaporator unit is adequately maintained. This list of recommendations is a compilation of the recommendations made throughout Section 2.0 of this IAR.

- The IQRPE recommends that all accessible equipment and grid points that were tested in this (2007) integrity assessment be tested during the next integrity assessment. In cases where only a portion of the UT points from the 1993 IA were tested in 2007 due to ALARA concerns (usually alternating columns within a test grid), the IQRPE recommends that the next IA collect data from the points not tested in 2007 (that is, collect data from the columns that were last tested in 1993) in order to allow statistical analysis of the measurements at these points over time
- The IQRPE recommends that measures be instituted to resolve the observations made as part of the visual inspection. Table 3.1 summarizes the outstanding observations and preliminary recommendations for resolution of these issues. Table 3.1 categorizes each observation by priority for resolution

Table 3.1

Recommendations

Item	Location	Observation	Recommendation	Priority
33306-1	Evaporator Pump Room	Dark fluid in sump; scaling, white stain on floor; minor surface corrosion on floor; hairline crack on western wall and in wall above door, chipped wall coating above jumper 38.	Clean floor surface to remove surface staining and corrosion; repair coating over crack.	3
33306-2	Evaporator Pump Room	Minor surface corrosion P-B-1 pump CS flange bolts.	Monitor; replace CS flange bolts with SS when servicing.	3
33306-3	Evaporator Pump Room	Minor dark staining on P-B-2 pump mounts and under pump.	Determine cause of staining and remove stains.	3
33306-4	Evaporator Pump Room	Paint chipped on P-B-1 support, crack in wall/wall coating.	Recoat supports.	2
33306-5	Evaporator Room Basement	Minor surface rust on valve actuator linkage.	Identify valve actuator shown; remove rust, recoat valve actuator linkage.	3
33306-6	Evaporator Room Basement	Pipe hanger and bolts show surface corrosion; bolt pulled free from wall; nut loose; U-bracket corroded.	Identify line, reanchor conduit hanger to wall, remove corrosion from hanger and replace bolts, replace U-bracket, ensure anchor nuts are tight.	2
33306-7	Evaporator Room Basement	Surface corrosion on valve actuator to CA1-7 and supports.	Remove corrosion and recoat.	3
33306-8	Evaporator Room Basement	Actuator linkage to CA1-7 is supported by pipe stand and restrained by U-hanger and loose pad underneath, creating groove in actuator linkage; support appears adequate (no stresses evident at base).	Another restraint or means to prevent grooving the actuator linkage should be considered.	3
33306-9	Evaporator Room Basement	White staining on flange (upstream of Location 15, Line 6"DR-335-M9).	Identify source of staining and remove staining.	3
33306-10	Evaporator Room Basement	Surface corrosion on actuator linkage and linkage support (valve ZS-CAI-9-2).	Remove corrosion and recoat.	3

Table 3.1 Cont'

Recommendations

Item	Location	Observation	Recommendation	Priority
33306-11	Evaporator Room Basement (see also Secondary Containment System)	Multiple chips in floor coating (approx 1"X1").	Repair coating over chips.	1
33306-12	Evaporator Room Basement	SS pressure line sensor not attached to unistrut hanger; line is open ended.	Attach line to hanger or if abandoned, remove line.	2
33306-13	Evaporator Room Ground Floor	Anchor bolt pulled out of wall.	Identify line, reanchor conduit hanger to wall, remove corrosion from hanger, and replace bolts.	2
33306-14	Evaporator Room Ground Floor	Loose U-anchor.	Replace U-bracket, ensure anchor nuts are tight.	2
33306-15	Evaporator Room Ground Floor	Missing bolts; two bolts in four bolt flange, 3/4 SS line connection.	Install any and all missing bolts.	2
33306-16	Evaporator Room Ground Floor	Unistrut hanger for 3/4 SS line pulling away from wall.	Secure hanger to wall.	2
33306-17	Evaporator Room First Floor	Support nuts and bolts show surface corrosion.	Monitor; replace when support is serviced.	3
33306-18	Evaporator Room First Floor	2" SS Water line anchor bolt pulled out of wall.	Identify line, re-anchor conduit hanger to wall, remove corrosion from hanger, and replace bolts.	2
33306-19	Evaporator Room First Floor	Concrete spalling and anchor possibly pulled away from wall, 2"SS Water line.	Identify line, inspect concrete and anchor to determine if anchor is firmly attached; repair if needed.	2
33306-20	Evaporator Room First Floor	3/4" Line unistrut anchor pulled away from north wall.	Identify line, reattach unistrut anchor.	2
33306-21	Evaporator Room Third Floor	Bent hanger/anchor bolt pulled away from wall, 2"SS line (east wall).	Identify line, replace/re-anchor SS line.	2
33306-22	Evaporator Room Third Floor	Nut on U-bolt appears to have pulled through 2"SS line anchor due to missing washers, U-bolt corroded. Anchor has pulled away from wall (east wall).	Place washers behind nuts, replace U-bolt, secure anchor to wall.	2

Table 3.1 Cont'

Recommendations

Item	Location	Observation	Recommendation	Priority
33306-23	Evaporator Room Fourth Floor	Pipeline appears to span two or more floors vertically with no anchoring (NW corner).	Verify adequate anchoring, support (anchor) vertical piping at every floor if necessary.	2
33306-24	Evaporator Room Fourth Floor	Inner line sitting on anchor strut without bracket.	Secure line to anchor strut; identify line shown (appears to be a 1/2" FRW).	2
33306-25	Evaporator Room Fourth Floor	Vertical structural support missing bolt.	Replace bolt.	2
33306-26	Condensate Collection Subsystem	Minor surface contamination/staining, possible scaling on the tank skirt of TK-C-100 condensate collection tank.	Recommended to clean the surface, monitor, and reassess the surface.	3
33306-27	Condensate Collection Subsystem	Surface corrosion on cast iron (CS) flange bolts; rust on vent and drain lines; housing of F-C-1 is chipped.	Replace CS flange bolts with stainless steel (SS) when servicing; monitor and reassess; recoat chipped and corroded surface.	3
33306-28	Condensate Collection Subsystem	Surface corrosion on CS flange bolts on foreground flange cover.	Replace CS flange bolts with SS when flange serviced; monitor flange connections for bolt breakage or flange leak.	3
33306-29	Condensate Collection Subsystem	Tool marks on foreground bolts.	Repaint bolts.	3
33306-30	Condensate Collection Subsystem	Flange bolts on top flange on the 6" vapor line are corroded.	Replace bolts when flanges or lines are serviced/monitor flange connections for bolt breakage or flange leak.	3
33306-31	Condensate Collection Subsystem	Appearance of missing and chipped paint on and near upper elbow, 6" vapor line.	Clean surface and repair coating.	3
33306-32	Condensate Collection Subsystem	Damage to coating on the First Floor North Wall of condenser room.	Recoat.	2
33306-33	Condensate Collection Subsystem	Staining on bottom 6" support wall on the First Floor West Wall.	Clean and recoat.	2

Table 3.1

Recommendations

Cont'	Location	Observation	Recommendation	Priority
33306-34	Condensate Collection Subsystem	Surface staining near drain and tank walls.	Clean and recoat.	2
33306-35	Condensate Collection Subsystem	Lube oil leak below pump and motor.	Needs monitoring and maintenance.	3
33306-36	Condensate Collection Subsystem	Staining below E-C-2.	Needs cleaning and paining if necessary.	3
33306-37	Condensate Collection Subsystem	Staining and rust inside the tray at F-C-3.	Clean or replace tray.	3
33306-38	Condensate Collection Subsystem	Surface staining on tank wall at several walls.	Needs cleaning and painting if necessary.	3
33306-39	Condensate Collection Subsystem	Surface staining on support walls for P-C-100 and P-C-106.	Needs cleaning and painting if necessary.	3
33306-40	Condensate Collection Subsystem	Rust on seal pot bottom flange bolts.	Needs monitoring and maintenance.	3
33306-41	Condensate Collection Subsystem	Lube oil leak below motor at TK-C-100 agitator flange.	Needs monitoring and maintenance.	3
33306-42	Condensate Collection Subsystem	Surface staining on TK-C-100 tank top at flanges E, F, and H.	Needs monitoring and maintenance.	3
33306-43	Condensate Collection Subsystem	White powder spots on valve #2-33.	Needs cleaning and maintenance.	3
33306-44	Secondary Containment System, Evaporator Basement (see also evaporator room basement)	There are several small chips in the floor of the Evaporator Basement that could potentially impact to the integrity of the secondary containment subsystem in the future if not addressed. Chips of various sizes were observed; the larger chips measuring from 1" by 1" to 1" by 2".	Repair and recoat chips.	1
33306-45	Pump Room	Nozzle E Leak	Tighten or replace in accordance with WFO-WO-07-2340	1

Note: Priority 1: Implement recommendation prior to next campaign.

Priority 2: Implement recommendation as part of routine maintenance.

Priority 3: Implementation of recommendation at the discretion of the unit.

4.0 RECOMMENDED SCHEDULE FOR FUTURE INTEGRITY ASSESSMENT

The 1993 IAR established a repeat integrity assessment frequency of five years/8,000 hours of operation between interim integrity assessments. The basis for the five year/8,000 hour frequency is that the 242-A Evaporator has an inherent corrosion protection, stringent operational controls, and aggressive preventive programs in place.

The 1998 IAR recommended that the next unit integrity assessment be performed no later than July 15, 2008 (10 years after submittal of the 1998 IAR). The recommendation was based on the results of the results of UT analysis that showed the "minimum remaining life" for all the equipment tested was greater than 20 years.

Based on the findings of this IA, the IQRPE recommends that the next integrity assessment be performed no later than 10 years after submittal of this IAR. This recommendation is based on the results of the UT analysis that show the "minimum remaining life" for all the equipment tested was greater than 20 years.

5.0 INTEGRITY ASSESSMENT CERTIFICATION

This IAR is stamped and signed by a registered professional engineer in the State of Washington, and is accompanied by the following certification statement:

"The 242-A Evaporator System has been reviewed by the IQRPE. System design, construction, operation and maintenance, and current conditions have been assessed based on the reviews and inspections described herein, and have been determined to be in compliance with the applicable sections of WAC 173-303-640 and the RCRA Permit for the 242-A Evaporator unit. This conclusion is based on a review of the documents, inspections, and test results described herein. The certification below is in accordance with the requirements of WAC 173-303-640(2)(c) and WAC 173-303-810(13)(a)."

Report Lead IQRPE:

"I certify under penalty of the law that this document and all attachments were prepared under my direction or supervision in accordance with a system designed to assure that qualified personnel properly gather and evaluate the information submitted. Based on my inquiry of the person or persons who manage the system, or those persons directly responsible for gathering the information, the information submitted is, to the best of my knowledge and belief, true, accurate, and complete. I am aware that there are significant penalties for submitting false information, including the possibility of fine or imprisonment for knowing violations."

PE seal

TIMOTHY JAMES OLIVER
STATE OF WASHINGTON
41543
REGISTERED
PROFESSIONAL ENGINEER
EXPIRES: 04/7/2008

12/27/07

Approved:

Timothy J. Oliver, PE 12/27/07
Date

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ATTACHMENT 2

STRUCTURAL SPECIFICATIONS

(16 Pages)

CONTENTS

2A.0 STRUCTURAL SPECIFICATIONS

2A.1 EARTHWORK

All excavating, backfilling, and finishing grading for Building 242-A and associated facilities was to conform to the following standards:

a. American Association of State Highway Officials (AASHO)

- T180-70 Moisture - Density Relations of Soils Using a 10 lb Rammer and a 19 in. Drop
- T191-64 (R1968) Density of Soil In-Place by the Sand Cone Method

b. Occupational Safety and Health Administration (OSHA)

- Department of Labor
  Federal Register
  Volume 37, Number 243, Title 29,
  Part 1926, Subpart P
  "Excavation, Trenching and Sharing."

2A.2 CONCRETE

Concrete work on the building and associated facilities used the following standards and specifications:

a. American Society for Testing and Materials (ASTM)

- ASTM A185-72 Weld Steel Wire Fabric for Concrete Reinforcement
- ASTM A615-72 Deformed and Plain Billett - Steel Bars for Concrete Reinforcement
- ASTM C33-71a Concrete Aggregates
- ASTM C94-72 Ready-Mixed Concretes
- ASTM C150-73a Portland Cement
- ASTM C156-71 Water Retention by Concrete Curing Materials
- ASTM C260-73 Air-Entraining Admixtures for Concrete

- ASTM D994-71 Preformed Expansion Joint Filler for Concrete (Bituminous Type)

b. Federal Specifications (FS)

- FS-TT-S-230 A Sealing Compound, Synthetic Rubber Base, Single Component, Chemically Curing (for Caulking Sealing, and Glazing in Building Construction)

c. American Concrete Institute (ACI)

- ACI 301-72 Structural Concrete for Buildings
- ACI 305-72 Recommended Practice for Hot Weather Concreting
- ACI 306-66 Recommended Practice for Cold Weather Concreting
- ACI 315-65 Manual for Standard Practice for Detailing Reinforced Concrete Structures
- ACI 318-71 Building Code Requirements for Reinforced Concrete

d. Occupational Safety and Health Administration

- Department of Labor
  Federal Register
  Volume 37, Number 243, Title 29,
  Part 1926, Subpart Q
  "Concrete, Concrete Forms, and Sharing."

2A.3 MASONRY

Masonry work was performed in accordance with the following guidelines:

a. American Society of Testing and Materials

- ASTM A82-72 Cold-Drawn Steel Wire for Concrete Reinforcement
- ASTM A615-72 Deformed and Plain Billet-Steel Bars for Concrete Reinforcement
- ASTM C90-70 Hollow Load-Bearing Concrete Masonry
- ASTM C144-70 Aggregate for Masonry Mortar
- ASTM C150-73a Portland Cement

- ASTM C207-49 Hydrated Line for Masonry Purposes
- ASTM C331-69 Lightweighted Aggregate for Concrete Masonry Units
- ASTM C404-70 Aggregate for Masonry Grout
- ASTM C516-67 Vermiculite Loose-Fill Insulation

b. Federal Specifications

- FS-SS-C-181E Cement, Masonry
- FS-TT-S-230A Sealing Compound, Synthetic Rubber Base, Single Component, Chemically Curing (for Caulking, Curing, Sealing, and Glazing in Building Construction).

2A.4 STRUCTURAL STEEL

Specifications used for structural steel plates, bars, shapes, and miscellaneous metal items were as follows:

a. American Institute of Steel Construction (AISC)

- AISC-1970 Manual of Steel Construction, 7th Edition
- AISC-1969 Specification for the Design, Fabrication, and Erection of Structural Steel for Buildings
- AISC-1966 Structural Joints Using ASTM A325 Bolts or A490 Bolts

b. American Society of Testing and Materials

- ASTM A36-70 Structural Steel
- ASTM A307-68 Carbon Steel Externally and Internally Threaded Standard Features
- ASTM A325-71a High Strength Bolts for Structural Steel Joints, Including Suitable Nuts and Plain Hardened Washers

c. American Welding Society (AWS)

- AWS-D1.1-72 AWS Structural Welding Code.

2A.5 ROOFING

The following roofing standards and specifications were applied to the facility:

a. Hanford Site Standard and Specifications

- HPS-542-AC Standard Specification for Insulating Concrete Roof Decks
- HPS-543-AC Standard Specification for Insulating Steel Roof Decks
- HPS-549-AC Standard Specification for Gravel-Surfaced Asphalt Roofs on Insulated Decks

b. West Coast Lumber Inspection Bureau (WCLIB)

- WCLIB No. 16-1970 Standard Grading Rules for West Coast Lumber.

2A.6 EARTHWORK

a. American Society for Testing and Materials

- D 653-86 Standard Terms and Symbols Relating to Soil and Rock
- D 653-87 Standard Terminology Relating to Soil, Rock, and Contained Fluids
- D 653-88 Standard Terminology Relating to Soil, Rock, and Contained Fluids

b. Washington State Department of Transportation (WSDOT)

- M41-10-88 Standard Specification for Road, Bridge, and Municipal Construction.

2A.7 HOT-LAID ASPHALTIC CONCRETE PAVEMENT

a. Washington State Department of Transportation

- M41-10-88 Standard Specifications for Road, Bridge, and Municipal Construction.

2A.8 CAST-IN-PLACE CONCRETE

a. American Concrete Institute

- ACI 301-84(Revised 1985) Specifications for Structural Concrete for Building

- ACI 306.1-87 Standard Specification for Cold Weather Concreting

b. American Society for Testing and Materials

- A 185-85 Standard Specifications for Steel Welded Wire Fabric, Plain, for Concrete Reinforcement
- A 615-87 Standard Specification for Deformed and Plain Billet-Steel Bars for Concrete Reinforcement
- C 33-86 Standard Specification for Concrete Aggregates
- C 94-86b Standard Specification for Ready-Mixed Concrete
- C 150-86 Standard Specification for Portland Cement
- C 150-86a Standard Specification for Portland Cement
- C 260-86 Standard Specification for Air-Entraining Admixtures for Concrete
- C 928-80 Standard Specification for Packaged, Dry, Rapid-Hardening Cementitious Materials for Concrete Repairs

c. National Ready Mixed Concrete Association (NRMCA)

- January 1, 1976 Certification of Ready Mixed Concrete (3rd Revision)Production Facilities

d. Washington State Department of Transportation

- M41-10-88 Standard Specifications for Road, Bridge, and Municipal Construction.

2A.9 MASONRY

a. American Concrete Institute

- ACI 531-79 Building Code Requirements for Concrete (Revised 1983)Masonry Structures

b. American Society for Testing and Materials

- A 82-85 Standard Specification for Steel Wire, Plain, for Concrete Reinforcement

- A 116-87 Standard Specification for Zinc Coating (Hot-Dip) on Iron and Steel Hardware
- A 153-82 (1987) Standard Specification for Zinc Coating (Hot-Dip) on Iron and Steel Hardware
- A 307-86a Standard Specification for Carbon Steel Bolts and Studs, 60,000 PSI Tensile Strength
- A 615-87 Standard Specification for Deformed and Plain Billet-Steel Bars for Concrete Reinforcement
- C 90-85 Standard Specification for Hollow Load-Bearing Concrete Masonry Units
- C 140-75 (1980) Standard Methods of Sampling and Testing Concrete Masonry Units
- C 270-87a Standard Specification for Mortar for Unit Masonry
- C 476-83 Standard Specification for Grout Masonry

c. International Conference of Building Officials (ICBO)

- 1985 Edition Uniform Building Code (UBC)

2A.10 STEEL JOINTS

a. American Society of Mechanical Engineers (ASME)

- 1986 Edition ASME Boiler and Pressure Vessel Code w/Addenda through December 1988
- Section IX Qualification Standard for Welding and Brazing Procedures. Welders, Brazers, and Welding and Brazing Operators.

b. American Society for Testing and Materials

- A 36-87 Standard Specification for Structural Steel

c. American Welding Society

- D1.1-88 Structural Welding Code - Steel

d. Steel Joist Institute (SJI)

- 1984 Edition — Standard Specification, Load Tables and Weight Tables for Steel Joists and Joist Girders.

2A.11 METAL DECKING

a. American Society of Mechanical Engineers

- 1986 Edition — ASME Boiler and Pressure Vessel Code w/Addenda through December 1988

- Section IX — Qualification Standard for Welding and Brazing Procedures, Welders, Brazers, and Welding and Brazing Operators

b. American Welding Society

- AWS D1.3-81 — Structural Welding Code - Sheet Steel

c. Steel Deck Institute (SDI)

- 1987 Edition — Design Manual for Composite Decks, Form Decks, and Roof Decks (Publication No. 26).

2A.12 METAL FABRICATION

a. American Institute of Steel Construction

- AISC M011-1980 — Manual of Steel Construction, 8th Edition

- AISC S326 — Specification for the Design, Fabrication November 1978 and Erection of Structural Steel for Buildings

b. American National Standards Institute (ANSI)

- ANSI B31.1 1986 Edition w/Addenda ANSI B31.1a, B31.1b, and B31.1c — American National Standards Code for Pressure Piping

c. American Society of Mechanical Engineers

- 1986 Edition w/Addenda through December 1987 — ASME Boiler and Pressure Vessel Code
- 1986 Edition w/Addenda through December 1988 — ASME Boiler and Pressure Vessel Code
- Section IX — Qualification Standard for Welding and Brazing Procedures, Welders, and Welding and Brazing Operators

d. American Society for Testing and Materials

- A 36-87 — Standard Specification for Structural Steel
- A 36-88c — Standard Specification for Structural Steel
- A 53-87b — Standard Specification for Pipe, Steel, Black and Hot-Dipped, Zinc-Coated Welded and Seamless
- A 53-88a — Standard Specification for Pipe, Steel, Black and Hot-Dipped, Zinc-Coated Welded and Seamless
- A 123-84 — Standard Specification for Zinc (Hot-Galvanized) Coating on Iron and Steel Products
- A 276-88a — Standard Specification for Stainless and Heat-Resisting Steel Bars and Shapes
- A 307-86a — Standard Specification for Carbon Steel Bolts and Studs 60,000 PSI Tensile Strength
- A 307-88a — Standard Specification for Carbon Steel Bolts and Studs 60,000 PSI Tensile Strength
- A 500-84 — Standard Specification for Cold-Formed Welded and Seamless Carbon Steel Structural Tubing in Rounds and Shapes
- A 507-85 — Standard Specification for Steel, Sheet, and Strip, Carbon, Hot-Rolled, Structural Quality
- A 563-84 — Standard Specification for Carbon and Alloy Steel Nuts

- A 563-88a — Standard Specification for Carbon and Alloy Steel Nuts
- A 570-85 — Standard Specification for Steel, Sheet, and Strip, Carbon, Hot-Rolled, Structural Quality
- A 786-85 — Standard Specification for Rolled Steel Floor Plates

e. American Welding Society

- AWS D1.1-88 — Structural Welding Code - Steel
- AWS D1.3-81 — Structural Welding Code - Sheet Steel

f. Federal Specifications

- RR-G-661E — Grating, Metal, Bar Type (Floor, except for Naval Vessels.

2A.13 ROUGH CARPENTRY

a. American Wood-Preservers' Association (AWPA)

- C2-85 — Lumber, Timbers, Bridge Ties and Mine Ties--Preservation Treatment by Pressure Process
- C9-85 — Plywood--Preservative Treatment by Pressure Processes

b. Federal Specifications

- FF-B-561C — Bolt, (Screw), Lag
- FF-B-575C — Bolts, Hexagon and Square
- FF-S-111D — Screw, Wood
- FF-S-325 including — Shield, Expansion; Nail, Expansion; and INT AMD 3Nail, Drive Screw (Devices, Anchoring, Masonry)
- MM-L-751H — Lumber, Softwood

c. U.S. Department of Commerce/National Bureau of Standards Voluntary Product Standards (PS)

- PS 20-81 — American Softwood Lumber Standard

d. West Coast Lumber Inspection Bureau

- No. 16-1970Standard Grading Rules for West Coast Lumber.(Revised 1983)

2A.14 ACCESS FLOORING

a. American Society for Testing and Materials

- E 84-87 — Standard Test Method for Surface Burning Characteristics for Building Materials

b. Ceiling and interior Systems Contractors Association (CISCA)

- Testing Standards

c. International Conference of Building Officials

- 1988 Edition — Uniform Building Code (UBC)

d. National Electrical Manufacturers Association (NEMA)

- PUB No. LD 3-1975 — Standard Publication, Laminates, High-Pressure Decorative.

2A.15 PRE-ENGINEERED STRUCTURES

a. American Institute of Steel Construction

- AISC M011-1980 — Manual of Steel Construction, 8th Edition

b. American and Iron Steel Institute (AISI)

- 1986 Edition — Specification for the Design of Cold-Formed Steel Structural Members

c. American Society for Testing and Materials

- A 446-87 — Standard Specification for Steel Sheet, Zinc-Coated (Galvanized) by the Hot-Dip Process, Structural (Physical) Quality
- A 525-87 — Standard Specification for General Requirements for Steel Sheet, Zinc-Coated (Galvanized) by the Hot-Dip Process
- C 665-88 — Standard Specification for Mineral Fiber Blanket Thermal Insulation for Light Frame Construction and Manufactured Housing

d. American Welding Society

- ASW D1.1-88 Structural Welding Code - Steel
- ASW D1.3-81 Structural Welding Code - Sheet Steel

e. International Conference of Building Officials

- 1988 Edition Uniform Building Code (UBC)

f. Metal Building Manufacturers Association (MBMA)

- 1986 Edition Low Rise Building Systems Manual

g. Underwriters Laboratories. Inc. (UL)

- January 1988 including July 1988 Supplement Building Materials Directory.

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ATTACHMENT 3

WASTE CHARACTERIZATION DATA ANALYSIS FROM HISTORICAL CAMPAIGNS

(43 PAGES)

Table A.3.1
Inorganic Concentrations In 242-A Evaporator Process Feed, Concentrated Slurry, and Process Condensate

Concentration (mg/mL)				
Compound	Units	Evaporator Feed	Concentrated Slurry	Process Condensate
Al	mg/mL	2.20E+01	3.20E+01	4.10E-02
NH4	mg/mL	9.30E-01	1.30E-01	2.30E+00
Ba	mg/mL	9.80E-03	1.40E-02	3.00E-05
B	mg/mL	1.20E-02	1.70E-02	3.50E-05
Ca	mg/mL	5.10E-02	7.30E-02	1.90E-03
Cd	mg/mL	1.10E-02	1.60E-02	3.10E-05
CO_3	mg/mL	8.70E+00	1.20E+01	2.40E-02
Cl	mg/mL	4.50E+00	6.40E+00	2.40E-02
Cr	mg/mL	4.20E-01	6.00E-01	3.40E-05
Cu	mg/mL	4.80E-03	6.90E-03	1.50E-05
CN	mg/mL	3.40E-02	4.80E-02	9.50E-05
F	mg/mL	2.70E-01	3.90E-01	4.30E-05
Fe	mg/mL	2.80E-02	3.90E-02	8.50E-05
OH	mg/mL	4.90E+01	7.00E+01	1.40E-01
Pb	mg/mL	5.10E-02	7.00E-02	4.60E-03
Mg	mg/mL	2.00E-02	2.90E-02	4.60E-04
Mn	mg/mL	2.00E-02	2.90E-02	5.80E-05
Hg	mg/mL	5.60E-03	8.00E-03	1.60E-05
Mo	mg/mL	4.20E-02	6.00E-02	1.20E-04
Ni	mg/mL	2.80E-02	4.00E-02	7.90E-05
NO_3	mg/mL	1.20E+02	1.80E+02	6.10E-01
NO_2	mg/mL	6.00E+01	8.60E+01	7.00E-02
PO_4	mg/mL	3.70E+00	5.30E+00	1.00E-02
P	mg/mL	3.40E+00	4.90E+00	9.60E-03
K	mg/mL	1.30E+01	1.80E+01	1.00E-02
Si	mg/mL	1.30E-01	1.90E-01	5.90E-04
Na	mg/mL	1.70E+02	2.40E+02	1.60E-02
SO_4	mg/mL	2.00E+00	2.90E+00	5.00E-03
W	mg/mL	1.50E-01	2.10E-01	4.10E-04
U	mg/mL	5.30E-02	7.50E-02	1.50E-04
Z	mg/mL	3.40E-02	4.80E-02	9.60E-05
TOC[1]	mg/mL	3.30E+00	4.60E+00	2.60E-01
TDS[1]	mg/mL	0.00E+00	0.00E+00	3.40E-04
Temperature[1]	°F	1.09E+02	1.26E+02	8.24E+01
Temperature[1]	°C	4.30E+01	5.20E+01	2.80E+01
pH	pH	1.30E+01	1.30E+01	1.00E+01
Sp.G	SpG	1.30E+00	1.40E+00	1.00E+00
Alpha[1]	µCi/ML	0.00E+00	2.90E-11	5.70E-11
Beta[1]	µCi/ML	0.00E+00	3.50E-10	6.80E-13

Note: 1 Values are from Table 2B-1, Appendix 2B of HNF-14755, Rev.1;
All other values are from Table 2.8, Chapter 2 of HNF-14755, Rev.1

Table A.3.2
Chemical Composition of Concentrated Slurry

Compound	Units	1994-01	1994-02	1995-01	1996-01	1997-01	1997-02	1999-01	2000-01	2001-01	2002-02	2003-01	2004-01	2005-01	2006-01	Statistics		
		Pre-Slurry[1]	Pre-Slurry[2]	Pre-Slurry[3]	Pre-Slurry	Pre-Slurry[4]	Pre-Slurry[5]	Pre-Slurry[6]	Pre-Slurry[7]	Pre-Slurry[8]	Pre-Slurry	Pre-Slurry	Pre-Slurry	Pre-Slurry	Pre-Slurry	Maximum	Minimum	Average
Al	mg/mL	2.02E+01	1.01E+01	9.85E+00	NA	6.34E+01	8.75E+01	2.21E+01	7.80E+01	9.74E-01	2.46E+01	3.74E+01	2.58E+01	2.05E+01	2.05E+01	8.75E+01	9.74E-01	3.24E+01
B	mg/mL	NA	NA	NA	NA	NA	NA	NA	NA	NA	6.03E-02	5.50E-02	2.43E-02	4.20E-02	4.20E-02	6.03E-02	2.43E-02	4.47E-02
Ba	mg/mL	NA	NA	NA	NA	NA	NA	NA	NA	NA	3.19E-02	2.16E-02	1.45E-02	9.28E-03	9.28E-03	3.19E-02	9.28E-03	1.73E-02
Be	mg/mL	NA	NA	NA	NA	NA	NA	NA	NA	NA	3.19E-03	2.16E-03	9.18E-04	5.88E-04	5.88E-04	3.19E-03	5.88E-04	1.49E-03
Ca	mg/mL	NA	NA	NA	NA	NA	NA	NA	NA	NA	8.54E-02	4.31E-02	1.48E-02	3.32E-02	3.32E-02	8.54E-02	1.48E-02	4.19E-02
Cd	mg/mL	NA	NA	NA	NA	NA	NA	NA	NA	NA	8.21E-03	2.16E-03	2.69E-03	1.01E-03	1.01E-03	8.21E-03	1.01E-03	3.02E-03
Cl	mg/mL	NA	NA	NA	NA	NA	NA	NA	NA	NA	6.14E+00	7.57E+00	4.09E+00	5.39E+00	5.39E+00	7.57E+00	4.09E+00	5.72E+00
CO_3	mg/mL	2.18E+01	1.97E+01	5.66E+01	NA	1.94E+01	2.95E+01	6.04E+01	4.03E+01	1.95E+01	NA	NA	NA	NA	NA	6.04E+01	1.94E+01	3.34E+01
Cr	mg/mL	NA	NA	NA	NA	NA	NA	NA	NA	1.46E-02	7.46E-01	7.81E-01	6.50E-01	9.48E-01	9.48E-01	9.48E-01	1.46E-02	6.81E-01
F	mg/mL	1.31E+01	3.67E+00	1.06E+01	NA	1.16E+00	1.69E+00	6.02E+00	2.75E+00	1.79E-01	1.98E+00	4.41E-01	1.45E+00	1.19E-01	1.19E-01	1.31E+01	1.19E-01	3.33E+00
Fe	mg/mL	NA	NA	NA	NA	NA	NA	NA	NA	7.00E-02	3.19E-02	2.16E-02	1.38E-02	8.85E-03	8.85E-03	7.00E-02	8.85E-03	2.58E-02
K	mg/mL	NA	NA	NA	NA	NA	NA	NA	NA	NA	2.56E+00	4.64E+00	1.54E+01	2.69E+00	2.69E+00	1.54E+01	2.56E+00	5.60E+00
La	mg/mL	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	2.16E-02	3.78E-03	2.43E-03	2.43E-03	2.16E-02	2.43E-03	7.57E-03
Mn	mg/mL	NA	NA	NA	NA	NA	NA	NA	NA	1.34E-03	6.37E-03	4.31E-03	1.56E-03	1.23E-03	1.23E-03	6.37E-03	1.23E-03	2.67E-03
Mo	mg/mL	NA	NA	NA	NA	NA	NA	NA	NA	NA	7.67E-02	9.97E-02	5.23E-02	6.77E-02	6.77E-04	9.97E-02	6.77E-04	5.94E-02
Na	mg/mL	NA	NA	NA	NA	NA	NA	NA	NA	5.38E+01	2.06E+02	2.34E-08	2.10E+02	1.81E+02	1.81E+02	2.10E+02	2.34E-08	1.39E+02
NH_3	mg/mL	NA	NA	NA	NA	NA	NA	NA	NA	NA	1.28E-01	8.14E-02	4.89E-02	1.75E-02	1.85E-02	1.28E-01	1.75E-02	5.89E-02
Ni	mg/mL	NA	NA	NA	NA	NA	NA	NA	NA	2.80E-01	6.95E-02	1.81E-02	1.48E-02	1.72E-02	1.72E-02	2.80E-01	1.48E-02	6.95E-02
NO_2	mg/mL	1.11E+02	4.11E+02	9.78E+01	NA	1.73E+02	3.05E+02	1.06E+02	2.15E+02	1.47E+01	9.00E+01	1.22E+02	8.44E+01	7.61E+01	7.61E+01	4.11E+02	1.47E+01	1.45E+02
NO_3	mg/mL	2.88E+02	2.44E+02	1.88E+02	NA	2.42E+02	3.41E+02	2.69E+02	3.40E+02	7.75E+01	2.13E+02	1.98E+02	1.84E+02	1.66E+02	1.66E+02	3.41E+02	7.75E+01	2.24E+02
OH	mg/mL	1.19E+02	1.36E+02	1.36E+02	NA	1.36E+02	1.31E+02	1.21E+02	1.36E+02	1.05E+01	2.40E+01	4.41E+01	5.27E+01	2.69E+01	2.69E+01	1.36E+02	1.05E+01	8.46E+01
Pb	mg/mL	NA	NA	NA	NA	NA	NA	NA	NA	NA	6.37E-02	4.90E-02	3.84E-02	2.87E-02	2.87E-02	6.37E-02	2.87E-02	4.17E-02
PO_4	mg/mL	4.75E-01	9.50E-02	9.50E-01	NA	2.66E+00	NA	1.61E+00	7.50E+00	8.86E-01	6.24E+00	5.78E+00	7.05E-01	4.02E+00	4.02E+00	7.50E+00	9.50E-02	2.91E+00
Se	mg/mL	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	2.41E-02	2.41E-02	2.41E-02	2.41E-02
Si	mg/mL	NA	NA	NA	NA	NA	NA	NA	NA	NA	7.87E-02	3.07E-02	6.02E-02	1.43E-02	1.43E-02	7.87E-02	1.43E-02	3.96E-02
SO_4	mg/mL	5.74E+01	2.98E+01	1.96E+01	NA	9.41E+00	3.09E+01	1.98E+01	8.36E+00	1.17E+00	3.65E+00	4.69E+00	3.15E+00	5.19E+00	5.19E+00	5.74E+01	1.17E+00	1.53E+01
U-235	mg/mL	NA	NA	NA	NA	NA	NA	NA	NA	NA	7.32E-05	2.10E-05	2.93E-04	3.65E-05	3.65E-05	2.93E-04	2.10E-05	9.20E-05
U-238	mg/mL	NA	NA	NA	NA	NA	NA	NA	NA	NA	3.86E-03	2.93E-03	3.94E-02	4.97E-03	4.97E-03	3.94E-02	2.93E-03	1.12E-02
U-total	mg/mL	NA	NA	NA	NA	NA	NA	NA	NA	3.42E-02	6.71E-03	2.59E-03	3.05E-02	2.79E-03	2.79E-03	3.42E-02	2.59E-03	1.33E-02
Zr	mg/mL	NA	NA	NA	NA	NA	NA	NA	NA	NA	6.37E-03	4.31E-03	3.00E-03	1.04E-03	1.04E-03	6.37E-03	1.04E-03	3.15E-03
Organic	mg/mL	1.41E+01	1.26E+01	1.19E+01	NA	6.13E+00	7.87E+01	9.43E+00	1.24E+01	NA	NA	NA	NA	NA	NA	7.87E+01	6.13E+00	2.07E+01
TC	mg/mL	NA	NA	NA	NA	NA	NA	NA	NA	6.23E+00	9.83E+00	7.17E+00	7.99E+00	7.69E+00	7.69E+00	9.83E+00	6.23E+00	7.77E+00
TIC	mg/mL	NA	NA	NA	NA	NA	NA	NA	NA	3.90E+00	3.44E+00	3.69E+00	5.28E+00	5.03E+00	5.03E+00	5.28E+00	3.44E+00	4.40E+00
TOC	mg/mL	NA	NA	NA	NA	NA	NA	NA	NA	5.39E+00	6.35E+00	4.43E+00	3.78E+00	3.63E+00	3.63E+00	6.35E+00	3.63E+00	4.54E+00
pH	pH	NA	NA	NA	NA	NA	NA	NA	NA	NA	>13.5	>13.6	NA	>13.5	>13.5	1.36E+01	1.35E+01	1.35E+01
SpG	SG	NA	NA	NA	NA	NA	NA	NA	NA	1.32E+00	1.38E+00	1.44E+00	1.46E+00	1.42E+00	1.42E+00	1.46E+00	1.32E+00	1.41E+00

Note:
1. Maximum of composite predict run from 6 passes.
2. Maximum of composite predict run from 8 passes.
3. Maximum of composite predict run from 5 passes.
4. Maximum of composite predict run from 3 passes.
5. Maximum of composite predict run from 3 passes.
6. Maximum of composite predict run from 5 passes.
7. Maximum of composite predict run from 4 passes.
8. Slurry values are conservatively calculated at WVRF of 85%

Table A.3.3
Chemical Composition of Evaporator Feed

Compound	MW	Units	1994-02 Post-Slurry	1994-02 Post-Slurry	1995-01 Post-Slurry	1996-01 Post-Slurry	1997-01 Post-Slurry	1997-02 Post-Slurry	1999-01 Post-Slurry	2000-01 Post-Slurry	2001-01 Post-Slurry[2]	2002-02 Post-Slurry	2003-01 Post-Slurry	2004-01 Post-Slurry	2005-01 Post-Slurry	2006-01 Post-Slurry	Statistics Maximum	Minimum	Average
Al	26.98154	mg/mL	1.37E+00	NA	5.29E+00	4.54E+00	7.38E+01	NA	8.28E+00	2.04E+01	2.46E+01	2.46E+01	3.74E+01	2.58E+01	2.05E+01	2.05E+01	7.38E+01	1.37E+00	2.23E+01
B	10.81	mg/mL	NA	NA	NA	NA	NA	NA	NA	NA	NA	6.03E-02	5.50E-02	2.43E-02	4.20E-02	4.20E-02	6.03E-02	2.43E-02	4.47E-02
Ba	137.34	mg/mL	NA	NA	NA	NA	NA	NA	NA	NA	NA	3.19E-02	2.16E-02	1.45E-02	9.28E-03	9.28E-03	3.19E-02	9.28E-03	1.73E-02
Be		mg/mL	NA	NA	NA	NA	NA	NA	NA	NA	NA	3.19E-03	2.16E-03	9.18E-04	5.88E-04	5.88E-04	3.19E-03	5.88E-04	1.49E-03
Ca		mg/mL	NA	NA	NA	NA	NA	NA	NA	NA	NA	8.54E-02	4.31E-02	1.48E-02	3.32E-02	3.32E-02	8.54E-02	1.48E-02	4.19E-02
Cd		mg/mL	NA	NA	NA	NA	NA	NA	NA	NA	NA	8.21E-03	2.16E-03	2.69E-03	1.01E-03	1.01E-03	8.21E-03	1.01E-03	3.02E-03
Cl		mg/mL	NA	NA	NA	NA	NA	NA	2.39E+00	5.27E+00	7.66E-01	6.14E+00	7.57E+00	4.09E+00	5.39E+00	5.39E+00	7.57E+00	7.66E-01	4.63E+00
CO_3	60.0092	mg/mL	NA	NA	NA	NA	2.23E+01	NA	NA	NA	NA	NA	NA	NA	NA	NA	2.23E+01	2.23E+01	2.23E+01
Cr	51.996	mg/mL	NA	NA	NA	NA	NA	NA	2.25E-01	1.50E+00	1.29E+00	7.46E-01	7.81E-01	6.50E-01	9.48E-01	9.48E-01	1.50E+00	2.25E-01	8.86E-01
F	18.9984	mg/mL	4.77E+00	NA	2.74E+00	8.89E+00	4.39E+00	NA	1.46E+00	1.22E+00	1.60E+00	1.98E+00	4.41E-01	1.45E+00	1.19E-01	1.19E-01	8.89E+00	1.19E-01	2.43E+00
Fe	55.847	mg/mL	NA	NA	NA	NA	NA	NA	2.01E-02	3.01E-02	1.17E-01	3.19E-02	2.16E-02	1.38E-02	8.85E-03	8.85E-03	1.17E-01	8.85E-03	3.15E-02
K	39.098	mg/mL	NA	NA	NA	NA	NA	NA	1.91E+01	5.24E+00	1.33E+01	2.56E+00	4.64E+00	1.54E+01	2.69E+00	2.69E+00	1.91E+01	2.56E+00	8.20E+00
La	138.9055	mg/mL	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	2.16E-02	3.78E-03	2.43E-03	2.43E-03	2.16E-02	2.43E-03	7.57E-03
Mn	54.938	mg/mL	NA	NA	NA	NA	NA	NA	4.01E-03	6.01E-03	6.01E-03	6.37E-03	4.31E-03	1.56E-03	1.23E-03	1.23E-03	6.37E-03	1.23E-03	3.84E-03
Mo		mg/mL	NA	NA	NA	NA	NA	NA	NA	NA	NA	7.67E-02	9.97E-02	5.23E-02	6.77E-02	6.77E-02	9.97E-02	5.23E-02	7.28E-02
Na	22.9877	mg/mL	4.28E+01	NA	1.20E+02	1.69E+02	NA	NA	1.60E+02	1.78E+02	3.00E+02	2.06E+02	2.34E-08	2.10E+02	1.81E+02	1.81E+02	3.00E+02	2.34E-08	1.59E+02
NH_3	17.0304	mg/mL	NA	NA	NA	NA	NA	NA	NA	NA	NA	1.28E-01	8.14E-02	4.89E-02	1.75E-02	1.85E-02	1.28E-01	1.75E-02	5.89E-02
NH_4	18.0383	mg/mL	1.40E-02	NA	3.12E-03	5.00E-03	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	1.40E-02	3.12E-03	7.37E-03
Ni	58.7	mg/mL	NA	NA	NA	NA	NA	NA	8.02E-03	1.20E-02	1.20E-02	6.95E-02	1.81E-02	1.48E-02	1.72E-02	1.72E-02	6.95E-02	8.02E-03	2.11E-02
NO_2	46.0055	mg/mL	1.54E+01	NA	4.05E+01	3.75E+01	2.24E+02	NA	4.32E+01	6.29E+01	3.51E+01	9.00E+01	1.22E+02	8.44E+01	7.61E+01	7.61E+01	2.24E+02	1.54E+01	7.57E+01
NO_3	62.0049	mg/mL	3.22E+01	NA	9.55E+01	1.89E+02	3.80E+02	NA	1.15E+02	1.96E+02	9.50E+01	2.13E+02	1.98E+02	1.84E+02	1.66E+02	1.66E+02	3.80E+02	3.22E+01	1.69E+02
OH	17.0073	mg/mL	5.87E+00	NA	3.15E+01	2.84E+01	1.36E+02	NA	4.20E+01	1.13E+01	3.82E+01	2.40E+01	4.41E+01	5.27E+01	2.69E+01	2.69E+01	1.36E+02	5.87E+00	3.90E+01
Pb	207.2	mg/mL	NA	NA	NA	NA	NA	NA	NA	NA	NA	6.37E-02	4.90E-02	3.84E-02	2.87E-02	2.87E-02	6.37E-02	2.87E-02	4.17E-02
PO_4	94.97136	mg/mL	1.01E+00	NA	1.14E+00	1.20E+01	7.12E+00	NA	1.51E+00	6.18E-01	3.36E+00	6.24E+00	5.78E+00	7.05E-01	4.02E+00	4.02E+00	1.20E+01	6.18E-01	3.96E+00
Se		mg/mL	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	2.41E-02	2.41E-02	2.41E-02	2.41E-02
Si		mg/mL	NA	NA	NA	NA	NA	NA	NA	NA	NA	7.87E-02	3.07E-02	6.02E-02	1.43E-02	1.43E-02	7.87E-02	1.43E-02	3.96E-02
SO_4	96.0576	mg/mL	2.67E+00	NA	5.78E+00	1.38E+01	7.68E+00	NA	5.18E+00	5.00E+00	3.81E+00	3.65E+00	4.69E+00	3.15E+00	5.19E+00	5.19E+00	1.38E+01	2.67E+00	5.48E+00
U-235	238.029	mg/mL	NA	NA	NA	NA	NA	NA	NA	NA	NA	7.32E-05	2.10E-05	2.93E-04	3.65E-05	3.65E-05	2.93E-04	2.10E-05	9.20E-05
U-238	238.029	mg/mL	NA	NA	NA	NA	NA	NA	NA	NA	NA	3.86E-03	2.93E-03	3.94E-02	4.97E-03	4.97E-03	3.94E-02	2.93E-03	1.12E-02
U-total	238.029	mg/mL	NA	NA	NA	NA	NA	NA	NA	NA	4.16E-02	6.71E-03	2.59E-03	3.05E-02	2.79E-03	2.79E-03	4.16E-02	2.59E-03	1.45E-02
Zr	91.22	mg/mL	NA	NA	NA	NA	NA	NA	NA	NA	NA	6.37E-03	4.31E-03	3.00E-03	1.04E-03	1.04E-03	6.37E-03	1.04E-03	3.15E-03
TC	1	mg/mL	NA	NA	NA	NA	NA	NA	NA	NA	NA	9.83E+00	7.17E+00	7.99E+00	7.69E+00	7.69E+00	9.83E+00	7.17E+00	8.07E+00
TIC	1	mg/mL	NA	NA	NA	NA	NA	NA	NA	NA	NA	3.44E+00	3.69E+00	5.28E+00	5.03E+00	5.03E+00	5.28E+00	3.44E+00	4.49E+00
TOC	1	mg/mL	NA	NA	NA	NA	NA	NA	NA	NA	NA	6.35E+00	4.43E+00	3.78E+00	3.63E+00	3.63E+00	6.35E+00	3.63E+00	4.36E+00
pH (Unitless)	1	pH	12.93	NA	13.5	13.46	NA	NA	13.51	12.98	NA	13.5	>13.6	NA	13.5	13.5	1.35E+01	1.29E+01	1.34E+01
SpG (Unitless)	1	Sp.G	1.097	NA	1.34	1.238	NA	NA	1.347	1.377	NA	1.38	1.44	1.46	1.42	1.42	1.46E+00	1.10E+00	1.35E+00
Gross Alpha	1	uCi/mL	NA	NA	NA	NA	NA	NA	4.49E-03	3.79E-03	2.01E-02	NA	NA	NA	NA	NA	2.01E-02	3.79E-03	9.46E-03
Gross Beta	1	uCi/mL	NA	NA	NA	NA	NA	NA	1.95E+02	2.22E+02	1.01E+02	NA	NA	NA	NA	NA	2.22E+02	1.01E+02	1.73E+02

2.Calculated slurry

Figure A.3.1 Al Slurry Concentrations

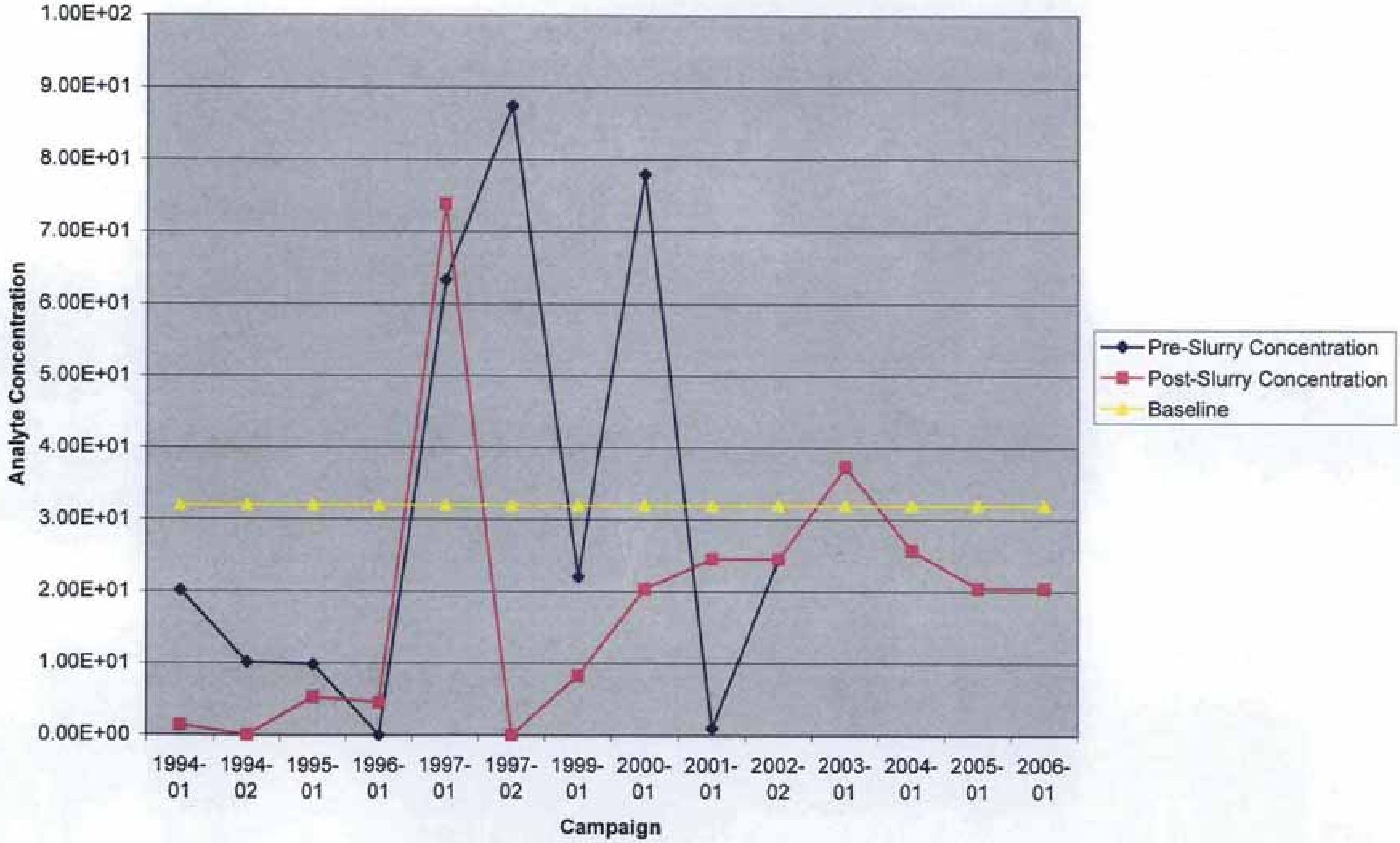


Figure A.3.2 B Slurry Concentrations

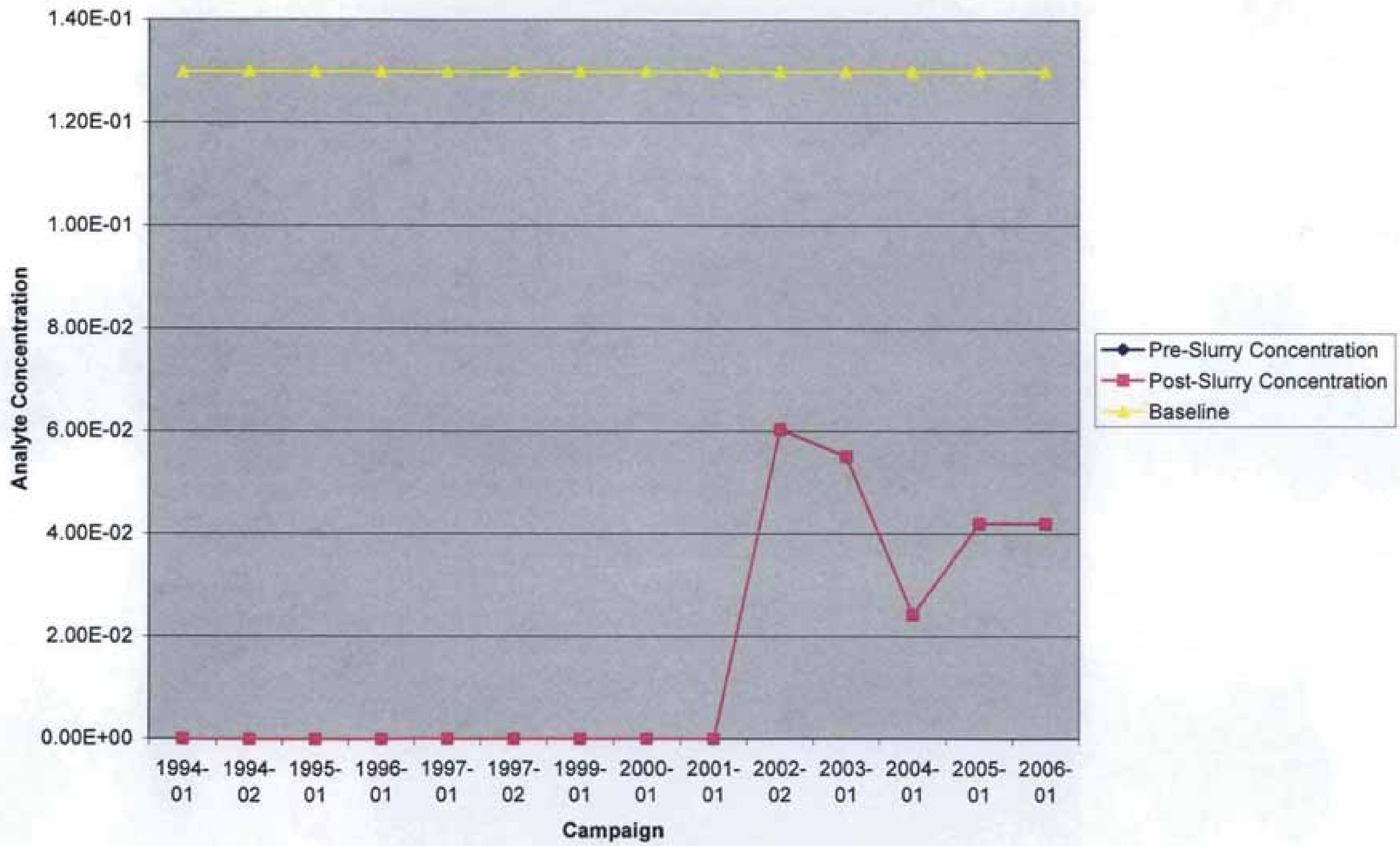


Figure A.3.3 Ba Slurry Concentrations

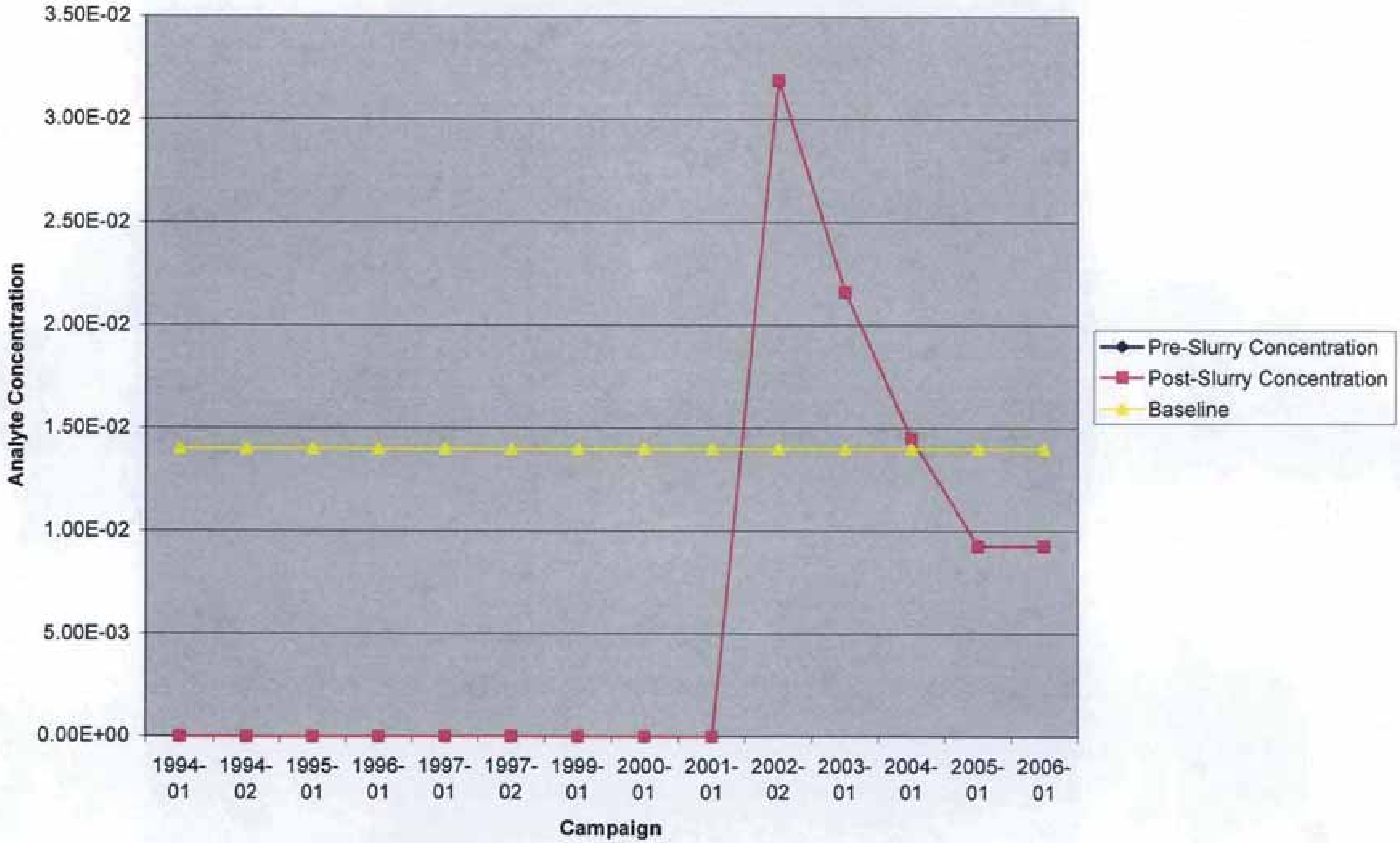


Figure A.3.4 Be Slurry Concentrations

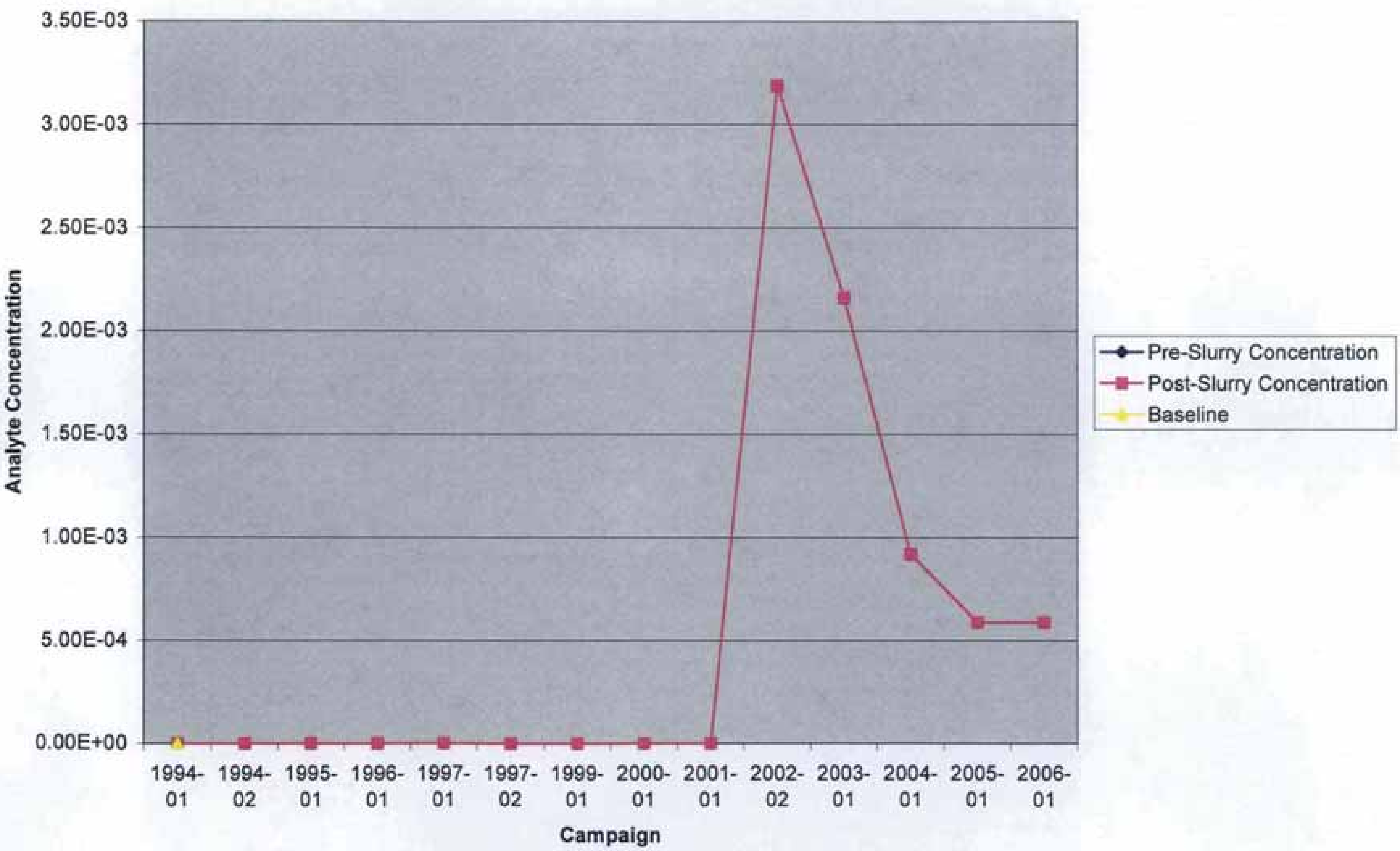


Figure A.3.5 Ca Slurry Concentrations

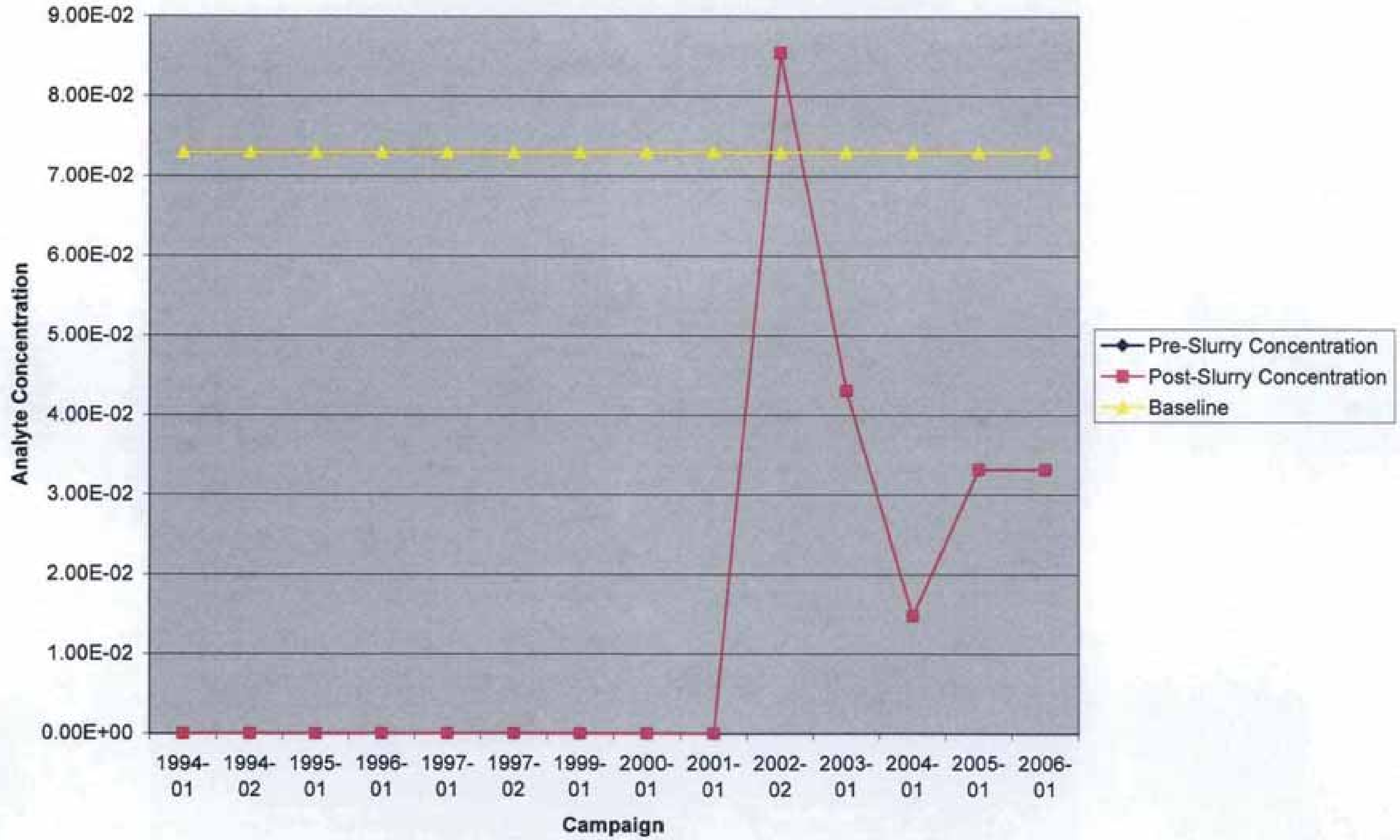


Figure A.3.6 Cd Slurry Concentrations

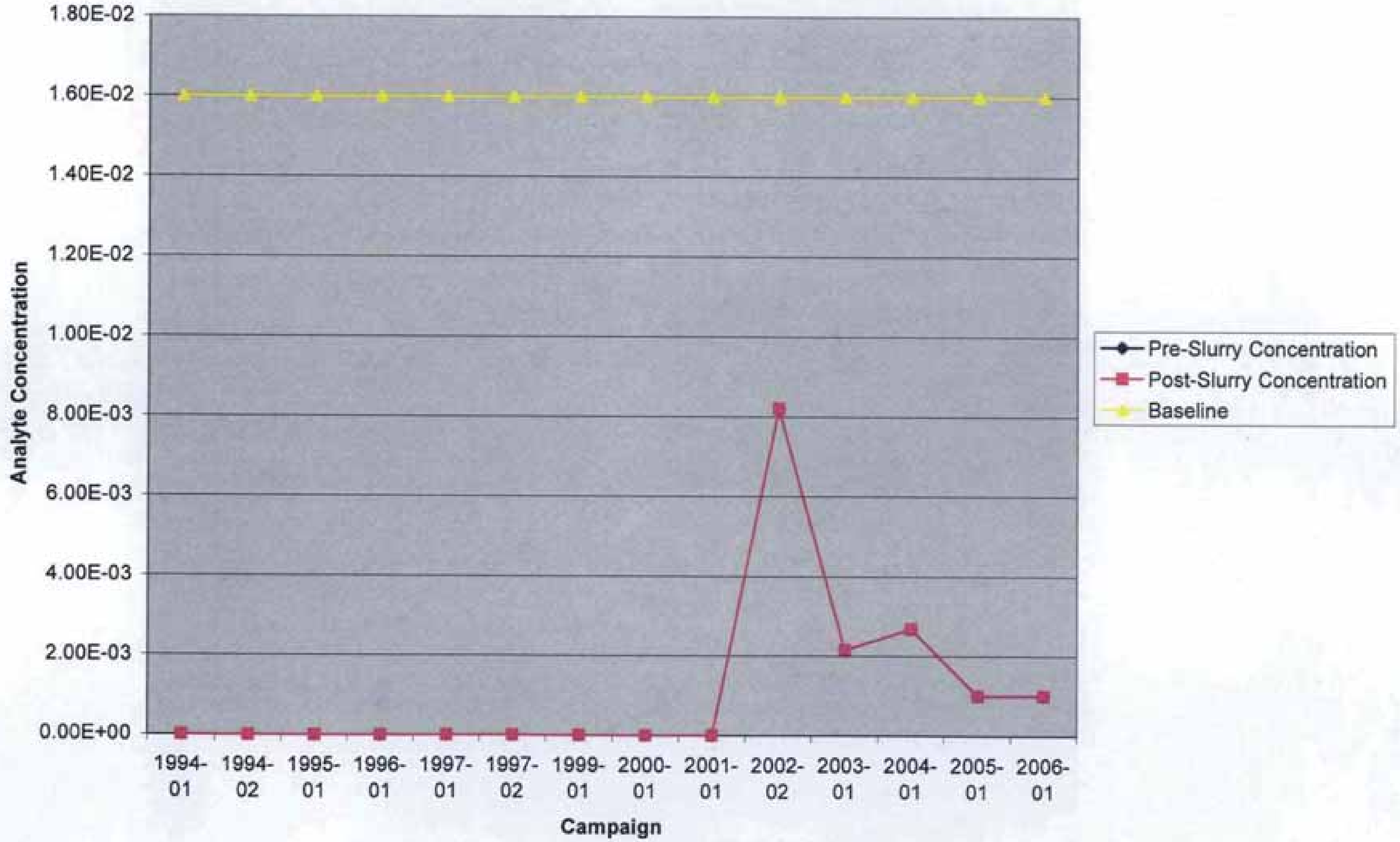


Figure A.3.7 Cl Slurry Concentrations

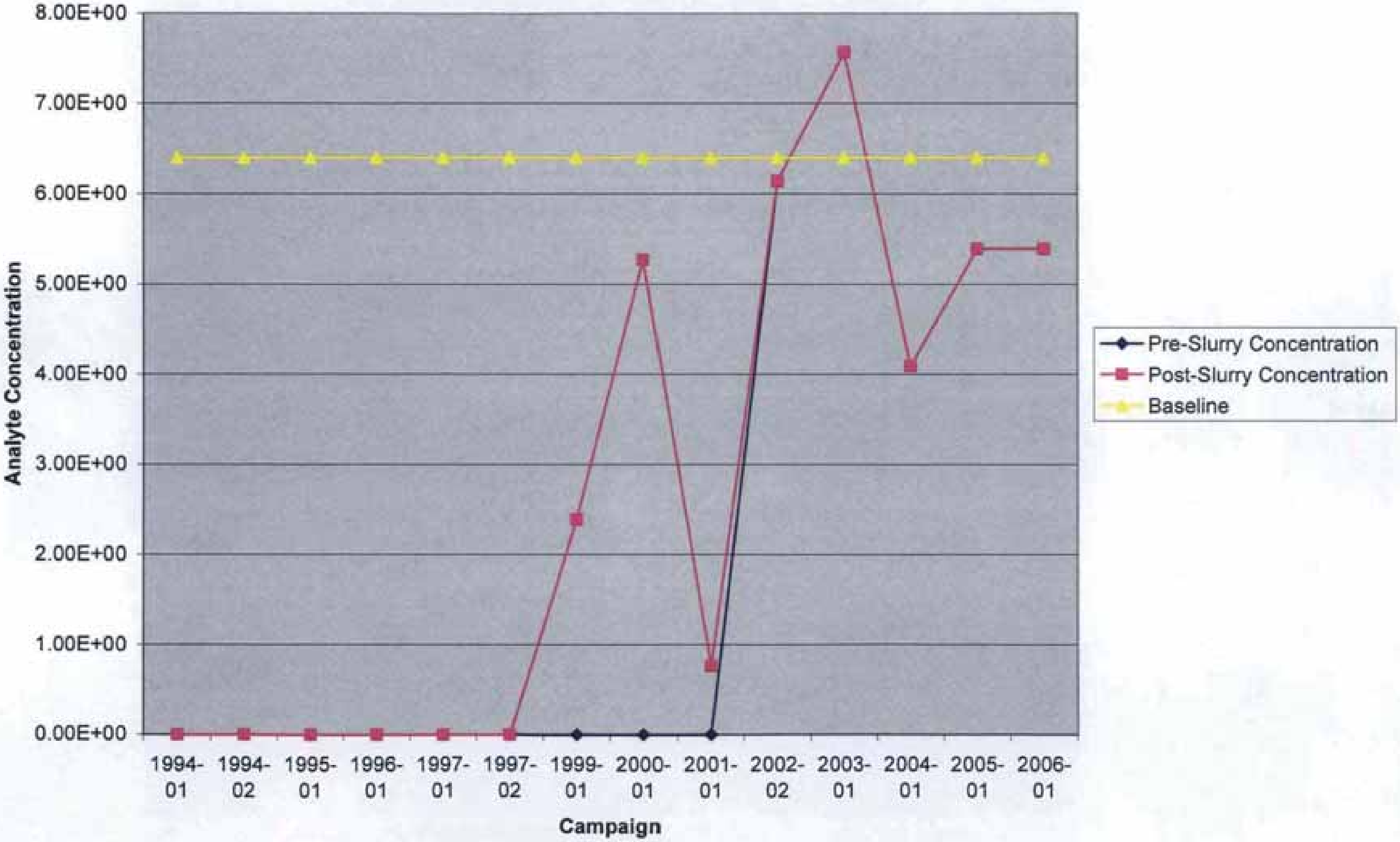


Figure A.3.8 Carbonate Slurry Concentrations

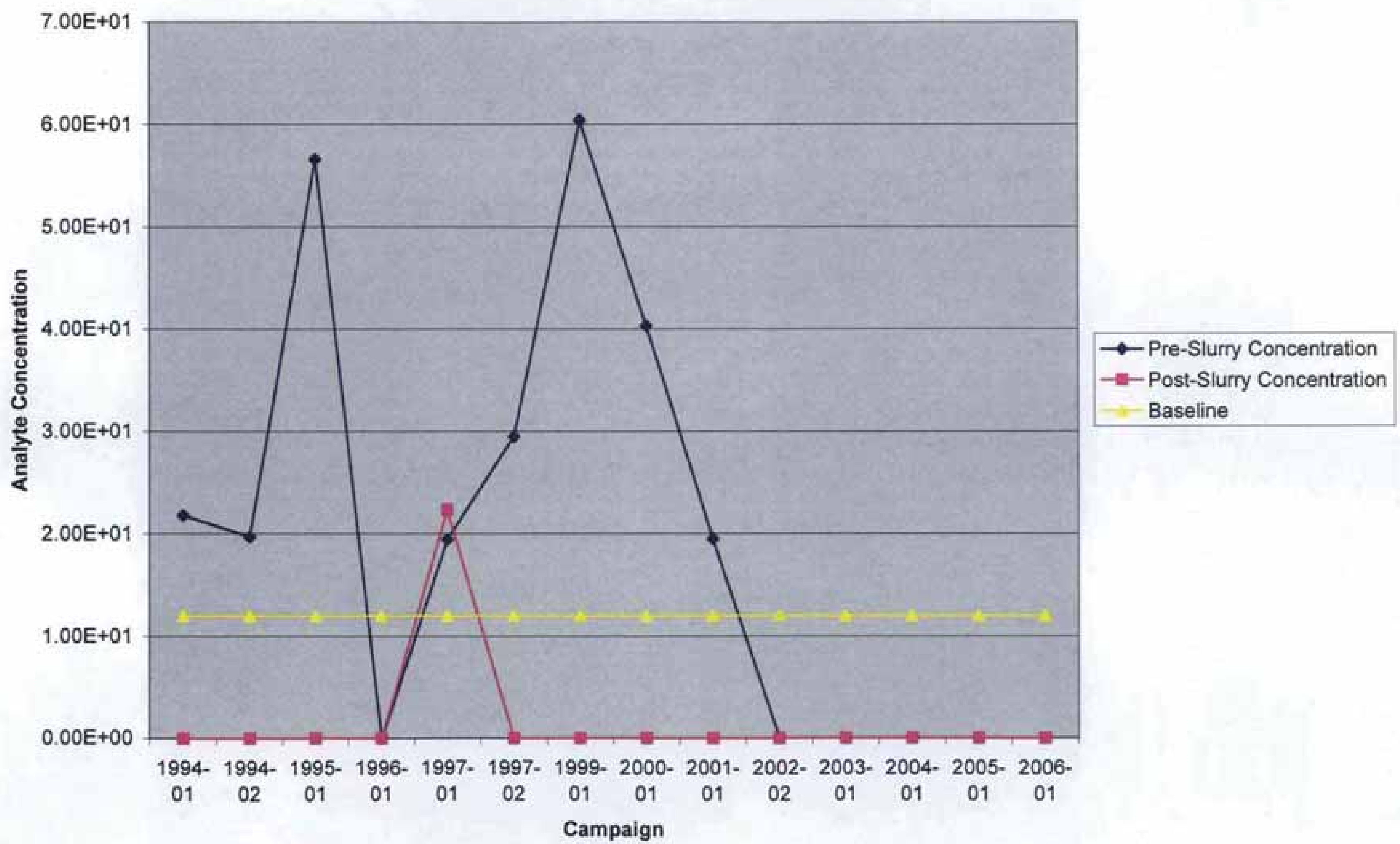


Figure A.3.9 Cr Slurry Concentrations

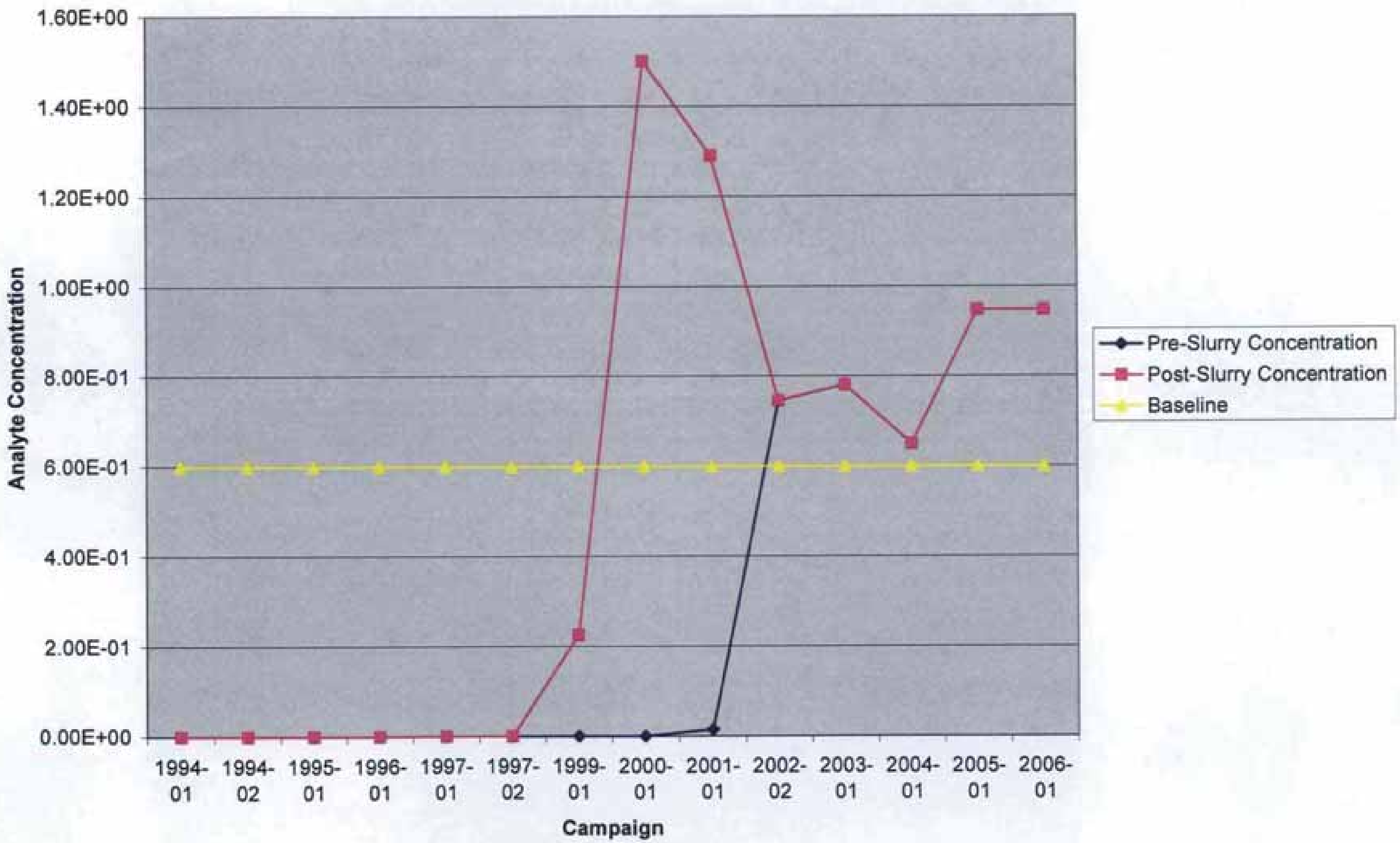


Figure A.3.10 F Slurry Concentrations

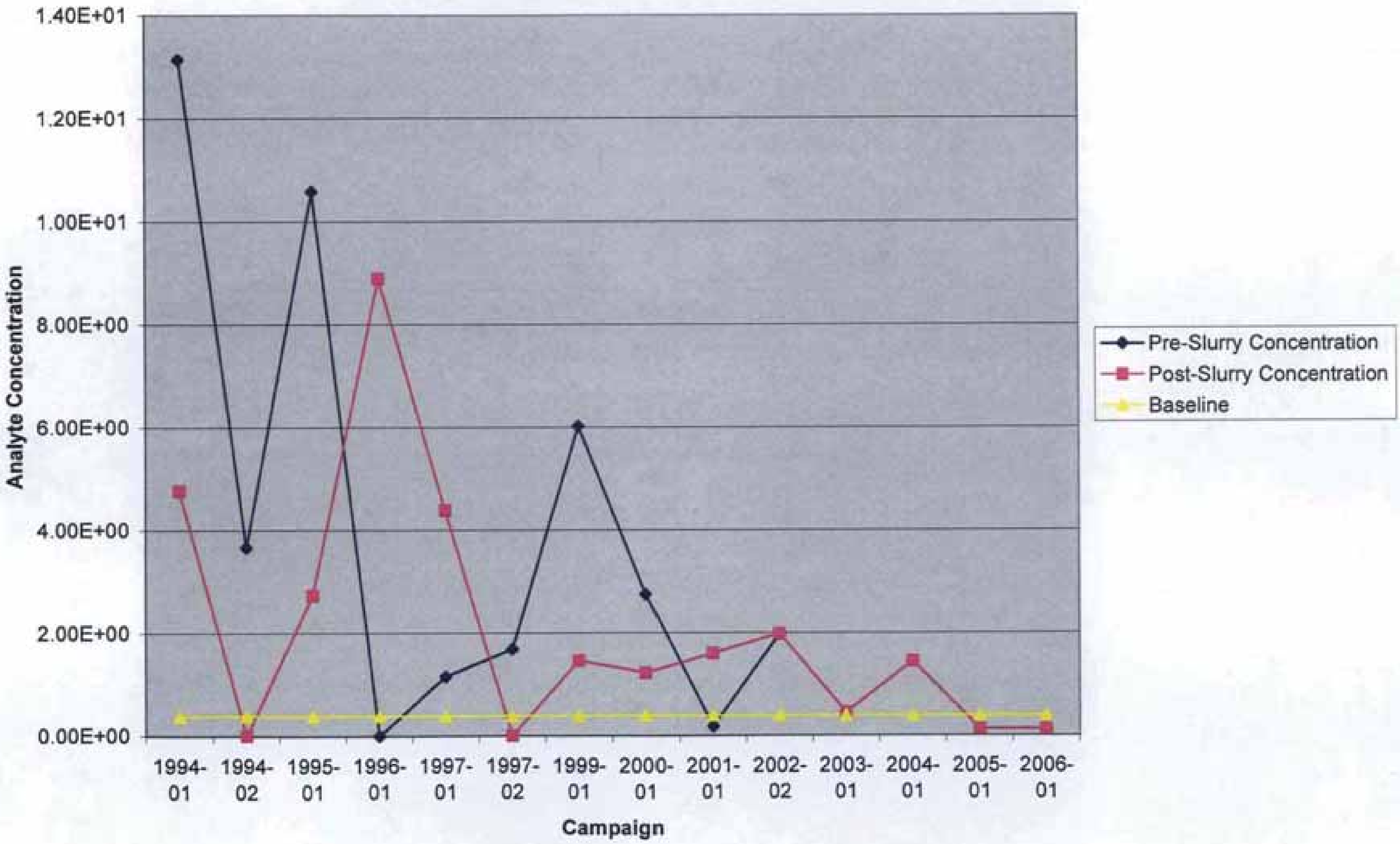


Figure A.3.11 Fe Slurry Concentrations

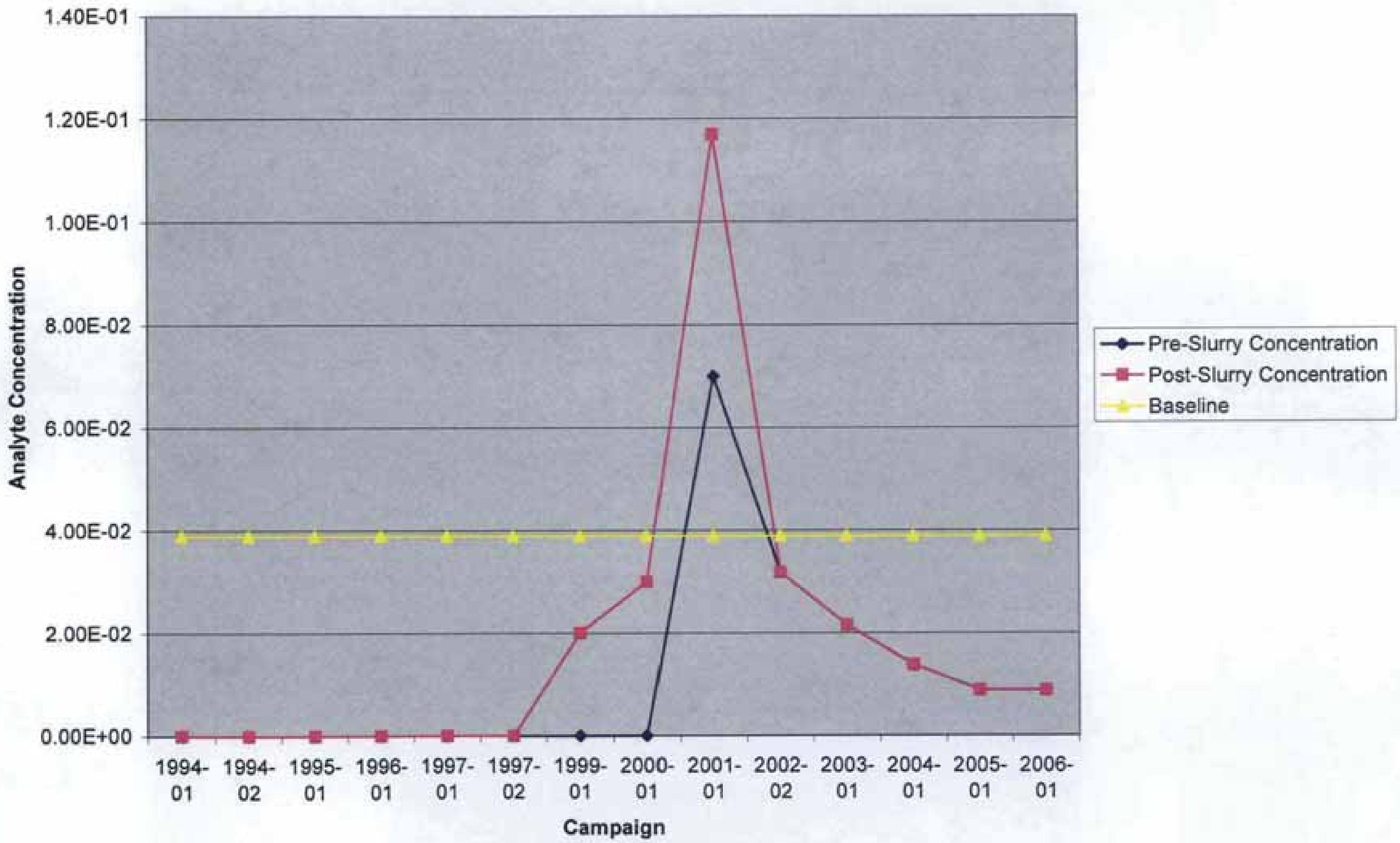


Figure A.3.12 K Slurry Concentrations

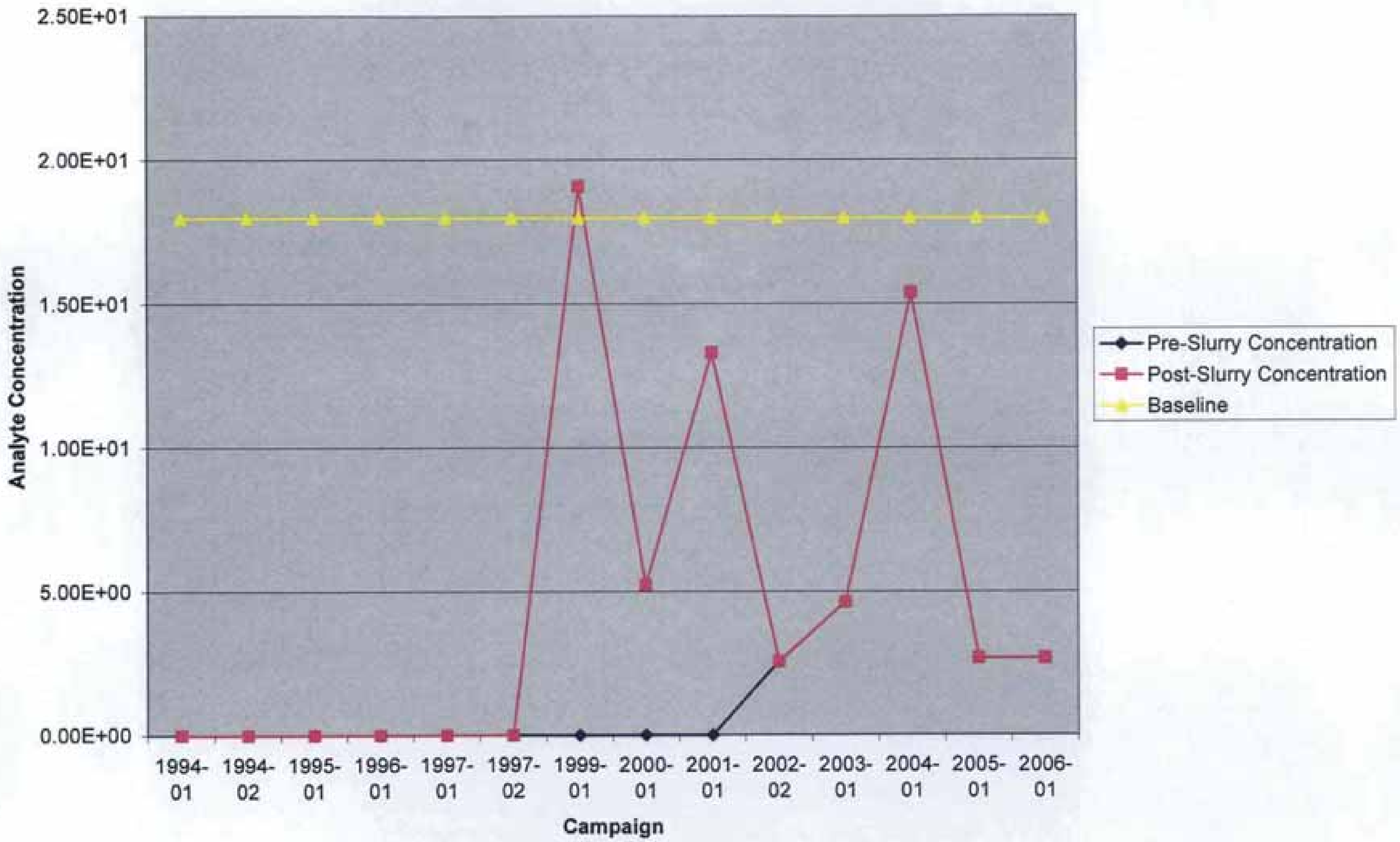


Figure A.3.13 La Slurry Concentrations

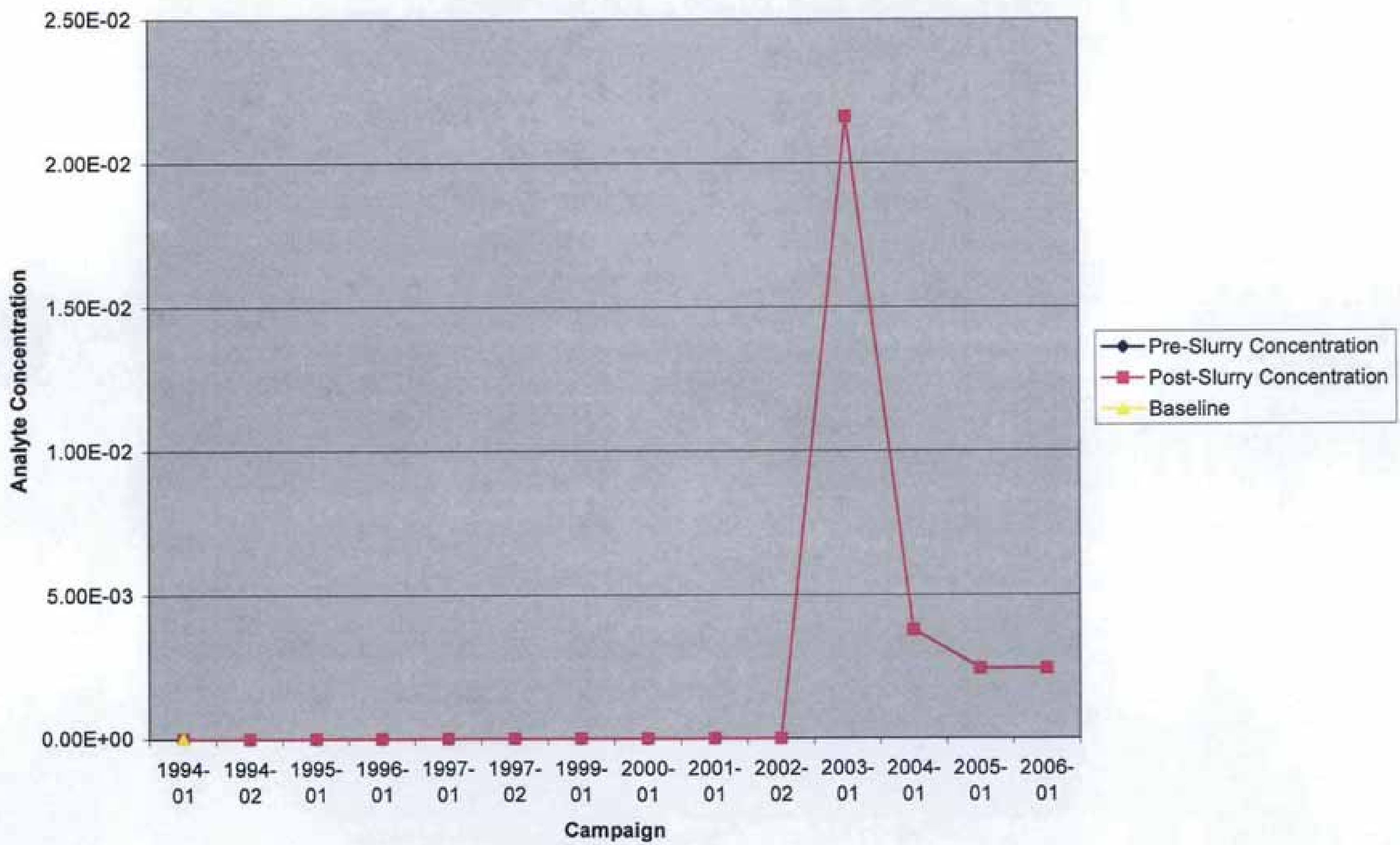


Figure A.3.14 Mn Slurry Concentrations

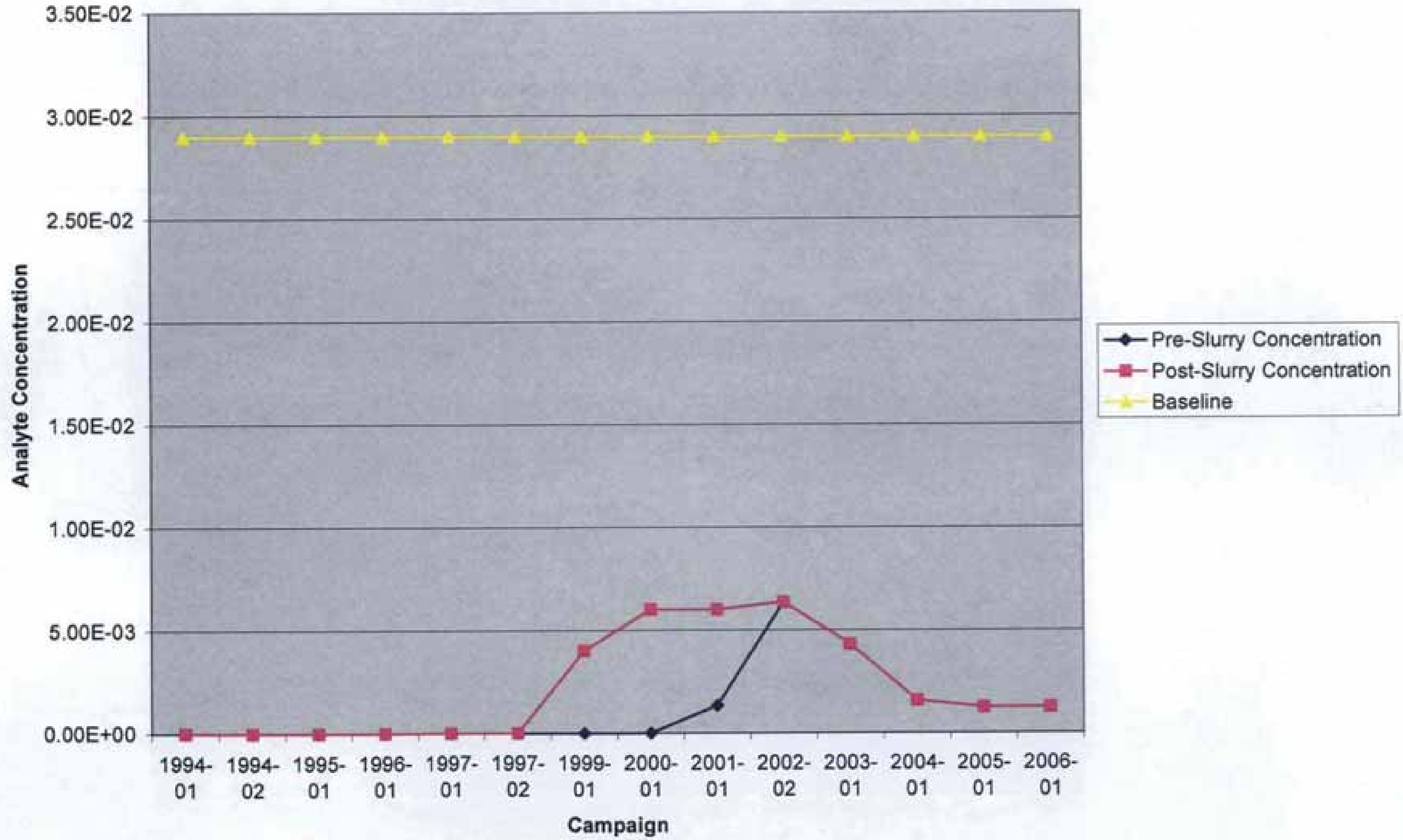


Figure A.3.15 Mo Slurry Concentrations

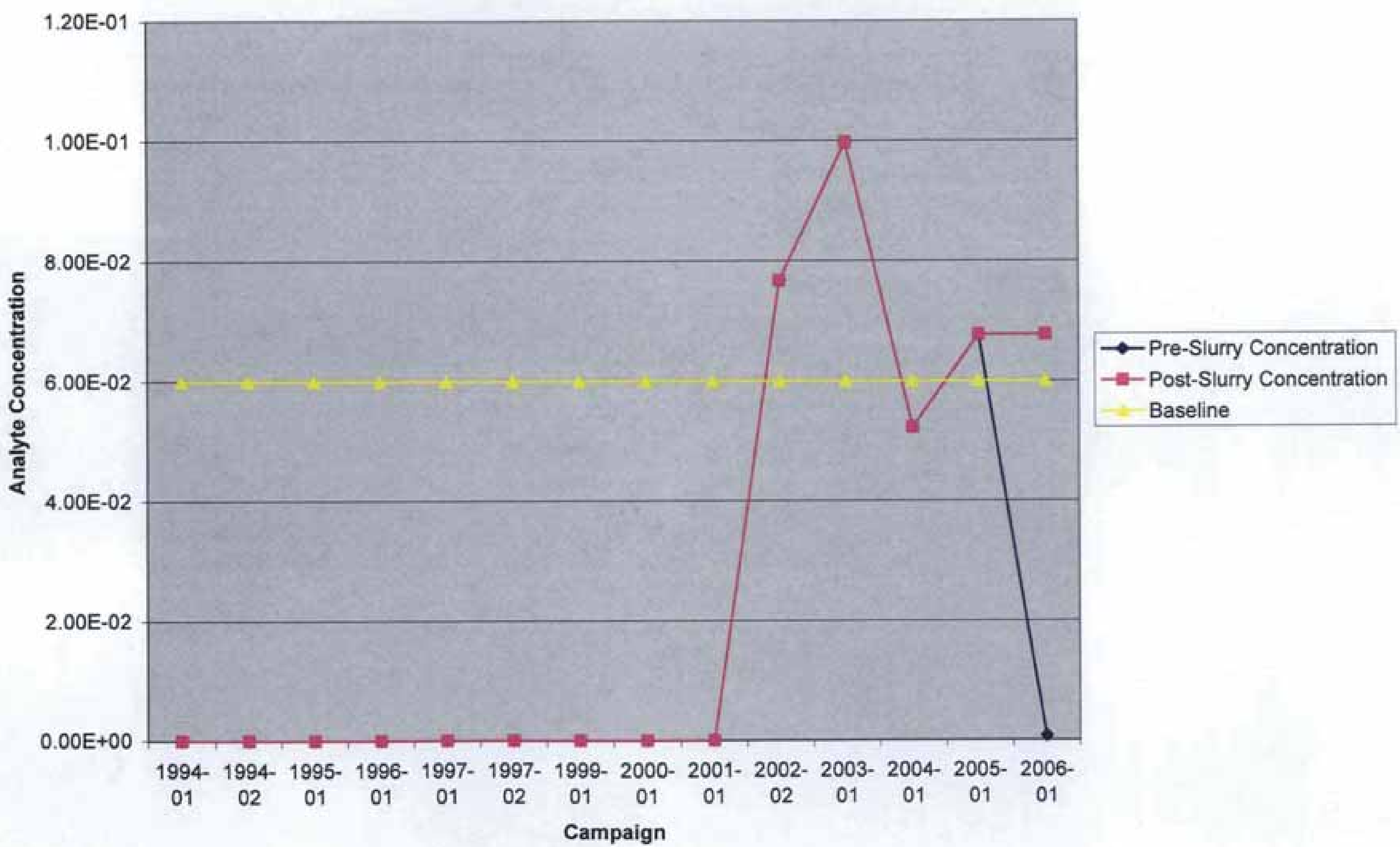


Figure A.3.16 Na Slurry Concentrations

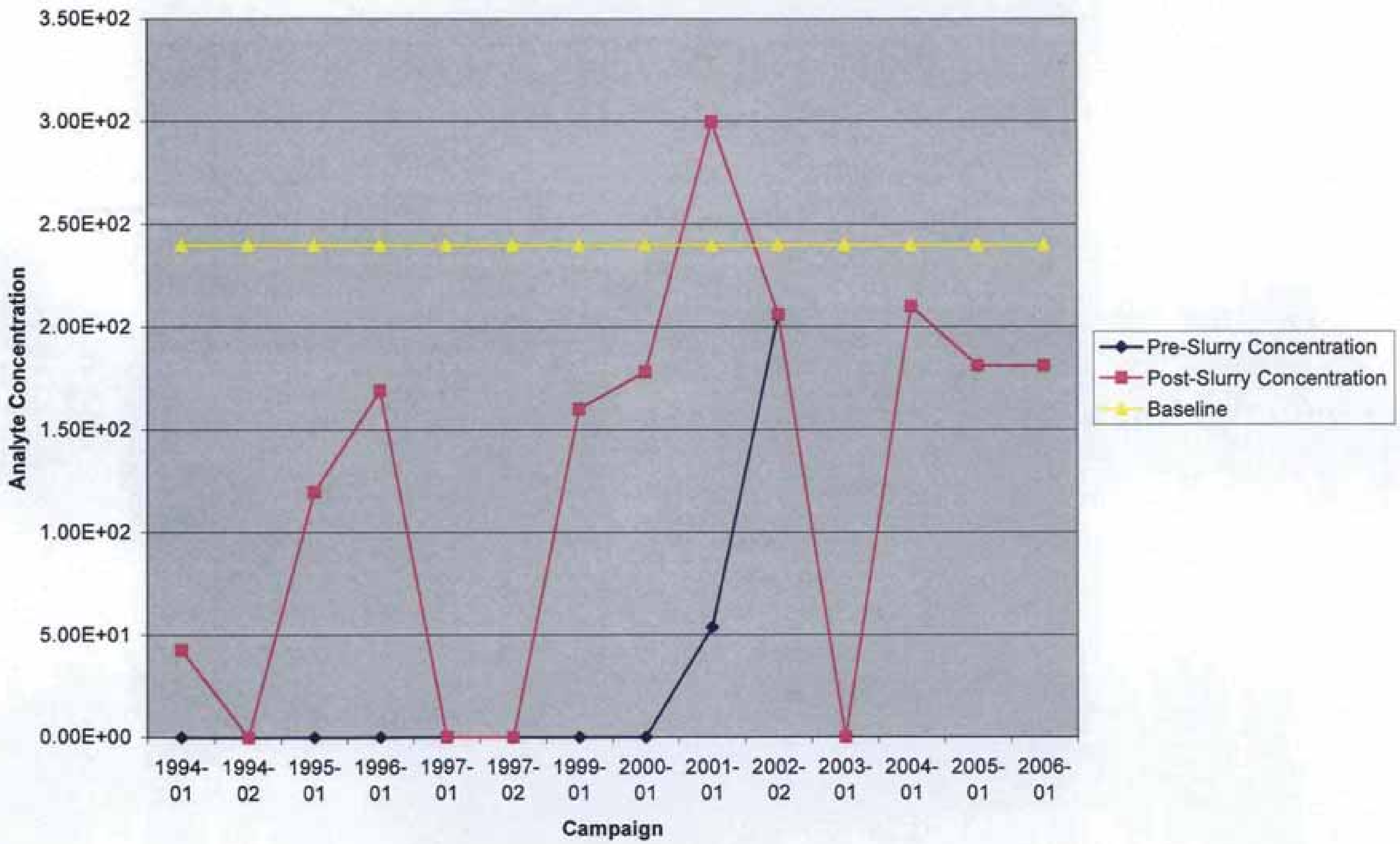


Figure A.3.17 Ammonia Slurry Concentrations

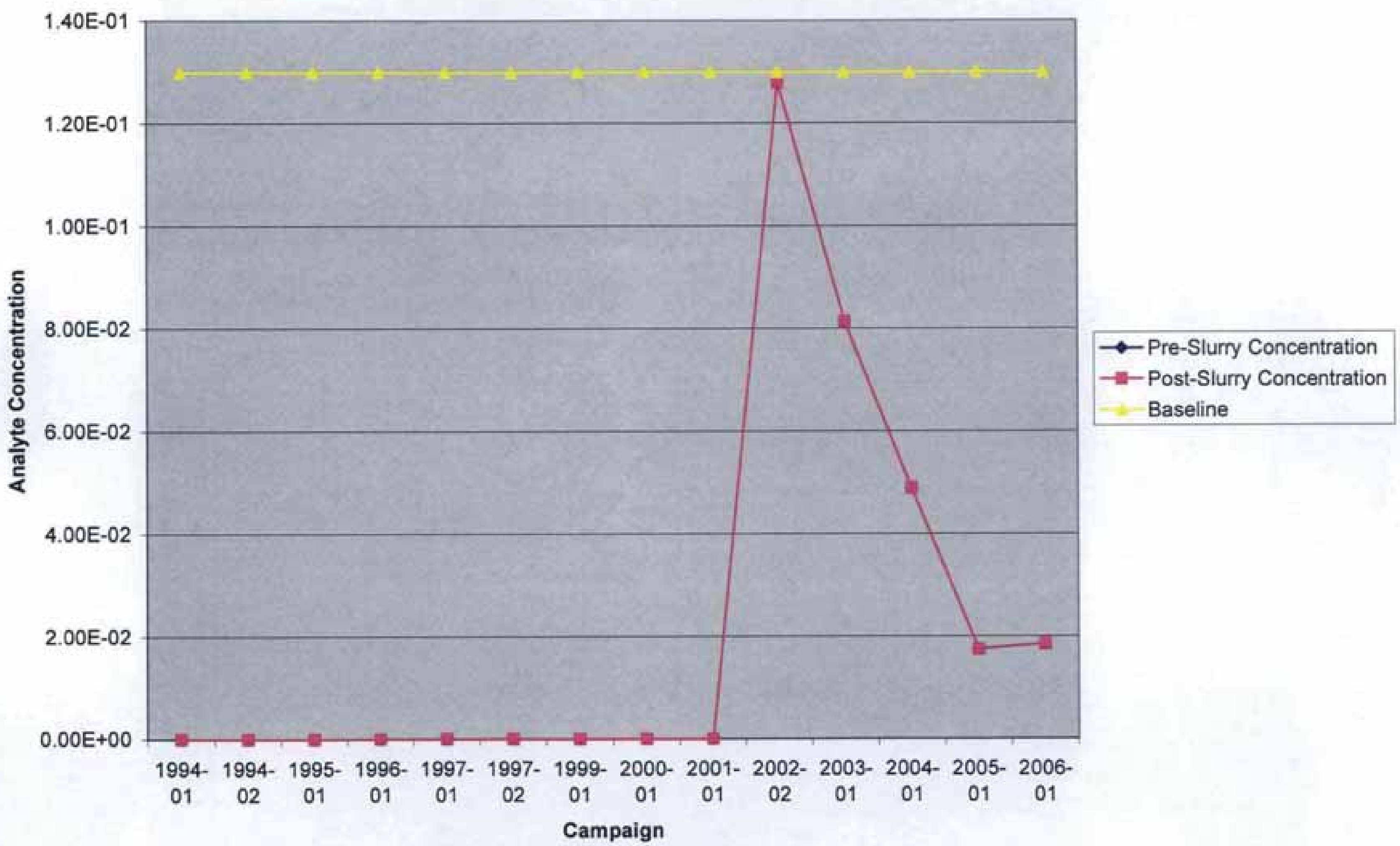


Figure A.3.18 Ammonium Slurry Concentrations

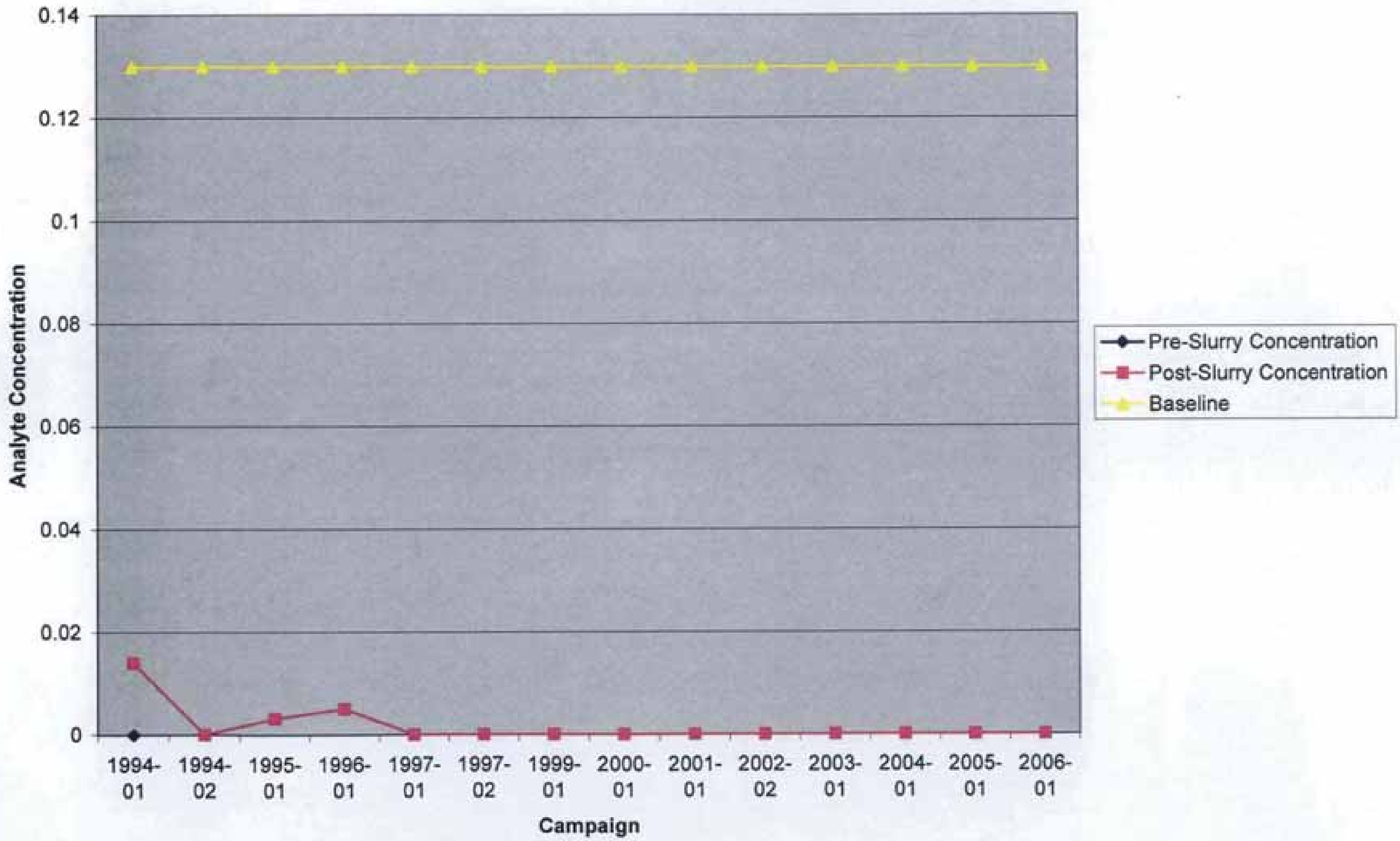


Figure A.3.19 Ni Slurry Concentrations

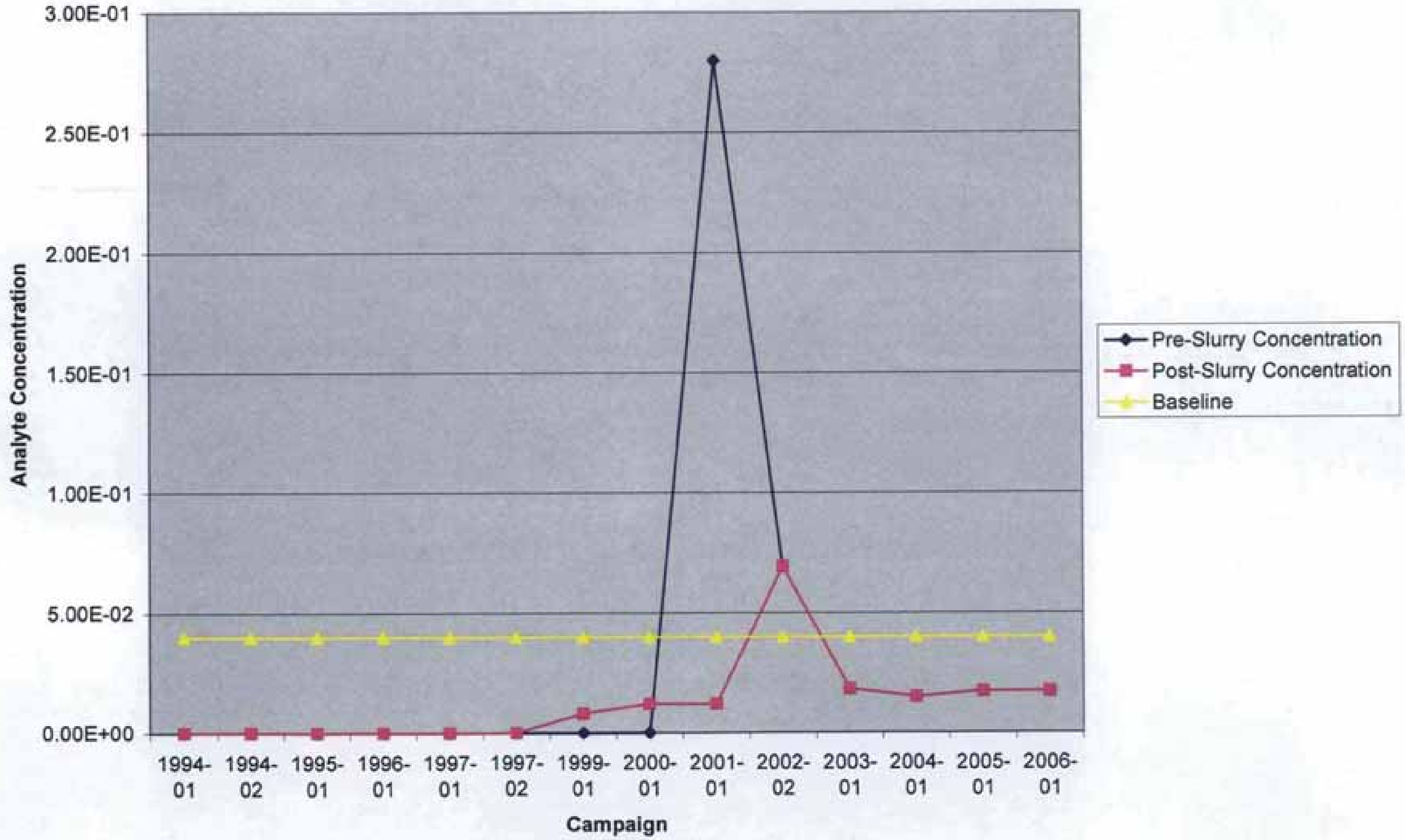


Figure A.3.24 PO4 Slurry Concentrations

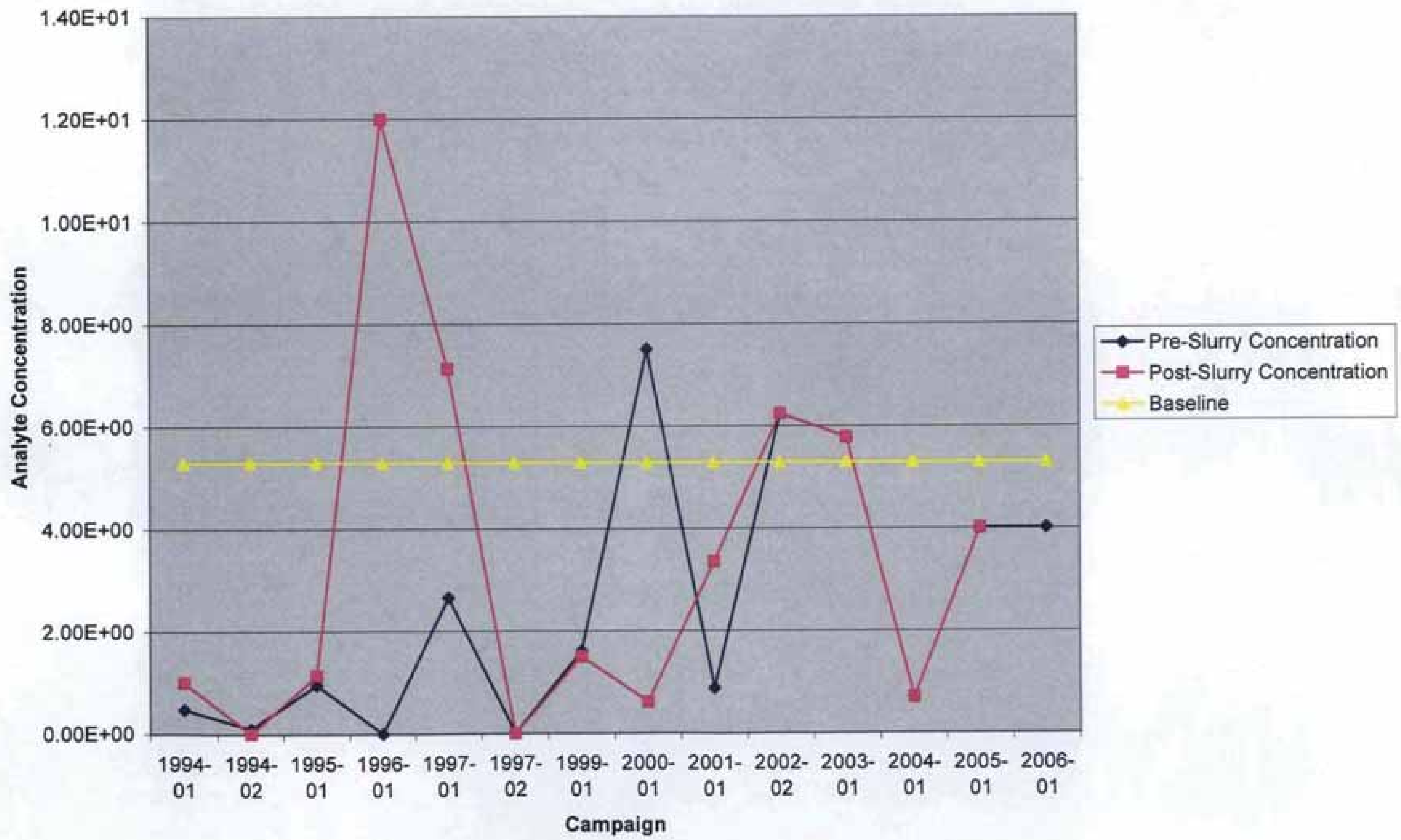


Figure A.3.20 NO2 Slurry Concentrations

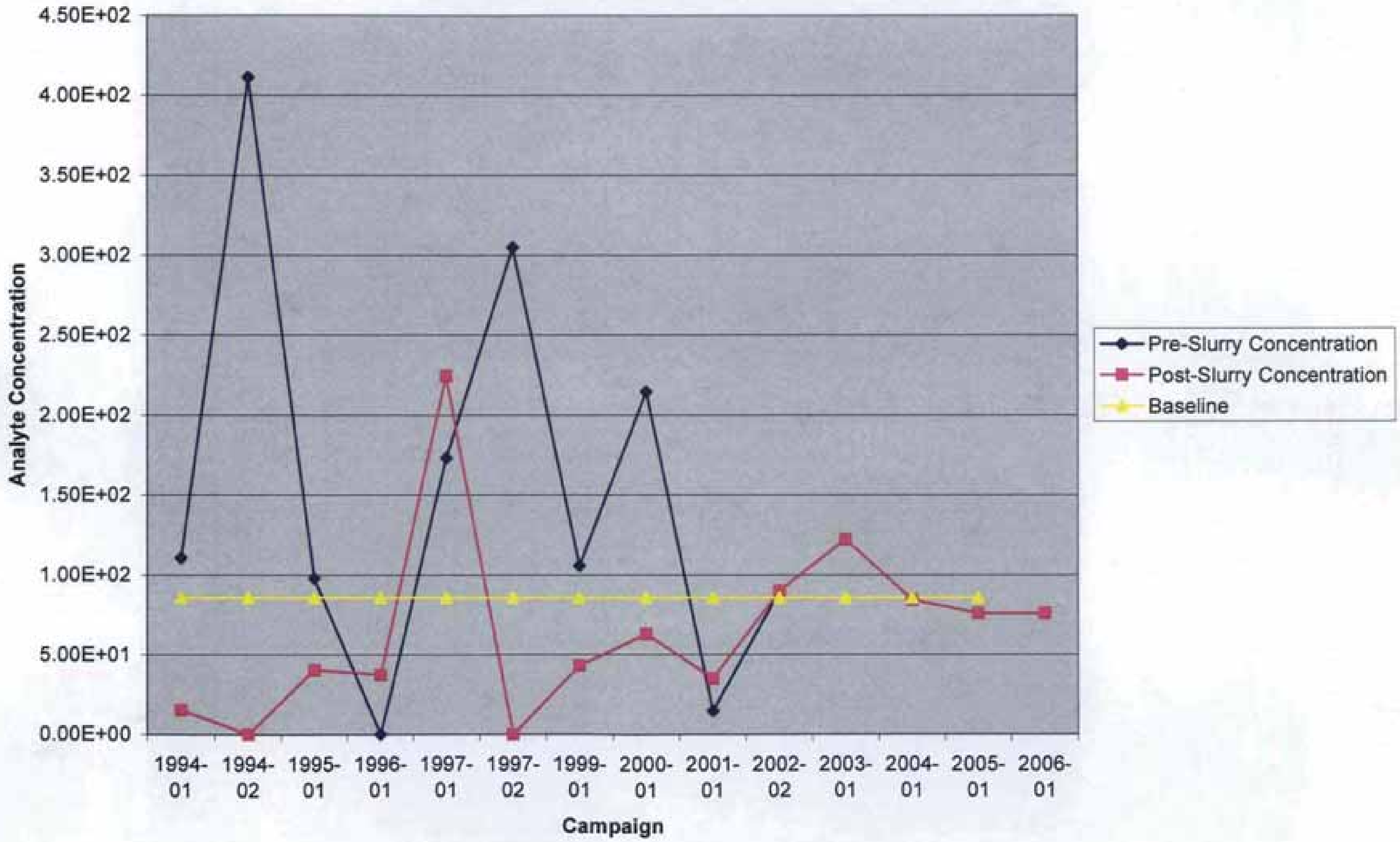


Figure A.3.21 NO3 Slurry Concentrations

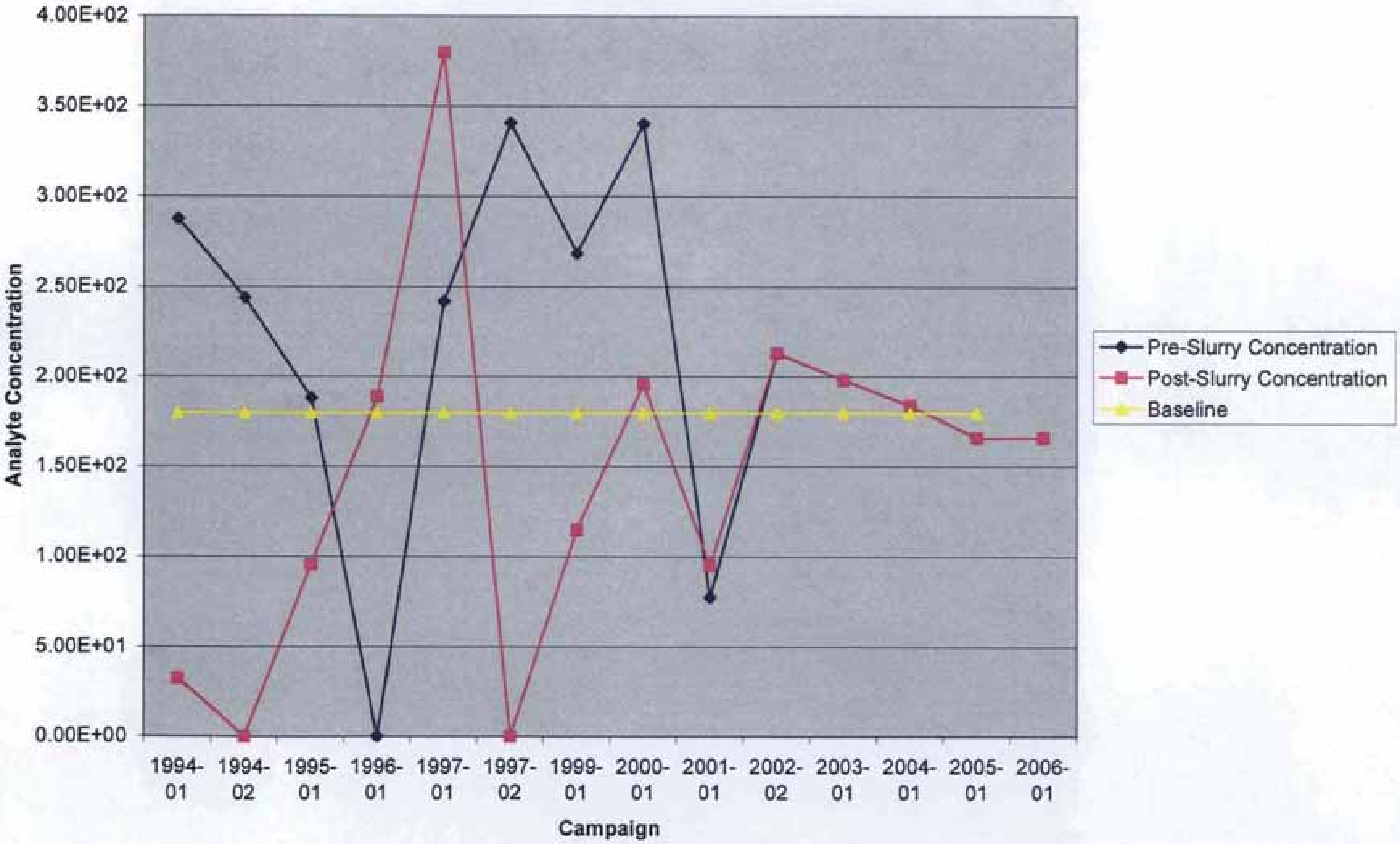


Figure A.3.22 OH Slurry Concentrations

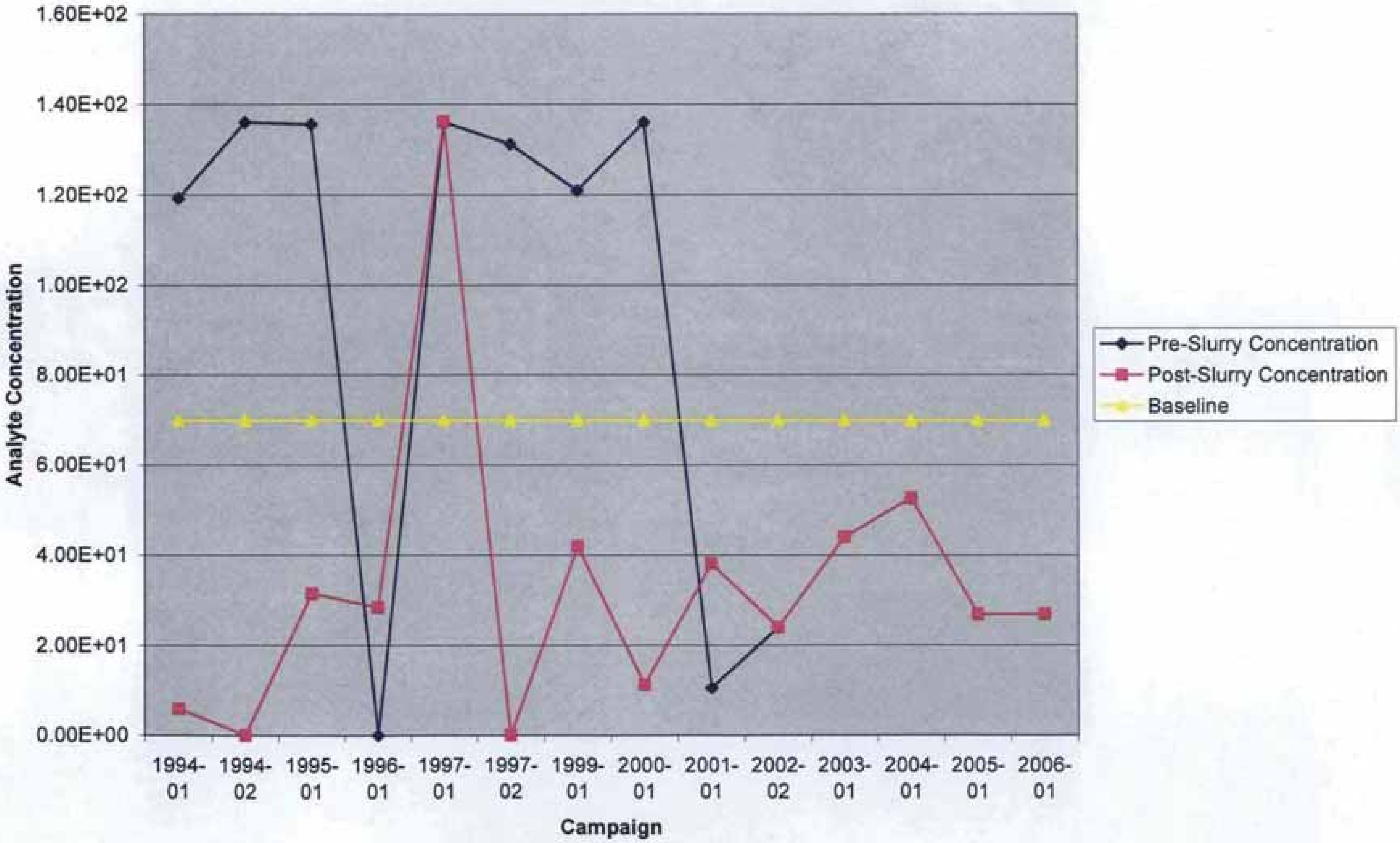


Figure A.3.23 Pb Slurry Concentrations

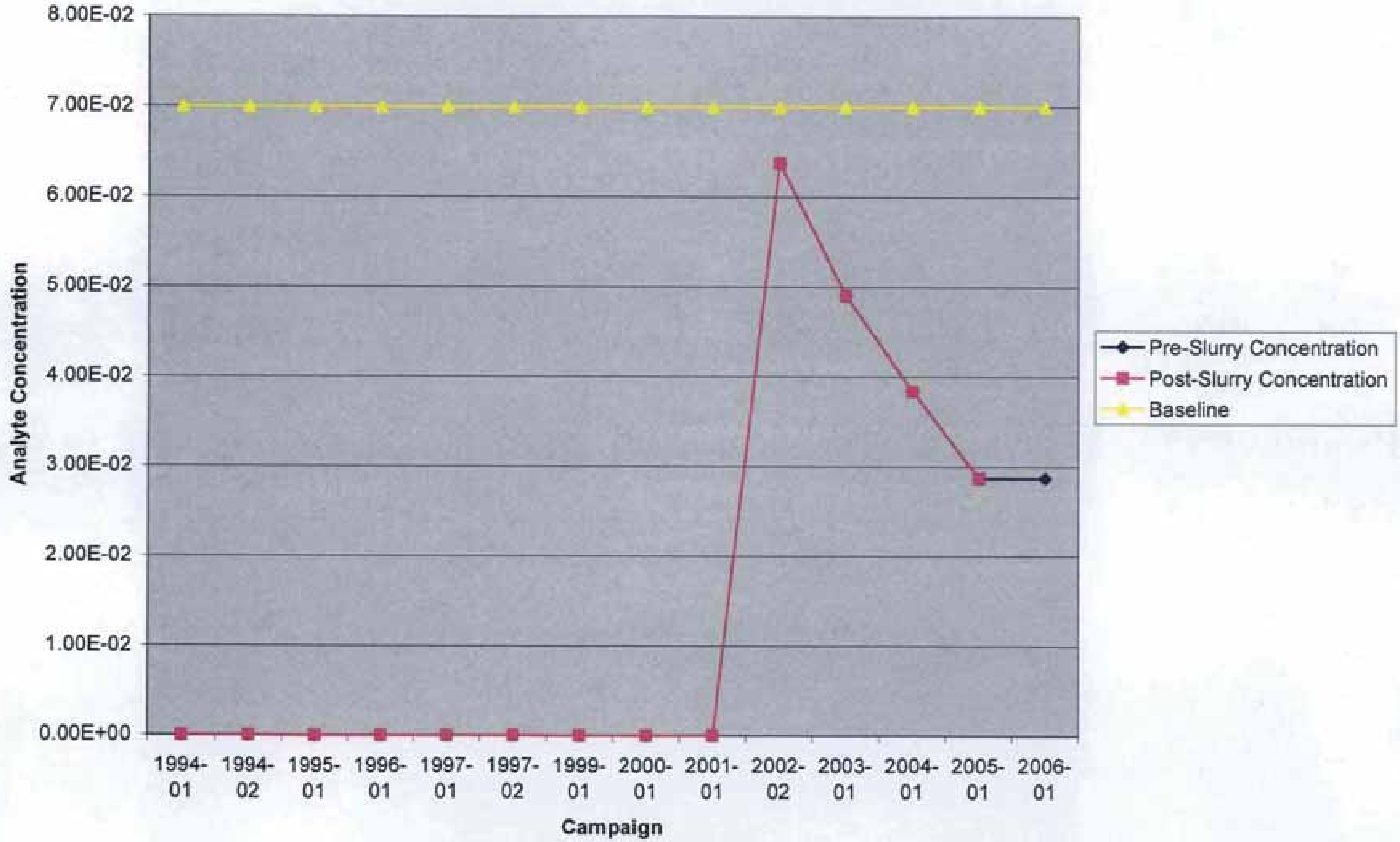


Figure A.3.24 PO4 Slurry Concentrations

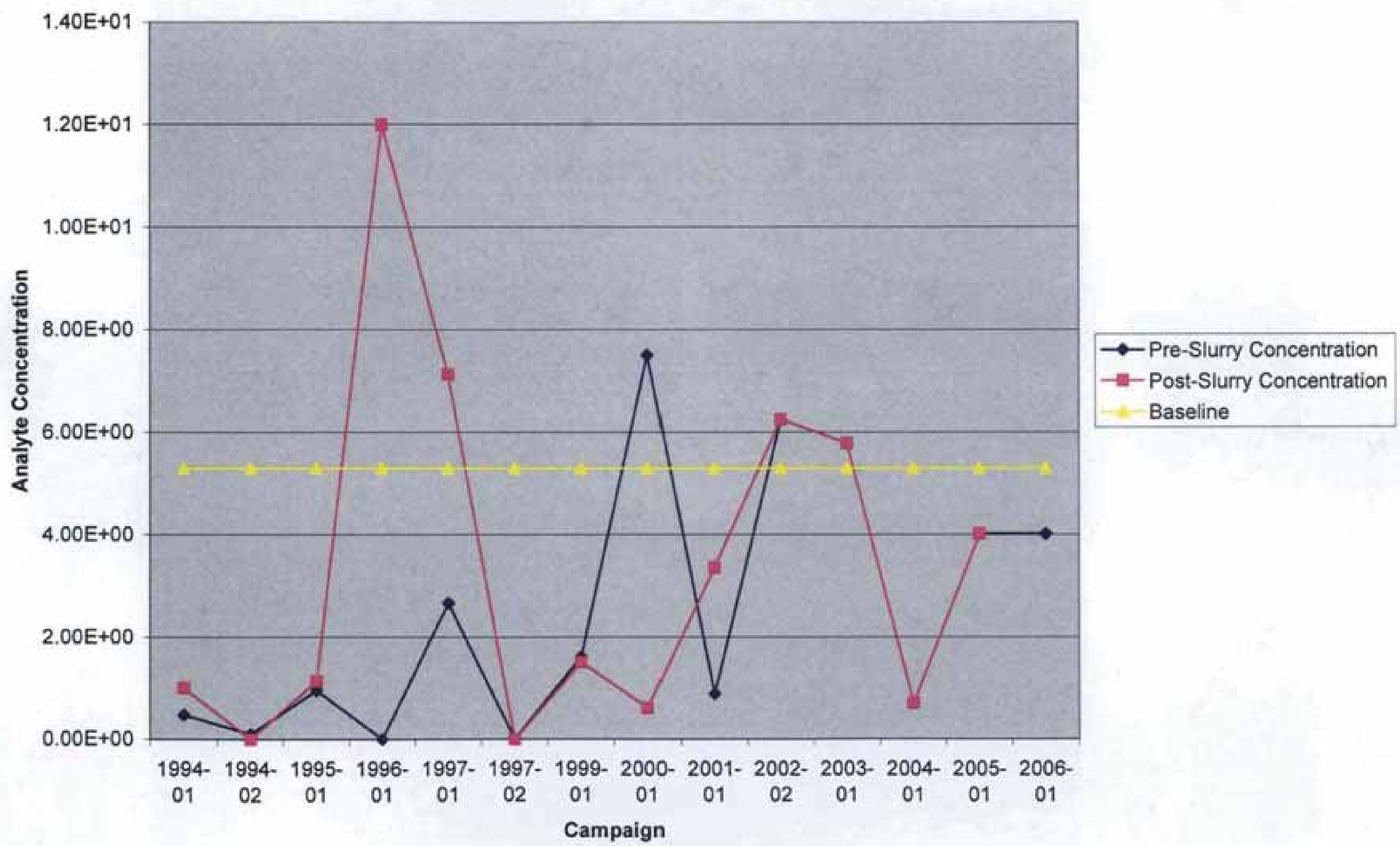


Figure A.3.25 Se Slurry Concentrations

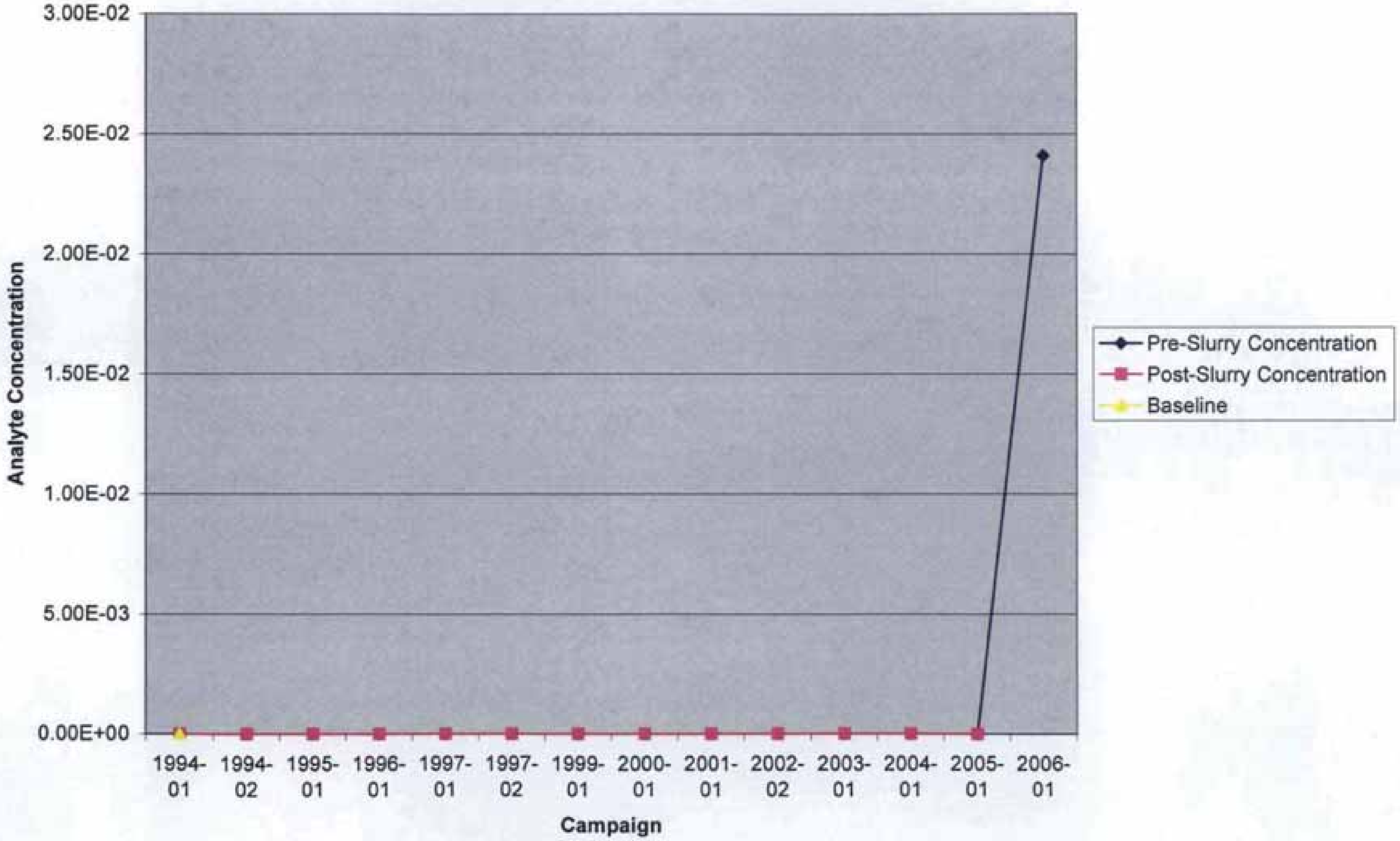


Figure A.3.26 Si Slurry Concentrations

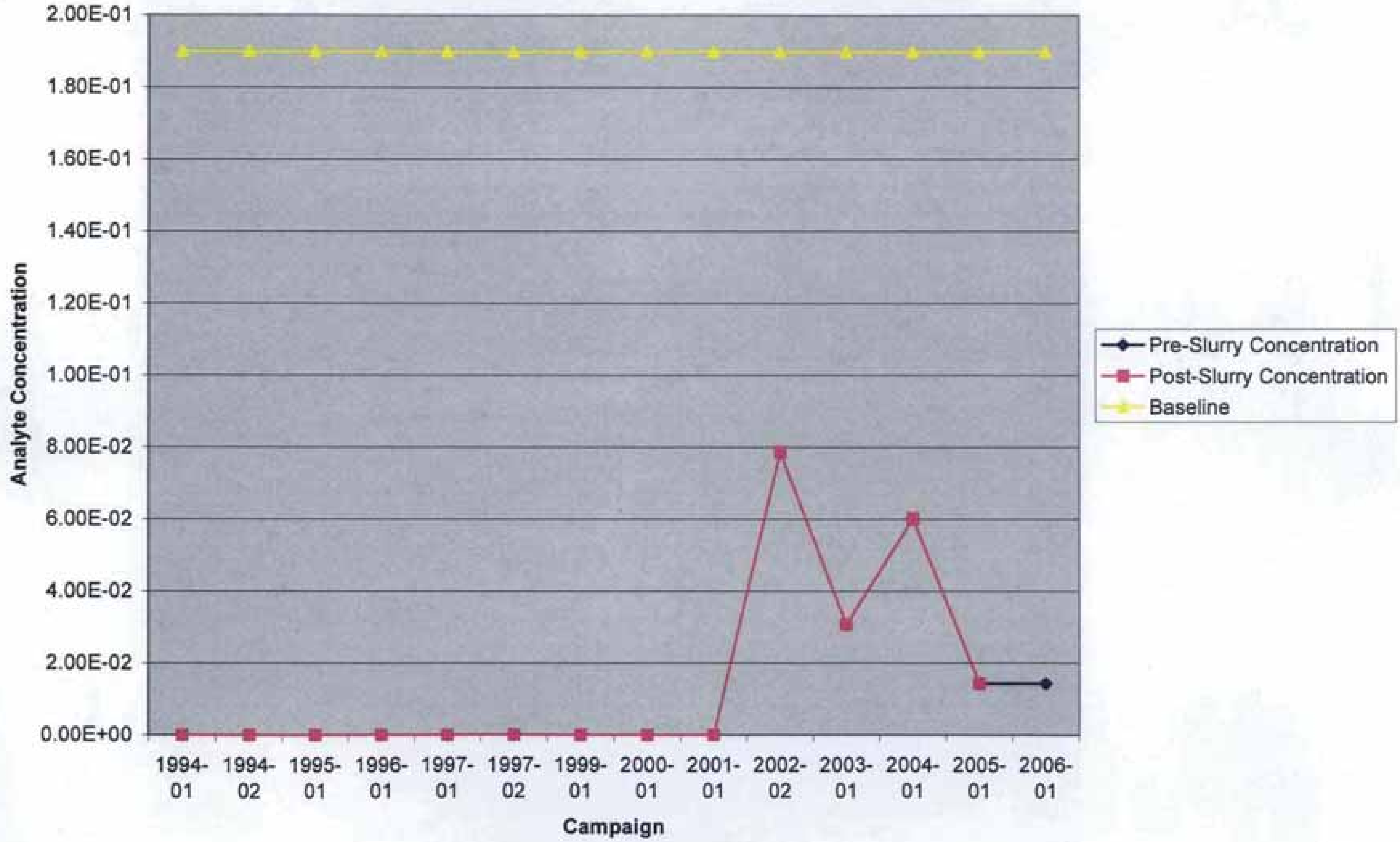


Figure A.3.27 SO4 Slurry Concentrations

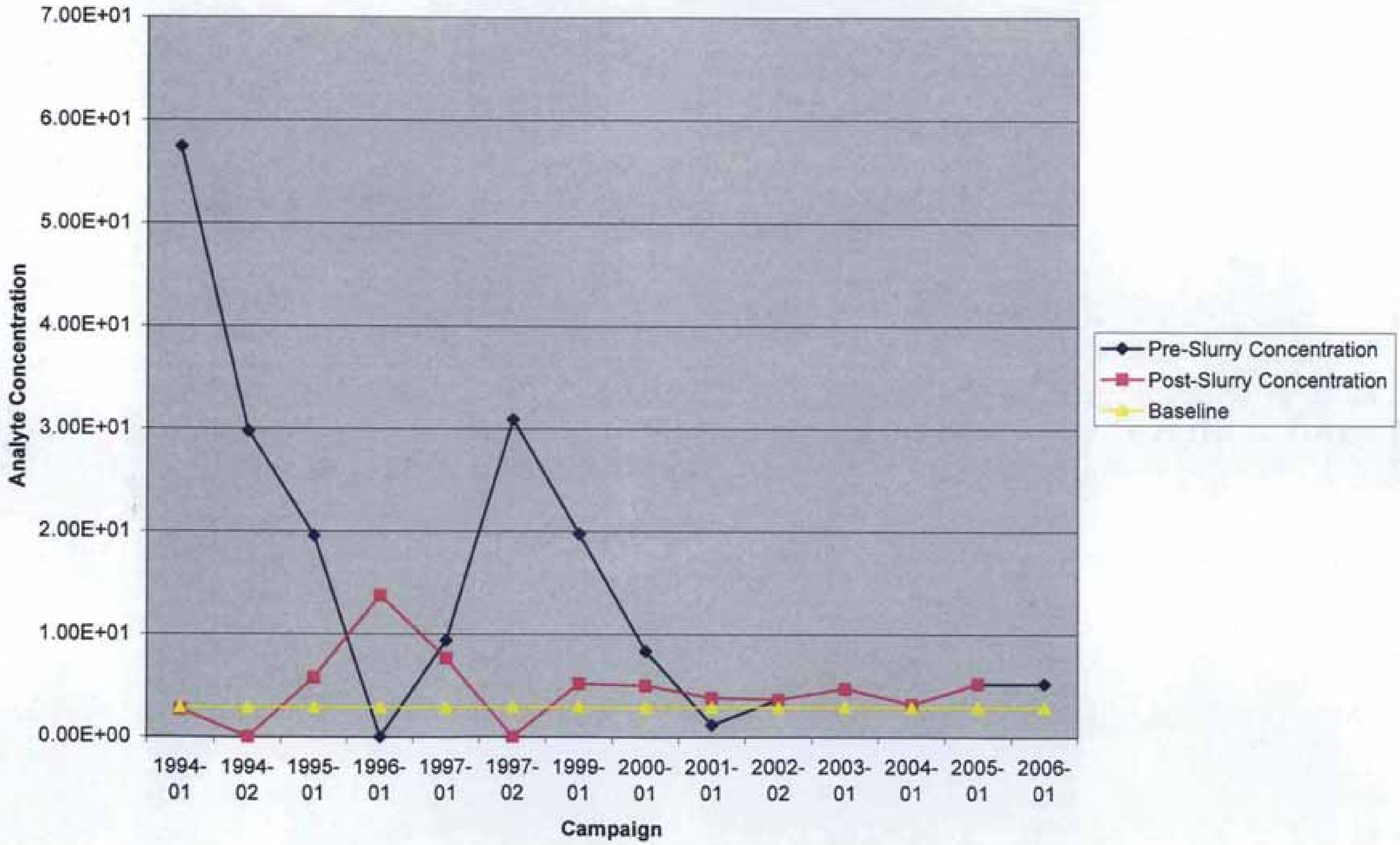


Figure A.3.28 U-235 Slurry Concentrations

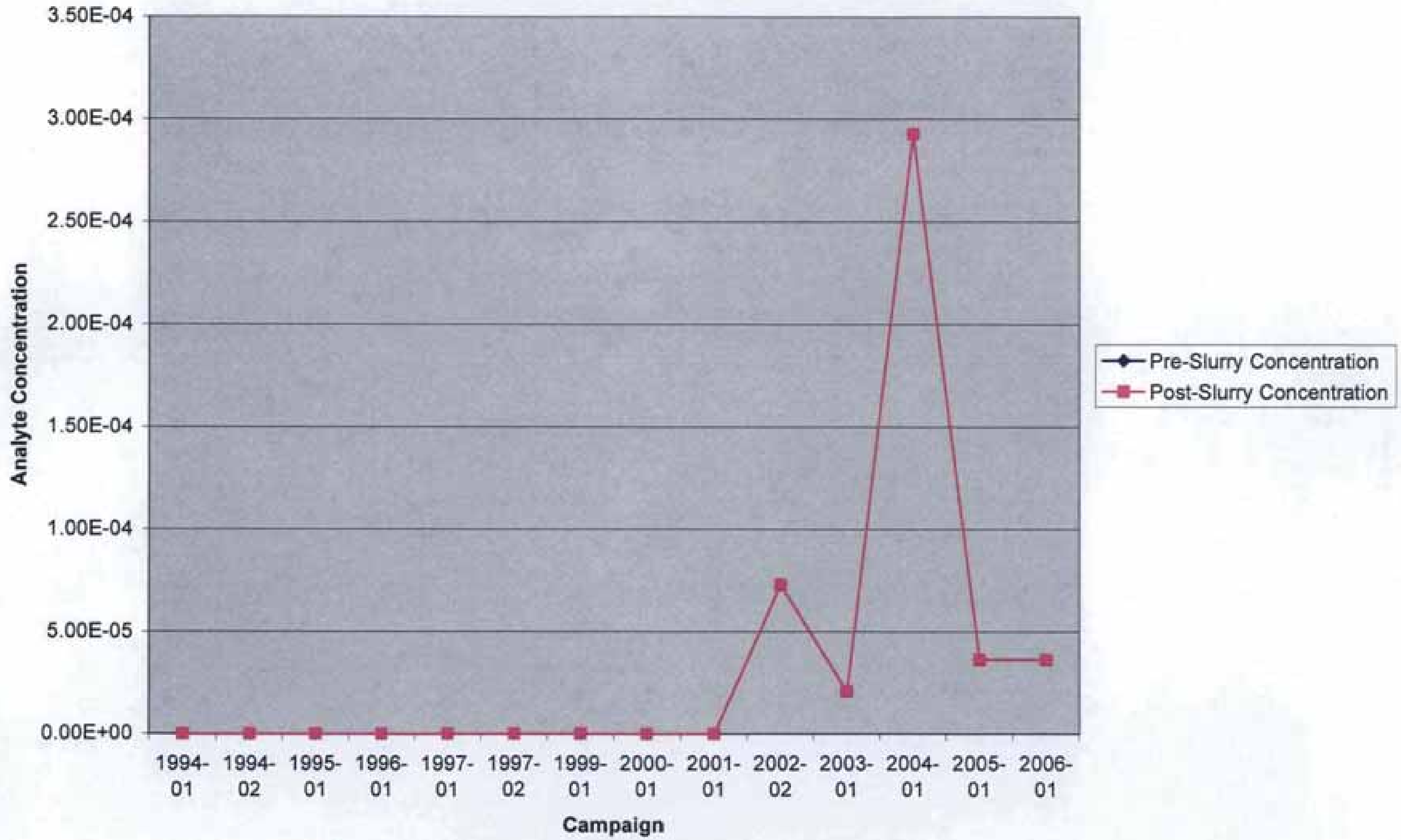


Figure A.3.29 U-238 Slurry Concentrations

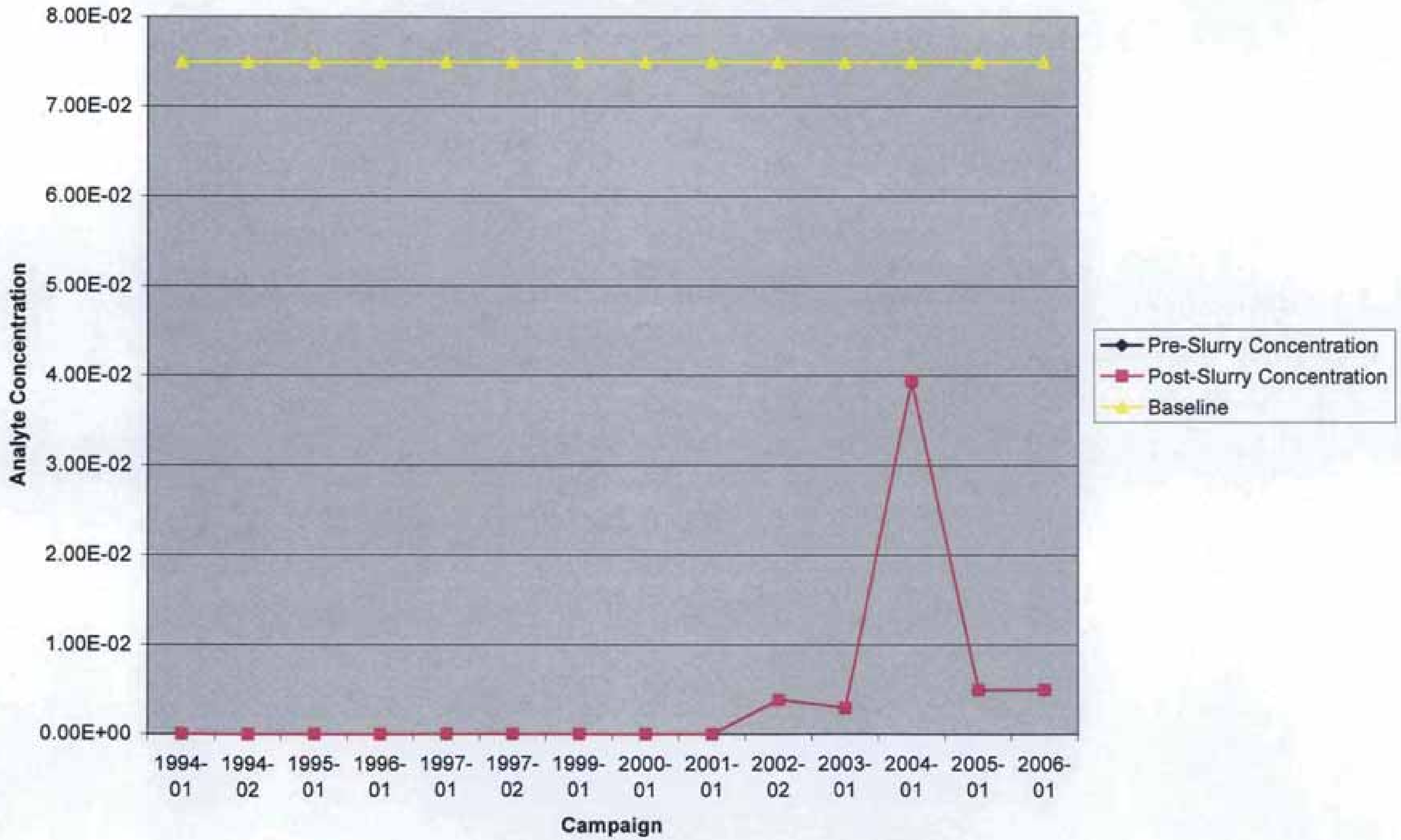


Figure A.3.30 U Slurry Concentrations

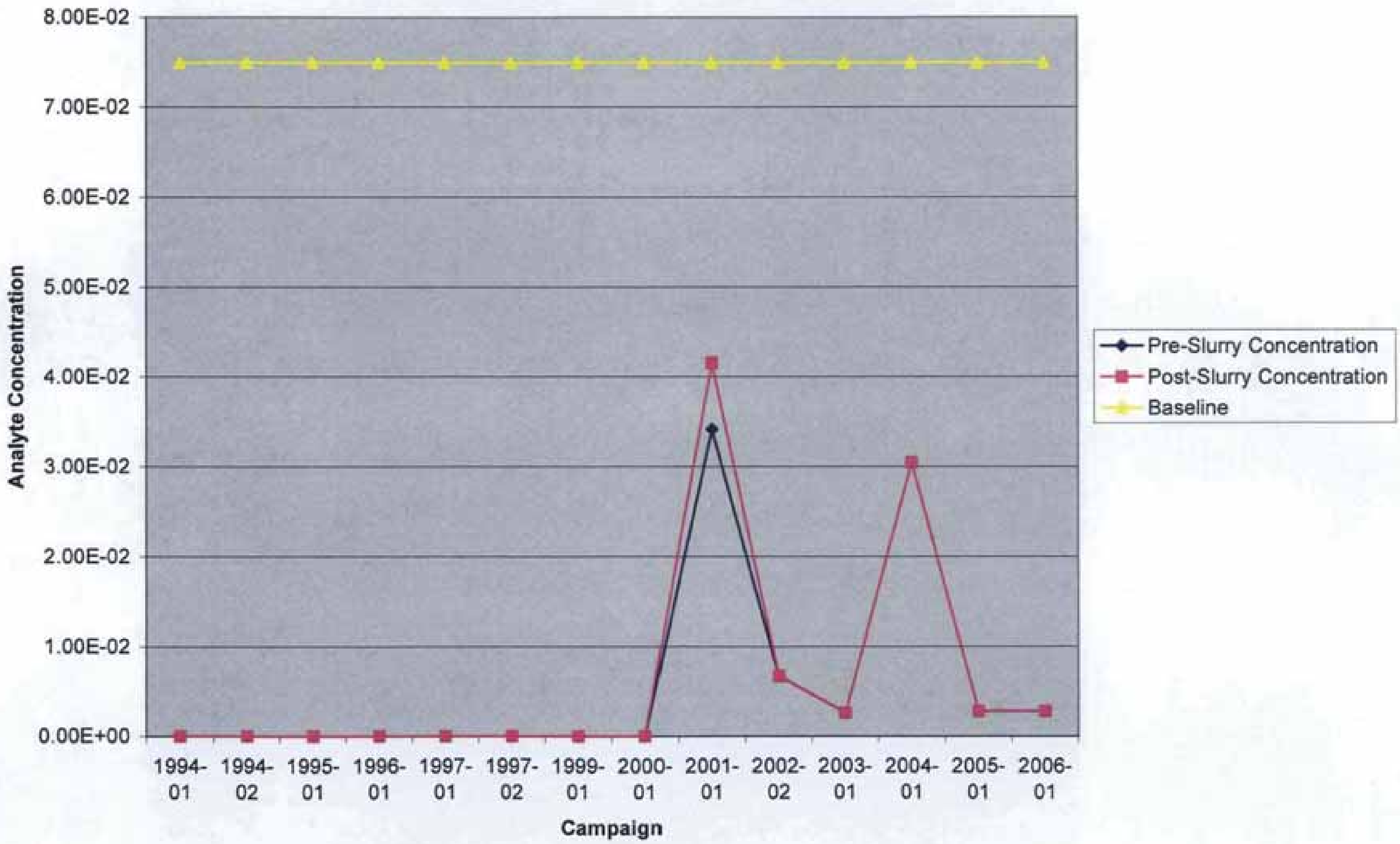


Figure A.3.31 Zr Slurry Concentrations

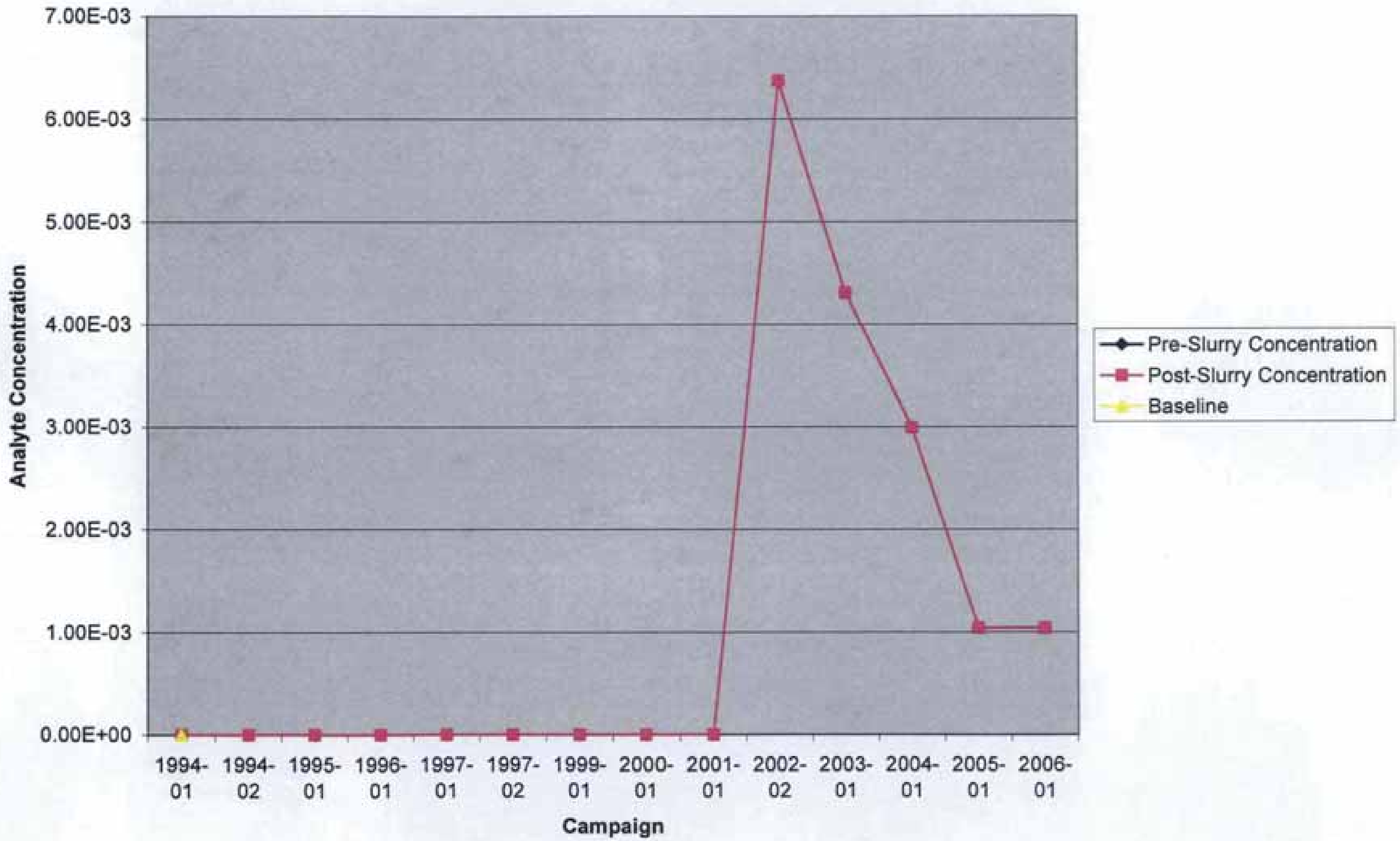


Figure A.3.32 Organic Slurry Concentrations

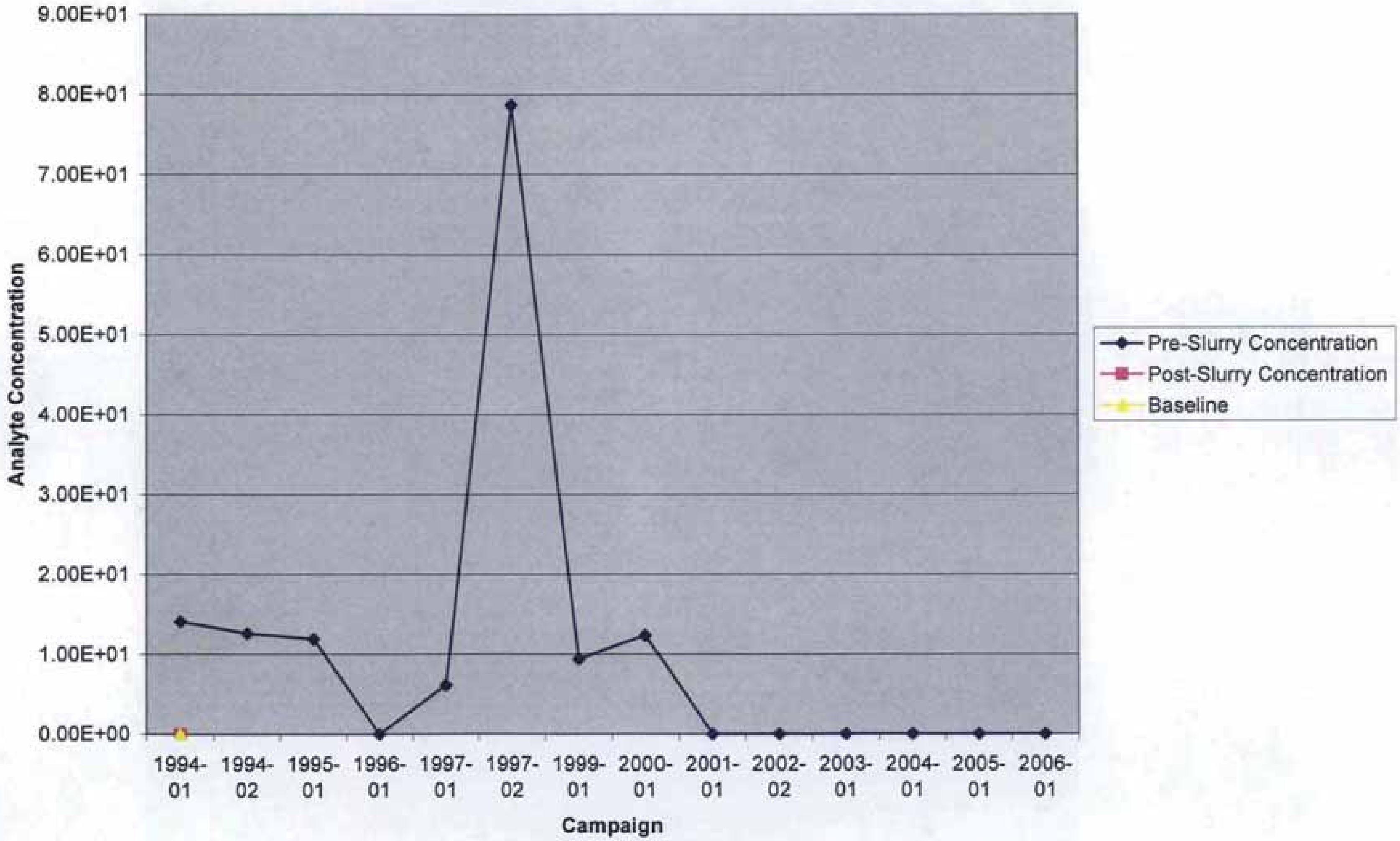


Figure A.3.33 TC Slurry Concentrations

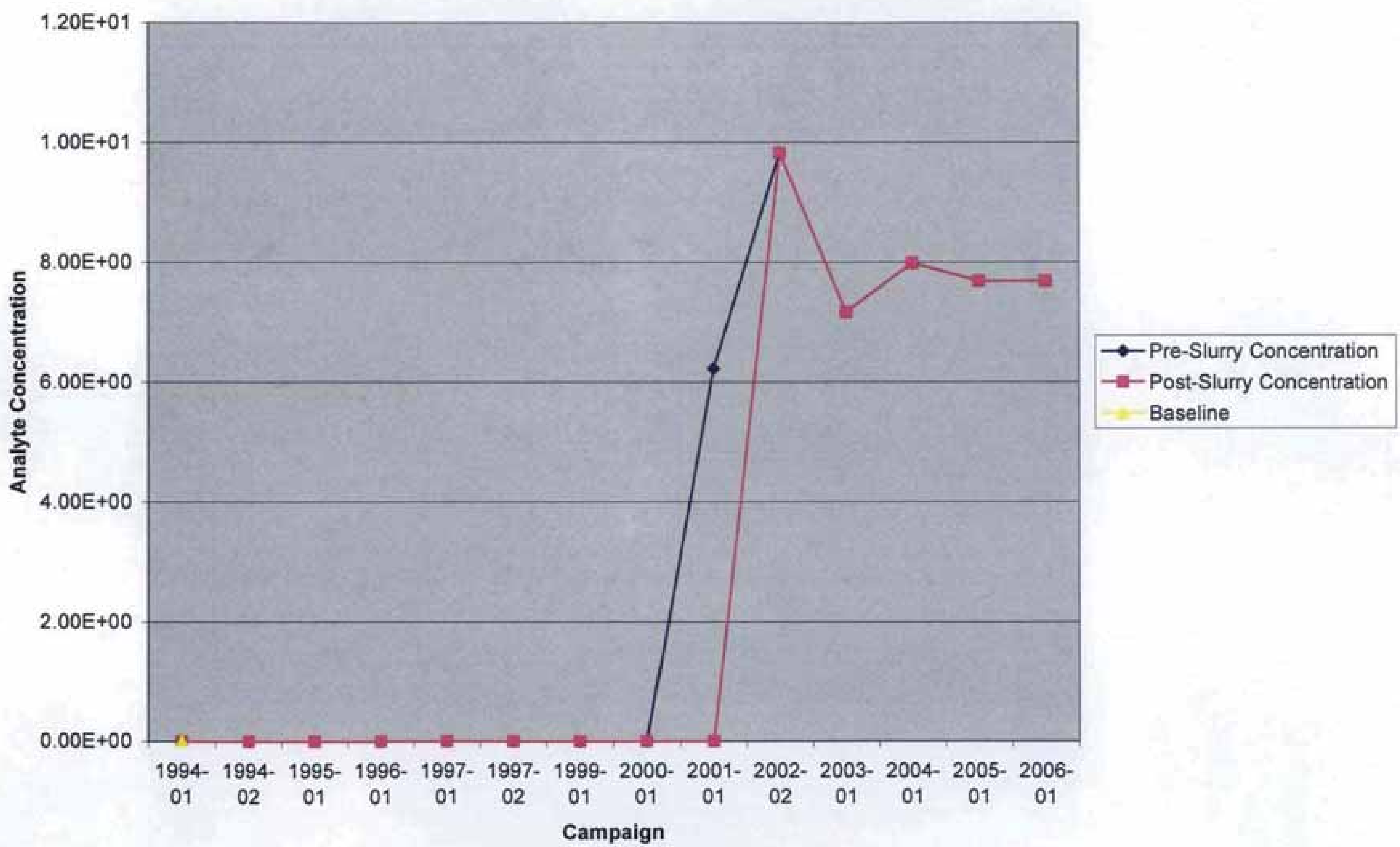


Figure A.3.34 TIC Slurry Concentrations

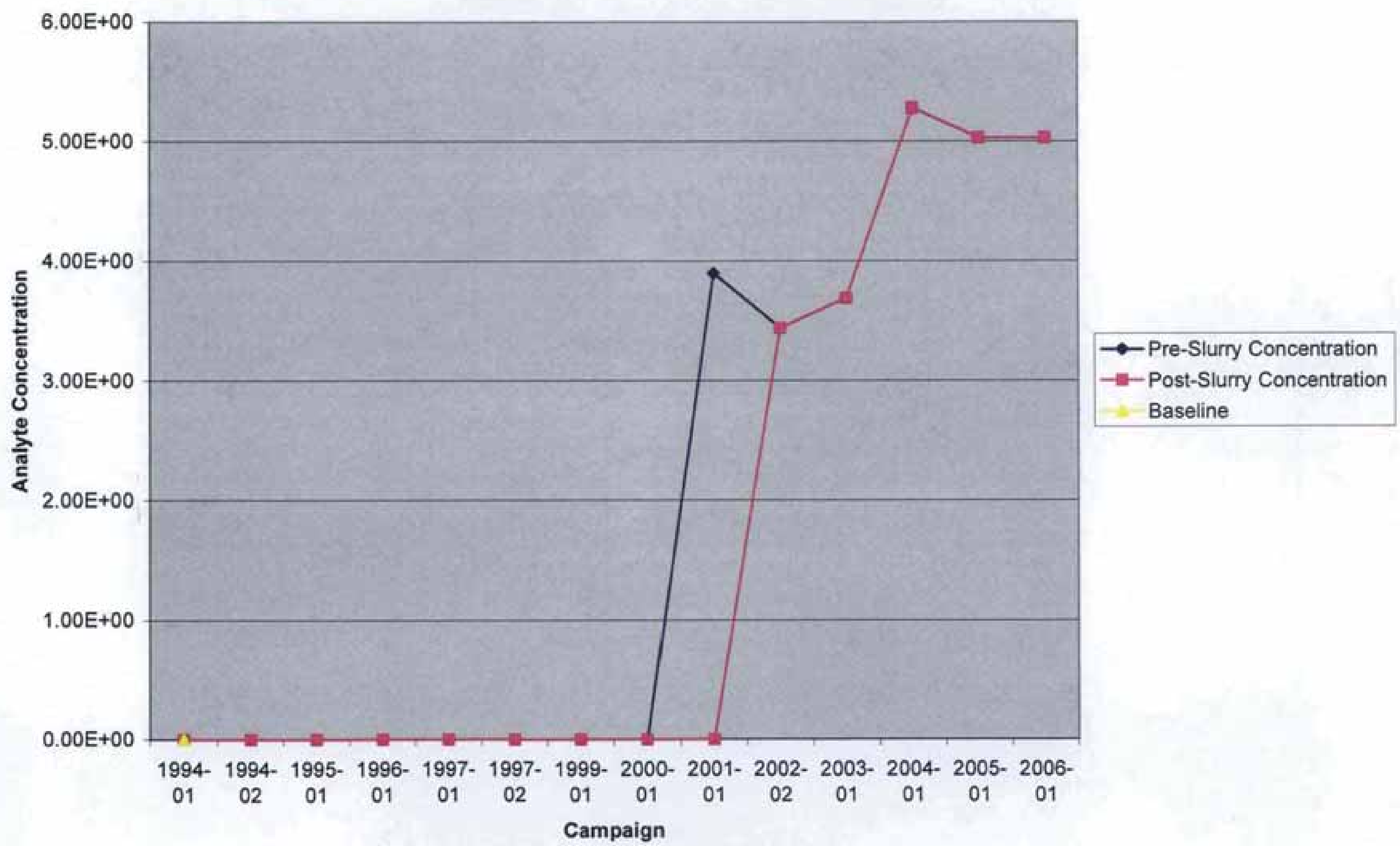


Figure A.3.35 TOC Slurry Concentrations

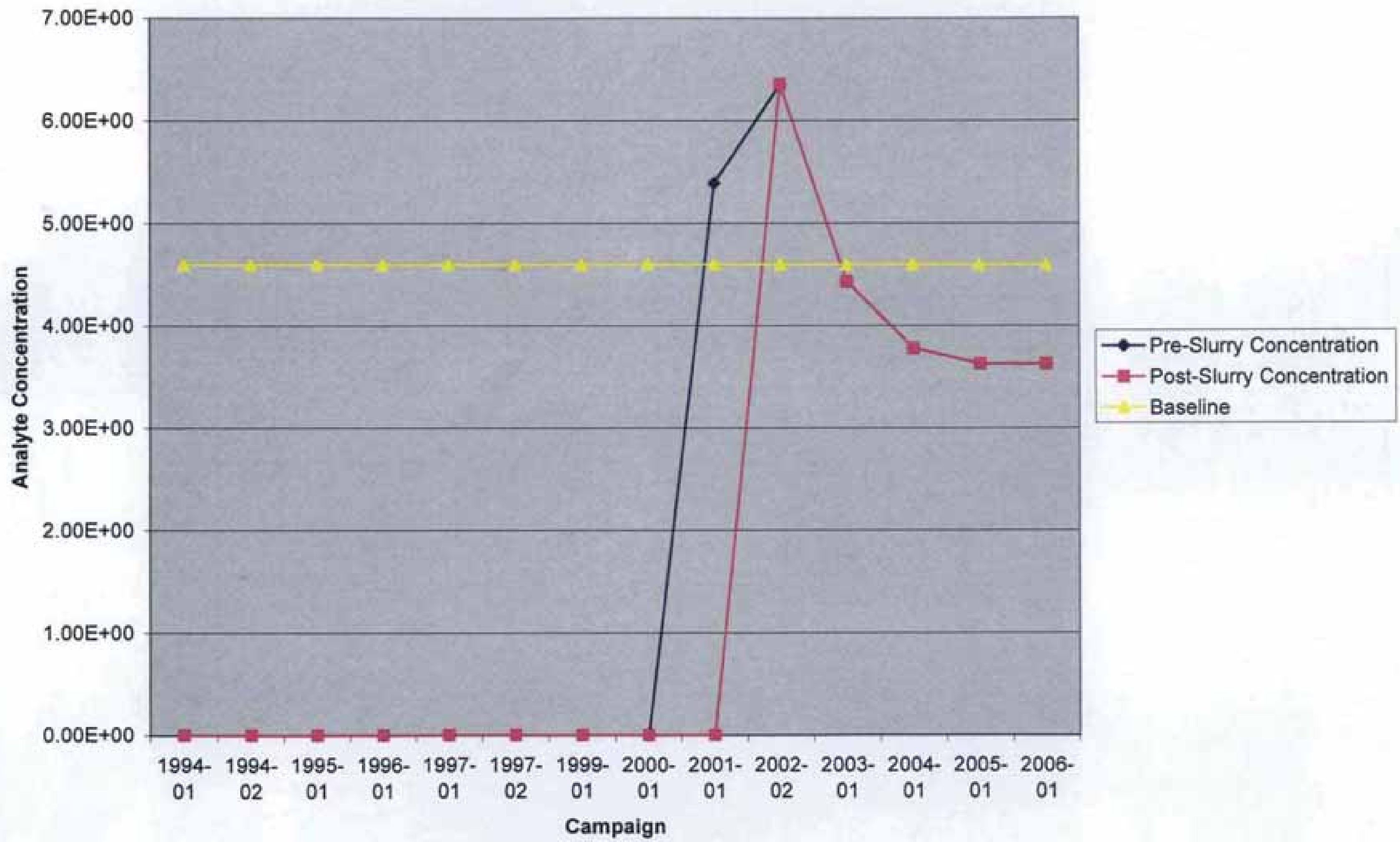


Figure A.3.36 pH Slurry Concentrations

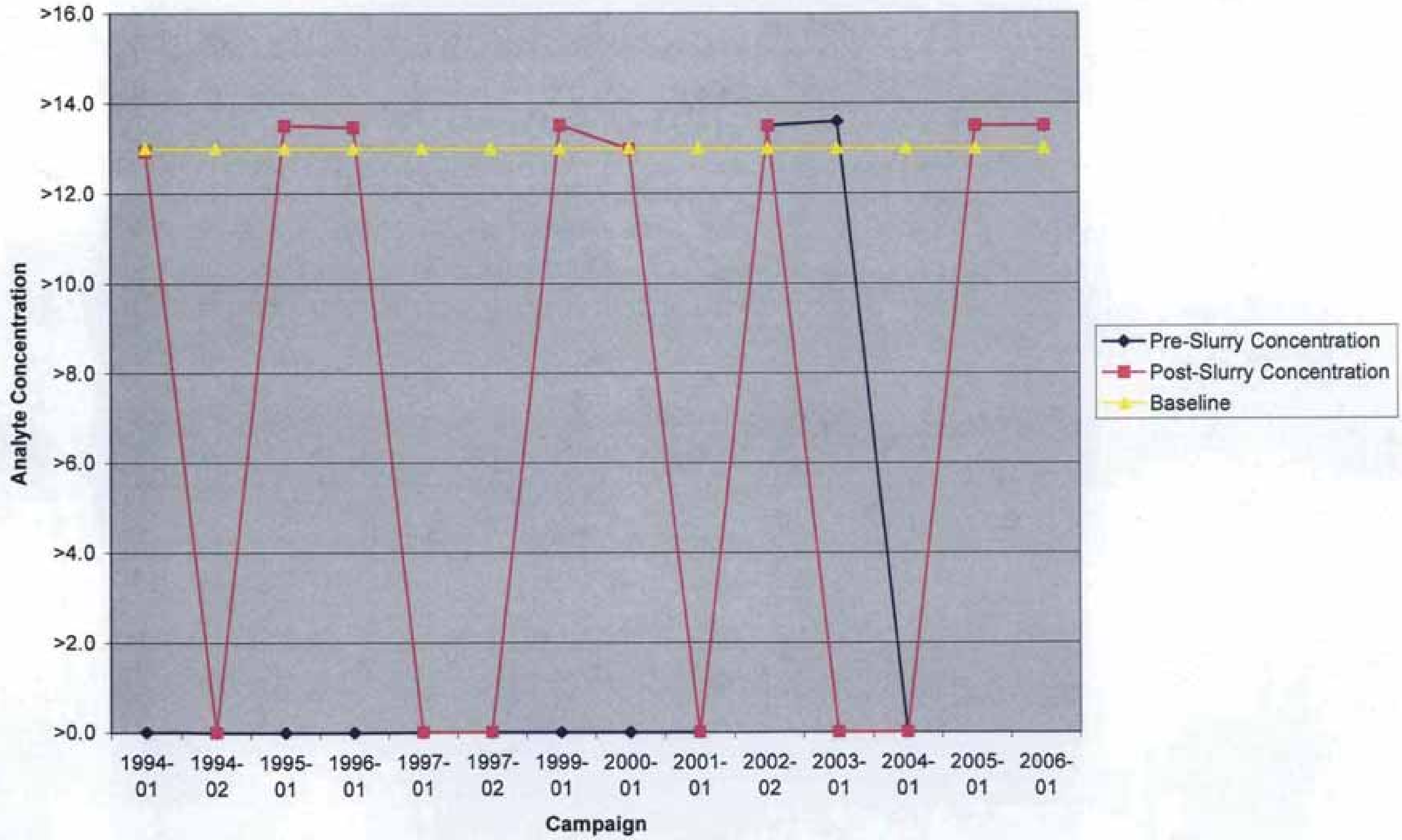


Figure A.3.37 SpG Slurry Concentrations

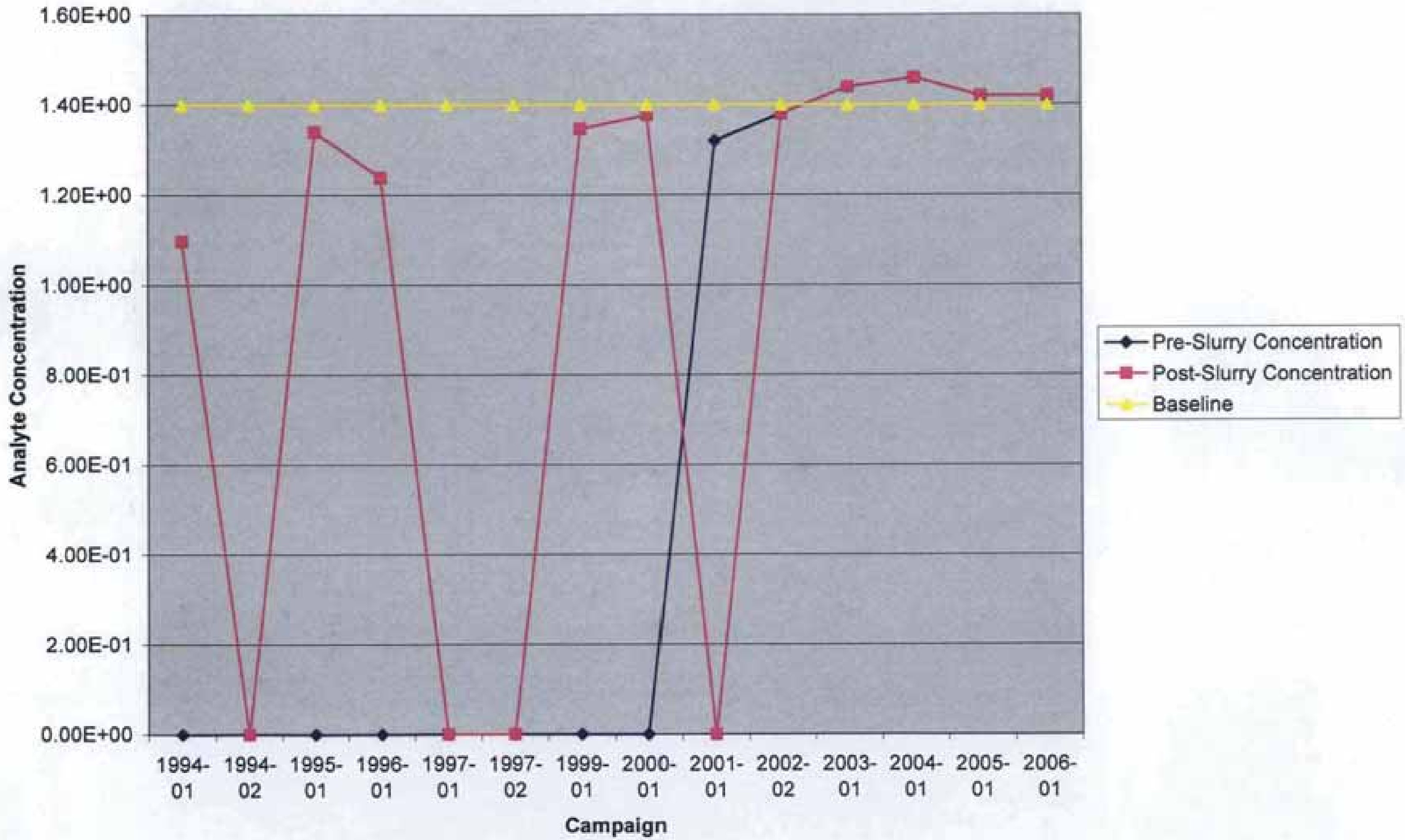
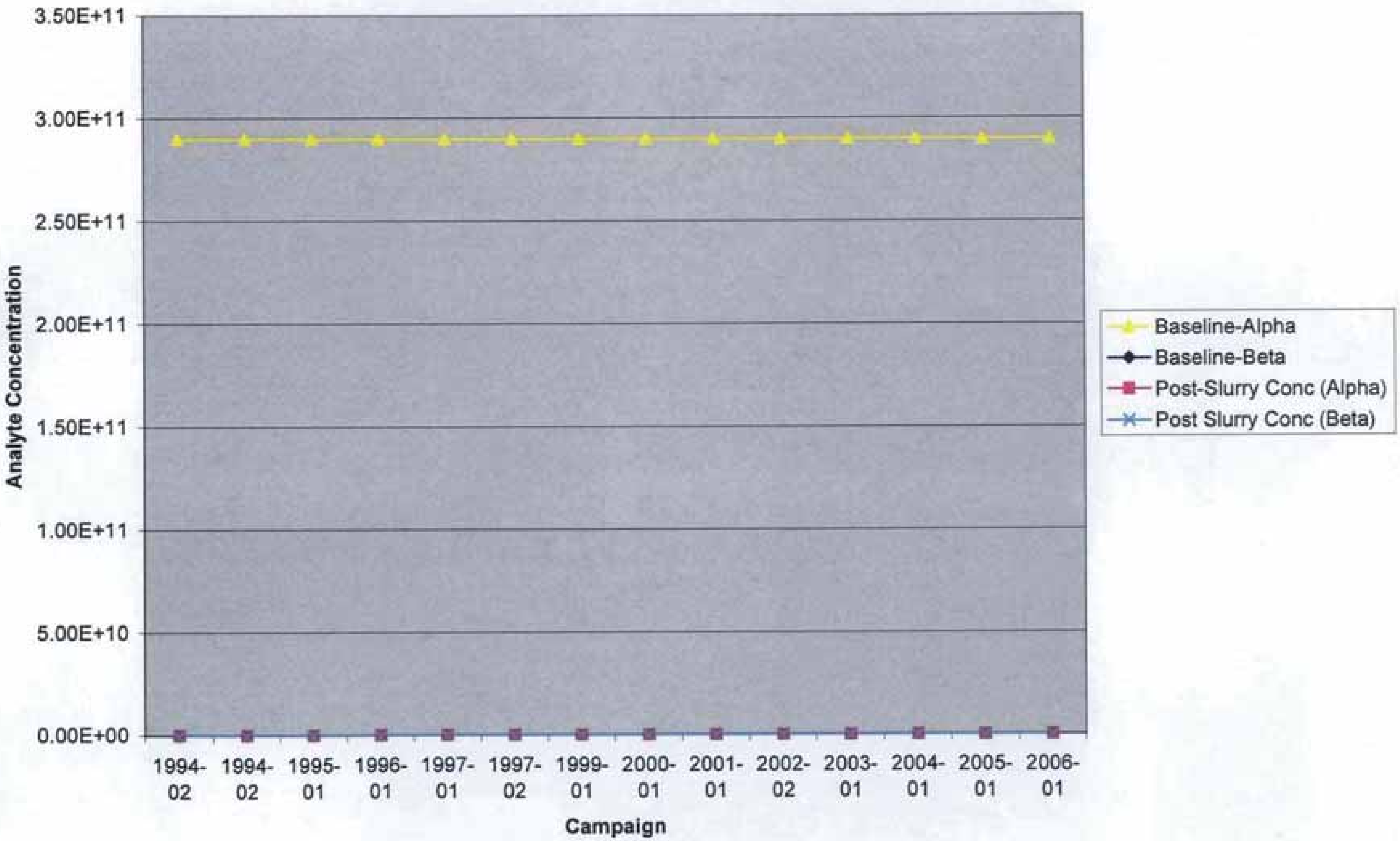


Figure A.3.38 Alpha-Beta Slurry Concentrations



ATTACHMENT 4

TK-C-100

LEAK TESTING PROCEDURES AND TEST RESULTS

(19 Pages)

ATTACHMENT 4A

TK-C-100

2007 HOLD TEST WORK INSTRUCTIONS AND TEST RESULTS

(12 Pages)

RPP WORK RECORD

1. Document Number: WFO-WO-07-1226

2. Work Item Title: 242-A INTEGRITY ASSESSMENT TK-C-100

Date	Turnover, Problem Description, Action Taken	Feed Back (X)	Name	Craft/ Resource Type	Hours
7/2/07	Conducted pre job with Crew to discuss work package, hazards, + controls. Facility Status: Operation Mode. PB-1 is off, Vacuum is off, steam is off to reboiler, liquid level of C-A-1 is 24,061 gallons, C-100 level is 64.3 %. PC-100 pump is 9/s awaiting repairs.		[signature]	FWS	
7/3/07	Verified 6 hour checks completed with no signs of leakage or intrusion, reference data sht 1, Verified once per 4 hour leak checks completed with no signs of leakage on any exposed surfaces, see data sheet 2. QC re-verified and photo's taken of same locations inspected on 7/2/07. QC completed data sheet 3 SAT. Field Work Complete		[signature]	FWS	

Summary by Craft/Resource Type

Craft/Resource Type	Total Hours	Craft/Resource Type	Total Hours

A-6003-243 (11/04)

Work Instructions RECORD COPY

WFO-WO-07-1226
242A INTEGRITY ASSESSMENT – TK-C-100

1.0 SCOPE

[✓] 1.1. Perform Leak Test of TK-C-100 in support of the Integrity Assessment Plan (IAP) for the 242-A Evaporator System. This Integrity Test is being conducted under the overview of an Independent Qualified Registered Professional Engineer (IQRPE). It is not necessary for state inspectors to witness the Integrity Test nor is it necessary to notify the state of the date and time of the test. Results of the leak test will be reported to the Washington State Department of Ecology with the final submittal of the 242-A Integrity Assessment.

[✓] 1.2. The external portions of the components, piping, flanges, and valves will be examined for evidence of leaks in accordance with the guidelines of ASME Section XI. Division 1. class 3 (1989) IWA-5240 "Visual examination (VT-2) and IWD-5000 "System Pressure Tests Visual Examination Methods' (VT-2).

[✓] 1.3. Testing will be performed under the supervision of IQRPE or designated QC Level II Inspector. A QC Level II Inspector shall perform visual inspection of the condensate tank (i.e. inspect the exposed portions of the condensate catch tank and connecting piping).

[✓] 1.4. Water will be the process solution used for testing.

[✓] 1.5. The acceptance criteria for this test are NO detectable leaks.

[✓] 1.6. Work will include:

- Filling of TK- C-100 to a level of approximately 65% as read on WFIC-C100.
- Obtaining weight factor data readings and recording levels hourly during the 24 hour test.
- Visual observations will be conducted and documented every four hours during the 24 hour test.
- Draining TK-C-100 to normal level.
- QC inspection of components to identify possible leaks.
- Taking photographs of components and suspected leak areas.
- IF leaks are observed, follow-up engineering analysis shall be conducted to identify the type and extent of repairs required.

[✓] 1.7. The equipment being worked on is general service (GS).

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[✓] 1.8. In accordance with the guidance contained in TFC-ESHQ-RP_RWP-C-03 "ALARA Work Planning", this task has been determined to be LOW radiological risk. (Ref. RWP TF-001, current rev.)

2.0 LIMITATIONS

[✓] 2.1. This work package will utilize radiological limits and controls specified on RWP TF-001 (Current Rev).

3.0 PREREQUISITES

[✓] 3.1. **CONDUCT** a Pre-Job Briefing and review the applicable Job Hazards, Limitations and Precautions sections.

[✓] 3.2. A preliminary review of the test location shall be performed to generalize the condition of that particular area from the initial walk downs report and photographs.

[✓] 3.3. A photograph of each test location shall be taken in order to illustrate the general test location per Attachment B-2.

[✓] 3.4. Ensure Process Condensate is not being utilized for seal water or other process.

[✓] 3.5. Below is a non-inclusive list of materials and equipment to be staged:

- Flashlights
- Radios
- Camera and supporting equipment.

NOTE - This note applies to section 4.0. Ensure Prerequisites have been completed. MULTIPLE ENTRIES may be performed.

4.0 SPECIFIC WORK INSTRUCTIONS

[✓] 4.1. **NOTIFY** Shift Manager (373-4446) Leak test of TK-C-100 is starting.

[✓] 4.2. **ENSURE** that P-C100 CONDSATE TANK PUMP status is CF-OFF:

[✓] 4.2.1. **SELECT** P-C100 (G18/7, F23)

[✓] 4.2.2. **IF** P-C100 status is NOT CF-OFF, **PRESS** CMD 0 twice to shut down the pump **AND**

CHECK that P-C100 status changes to CF-OFF.

[✓] 4.3. **POSITION** the valves as listed in Attachment 1 in the order given.

[✓] 4.4. **OPEN** valve 2-35 to start raw water flow to TK-C-100

[✓] 4.5. **AFTER** TK-C-100 has reached a minimum of 65%, **CLOSE** valve 2-35 to stop Raw Water flow to TK-C-100.

NOTE: After the tank is filled to test level, it must be left at this condition for a minimum of 24 hours. The liquid level should remain constant throughout the 24 hour hold period and no additional liquid should be required to maintain the level. Small erratic up and down variations in liquid level indication may be due to expansion and contraction due to temperature changes. This would not be cause for concern. However, a slow steady downward trend in level is more likely to be indicative of a leak.

[✓] 4.6. **RECORD** date/time and initial level of TK-C-100 at the start of the 24 hour hold period as read on WFIC-C100 and document on Data Sheet 1.

[✓] 4.6.1. QAT VERIFY starting level of TK-C-100.

7-02-07 / 09:50 _[signature]_ 70.

Date/ Time CH2M HILL QAT Signature Level

[✓]4.6.2. **RECORD** weight factor data reading hourly by monitoring WFIC-C100 and record on Data Sheet 1.

[✓]4.6.2.1. **IF** the water level begins to drop noticeably, notify the 242-A System Engineer so an evaluation of the situation may be performed. The System Engineer shall decide whether to continue with the leak test.

[✓]4.6.2.2. Leak Criteria:

Decreasing trend in TK-C-100 as read on WFIC-C100 level of 1% or more during the 24 hour hold period.

And

- Any visual evidence of a leak discovered during an inspection of the tank and condenser room floor.

[✓]4.6.3. **CONDUCT** Visual observations every four hours during the hold period to determine if leaks are visible or whether liquid is accumulating on the floor of the condenser room, on the pipes, or equipment. Results will be recorded on the four hour visual inspection Data Sheet 2.

[✓]4.6.4. **IF** no leak is visually verified and the level is still decreasing, additional isolation valves shall be closed per SOM direction to verify integrity and determine if valves are leaking.

[✓] 4.7. **AFTER** a minimum of 24 hours steady state, QC Level II Inspector will inspect the exposed portions of TK-C-100 and connecting piping looking for any leaks by performing the following:

[✓]4.7.1. **EXAMINE** external accessible areas of the tank paying particular attention to the welds, joints, and seams.

[✓]4.7.2. **EXAMINE** external accessible areas of the pipe surfaces next to structural supports for evidence of wear caused by vibration.

[✓]4.7.3. **EXAMINE** the bottom side of the tank TK-C-100 with the associated drain line.

[✓] 4.7.4. **PHOTOGRAPH** areas/items as identified in Attachment B-2.

[✓] 4.7.4.1. **ENSURE** photographs are taken which clearly show any source of leak and its location.

[✓] 4.7.5. **COMPLETE** Data Sheet 3 with visual inspection results

[✓] 4.8. **AFTER** completion of the visual examination, the 242-A System Engineer shall review the observations and ACCEPT or REJECT the results as identified by signature on Data Sheet 3.

5.0 POST MAINTENANCE TESTING

N/A

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NOTE - Steps in section 6.0 may be worked concurrently.

6.0 RESTORATION ACTIONS

[ ] 6.1. FWS Ensure documentation and any picture files are forwarded to Al Friberg (376-1190) OR Rob Dale (373-9207).

[ ] 6.2. FWS to review work package for trends and lessons learned. Conduct a Post Job Review on all fieldwork and mark "X" in Feedback block on work record, where appropriate.

[ ] 6.3. Closeout review.

Attachment 1

CHECK	VALVE	POSITION	FUNCTION
✓	1-3	CLOSE	Tank C-100 Drain
✓	1-3A	CLOSE	Tank C-100 Drain
✓	1-2	CLOSE	Seal Loop Drain
✓	1-5	CLOSE	Tank C-100 Drain to Funnel
✓	1-6	OPEN	Seal Loop Sight Glass Isolation
✓	1-7	OPEN	Seal Loop Sight Glass Isolation
✓	1-8	CLOSE	C-100 Inlet to Pump
✓	1-9	CLOSE	C-100 Outlet from Pump
✓	2-33	CLOSE	PC to LERF
✓	2-35	CLOSE	RW to PC Line
✓	HV-RC3-3	DIVERT	PC to LERF Diversion Valve
✓	1-16	CLOSE	PC to C-100
✓	1-17	OPEN	PC to 241-AW-102
✓	1-18	OPEN	PCV-RC3-1 Isolation
✓	1-19	CLOSE	PCV-RC3-1 Bypass
✓	1-20	OPEN	PCV-RC3-1 Pressure Control
✓	1-21	CLOSE	PCV-RC3-1 Isolation
✓	1-27	CLOSE	AFPC Return from Sampler
✓	1-28	CLOSE	PC Flow Path
✓	1-29	CLOSE	PC Line to RC3 Sampler
✓	2-32	CLOSE	Flex Hose Isolation
✓	2-36	CLOSE	TK-E-101 to PC Line
✓	1-26A	CLOSE	Sample Isolation

Work Instructions

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DATA SHEET 1

Date	Time	Tank Weight Factor WFIC-C100	Recorded By
7-2-07	0950	70.582	KFA (initial)
7-2-07	1050	70.410	KFA
7-2-07	1150	70.427	KFA
7-2-07	1250	70.457	KFA
7-2-07	1350	70.45	KFA
7-2-07	1450	70.478	KFA
7-2-07	1550	70.488	KFA
7-2-07	1650	70.490	KFA
7-2-07	1750	70.500	KFA
7-2-07	1850	70.502	KJY
7-2-07	1950	70.505	KJY
7-2-07	2050	70.512	RS / KJY
7-2-07	2150	70.530	KJY
7-2-07	2250	70.530	KJY
7-2-07	2350	70.531	RS / KJY
7-3-07	0050	70.541	KJY
7-3-07	0150	70.523	KJY
7-3-07	0250	~~70.54~~ 70.522	KJY
7-3-07	0350	70.524	KJY
7-3-07	0450	70.536	KJY
7-3-07	0550	70.54	KJY
7-3-07	0650	70.51	KFA
7-3-07	0750	70.52	AbA
7-3-07	0850	70.53	AbA
7-3-07	0950	70.52	AbA

Work Instructions

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DATA SHEI

Date	Time	Visual Observation	Recorded By
7-2-07	0900	No lea	A. G. Hammack
7/2/07	1300	No leaks	Rob Phipps
7/2/07	1700	No leak	Rob Phipps
7/2/07	2100	NO LEA	[illegible]
7/3/0	0100	NO LEA	[illegible]
7/3/0	0500	NO LEAK	[illegible]
7/3/07	0900	No le	Rob Phipps

Work Instructions

RECORD COPY

DATA SHEET 3

TK-C-100 LEAK TEST VISUAL ISPECTION

Time and date when Vessel was filled: 0940 7/2/07

Time and Date when inspection began: 0950 7/2/07

(1) Shell of tank:

NO LEAKS

(2) Connections to tank:

(2.1) To P-C100 isolation valve

NO LEAKS

(2.2) To Tank Drain Valve:

NO LEAKS

Operations Manager: [signature] EA.5

QC Inspectors: RON COWGILL [signature]

Comments:

✓ System and components are acceptable based on the inspe
No further evaluation is required.

System and components require further evaluation.
Reference:

242-A System Engineer: [signature]

QC Level II Inspector: [signature] @ 10:10 AM

ATTACHMENT 4B

TK-C-100

2007 HOLD TEST DATA EVALUATION

(6 Pages)

Attachment 4B

TK-C-100 2007 Hold Test Evaluation

This leak test was conducted with the same criterion as the 1993 and 1998 integrity assessment. The leak test for TK-C-100 was conducted on July 02, 2007 following the work instructions in WFO-WO-07-1226 for the 242-A Integrity Assessment, TK-C-100 (Attachment 3). Liquid levels in the tank TK-C-100 were recorded hourly by observing the weight factor from WFIC-C100 level indicator. Visual inspection was performed every 4 hours on the shell of TK-C-100 and connections to the tank:

(1) To P-C100 isolation valve
(2) To tank drain valve.

Test results and visual inspection data sheets showed no detectable leak from the TK-C-100 condensate collection tank (Attachment 4A). The leak test duration was 24 hours and the result was that the system passed the test on the first attempt.

The tank was filled to 64.3% of full. Plan was to fill the tank to approximately 65% per WFO-WO-07-1226.

Data from the 2007 hold test is tabulated in Table 4B.1. Data is shown as both raw weight factor data as collected by field personnel and as converted to gallons using weight factor conversions (see also Table 4B.2). A review of 2007 hold test data (Table 4B.1) indicates that the tank level appears to increase from an initial level of 11730.412 gallons at 9:50 AM on July 2, 2007 and reaches an apparent baseline of approximately 11753.5 gallons, +/- 2.5 gallons at 8:50 PM on July 2, 2007. The tank remains at this level for the remainder of the test (see Figure 4B.1). While this represents an apparent gain of approximately 23 gallons, it represents an increase in weight factor measurement of only 0.16. This is well within the expected accuracy of this instrumentation, which is accurate to within +/- 0.5 inch. Therefore, the apparent increase is attributable either or both of the following effects: (1) instrumentation drift; (2) equilibrating pressure within the tank affecting initial weight factor readings.

Finally, the context of the 2007 test is seen in Figure 4B.2, where it is trended together with the 1993 and 1998 hold tests. In this context, it can be seen the data from each hold test are very similar, as well as that data from all three Integrity Assessments are comparatively flat and change very little during the duration of each hold test.

TABLE 4B.1
2007 TK-C-100 Hold Test

Date	Time	Tank WF	Gallons
7/2/07	9:50	70.382	11730.41
7/2/07	10:50	70.410	11735.06
7/2/07	11:50	70.427	11737.88
7/2/07	12:50	70.457	11742.86
7/2/07	13:50	70.45	11741.7
7/2/07	14:50	70.478	11746.35
7/2/07	15:50	70.488	11748.01
7/2/07	16:50	70.490	11748.34
7/2/07	17:50	70.500	11750
7/2/07	18:50	70.502	11750.33
7/2/07	19:50	70.505	11750.83
7/2/07	20:50	70.512	11751.99
7/2/07	21:50	70.530	11754.98
7/2/07	22:50	70.530	11754.98
7/2/07	23:50	70.531	11755.15
7/3/07	0:50	70.541	11756.81
7/3/07	1:50	70.523	11753.82
7/3/07	2:50	70.522	11753.65
7/3/07	3:50	70.524	11753.98
7/3/07	4:50	70.536	11755.98
7/3/07	5:50	70.54	11756.64
7/3/07	6:50	70.51	11751.66
7/3/07	7:50	70.52	11753.32
7/3/07	8:50	70.53	11754.98
7/3/07	9:50	70.52	11753.32

TABLE 4B.2
WEIGHT FACTOR - GALLON CONVERSIONS

Weight Factor (inch)	Gallons	Weight Factor (inch)	Gallons	
0	0	49	8167	
1	167	50	8333	
2	333	51	8500	
3	500	52	8667	
4	667	53	8833	
5	833	54	9000	
6	1000	55	9167	
7	1167	56	9333	
8	1333	57	9500	
9	1500	58	9667	
10	1667	59	9833	
11	1833	60	10000	
12	2000	61	10167	
13	2167	62	10333	
14	2333	63	10500	
15	2500	64	10667	
16	2667	65	10833	
17	2833	66	11000	
18	3000	67	11167	
19	3167	68	11333	
20	3333	69	11500	
21	3500	70	11667	
22	3667	71	11833	
23	3833	72	12000	
24	4000	73	12167	
25	4167	74	12333	
26	4333	75	12500	
27	4500	76	12667	
28	4667	77	12833	
29	4833	78	13000	
30	5000	79	13167	
31	5167	80	13333	
32	5333	81	13500	
33	5500	82	13667	
34	5667	83	13833	
35	5833	84	14000	
36	6000	85	14167	
37	6167	86	14333	
38	6333	87	14500	
39	6500	88	14667	
40	6667	89	14833	
41	6833	90	15000	
42	7000	91	15167	
43	7167	92	15333	
44	7333	93	15500	
45	7500	94	15667	
46	7667	95	15833	
47	7833	96	16006	overflow
48	8000			

Figure 4B.1 - 2007 IA TK-C-100 Hold Test

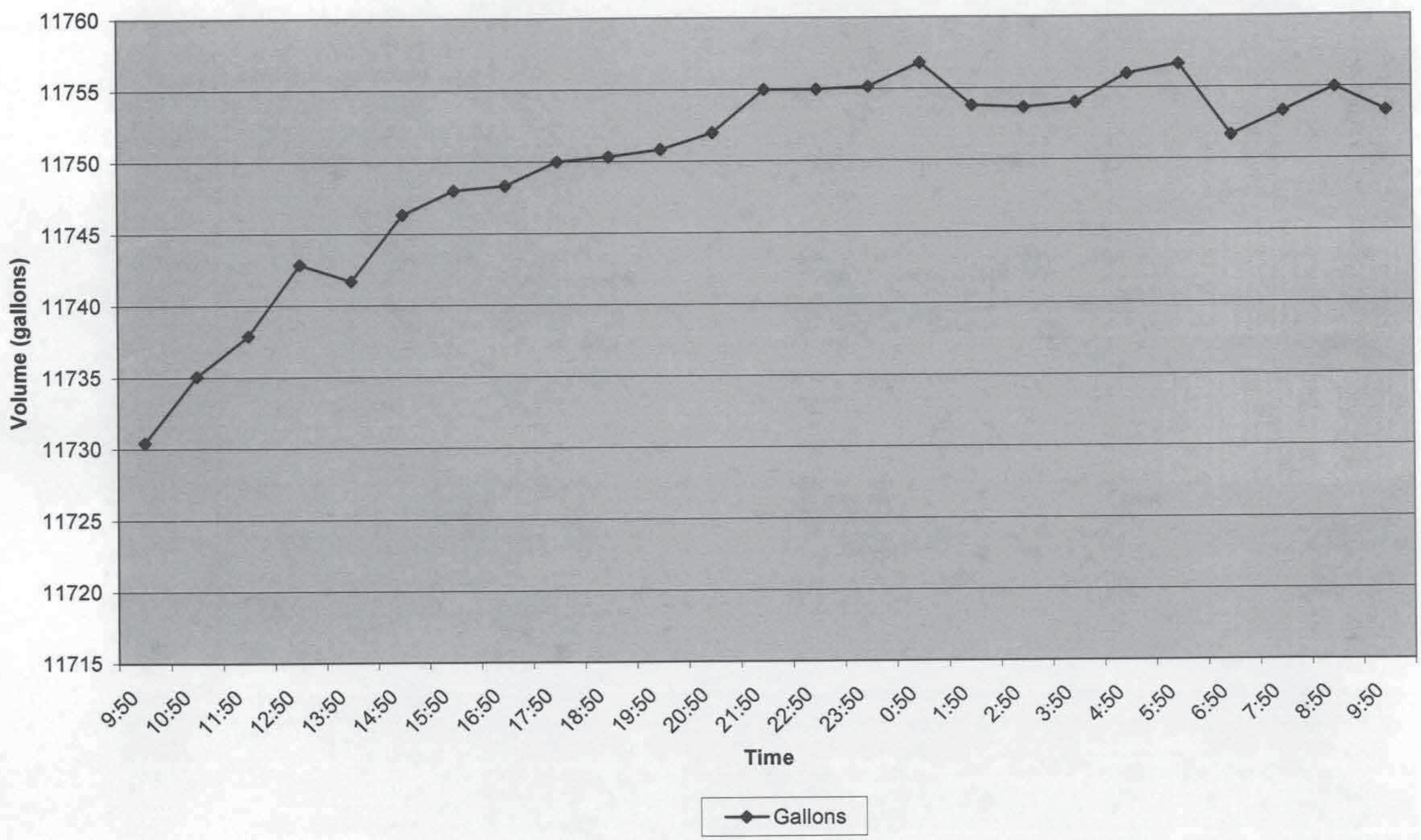
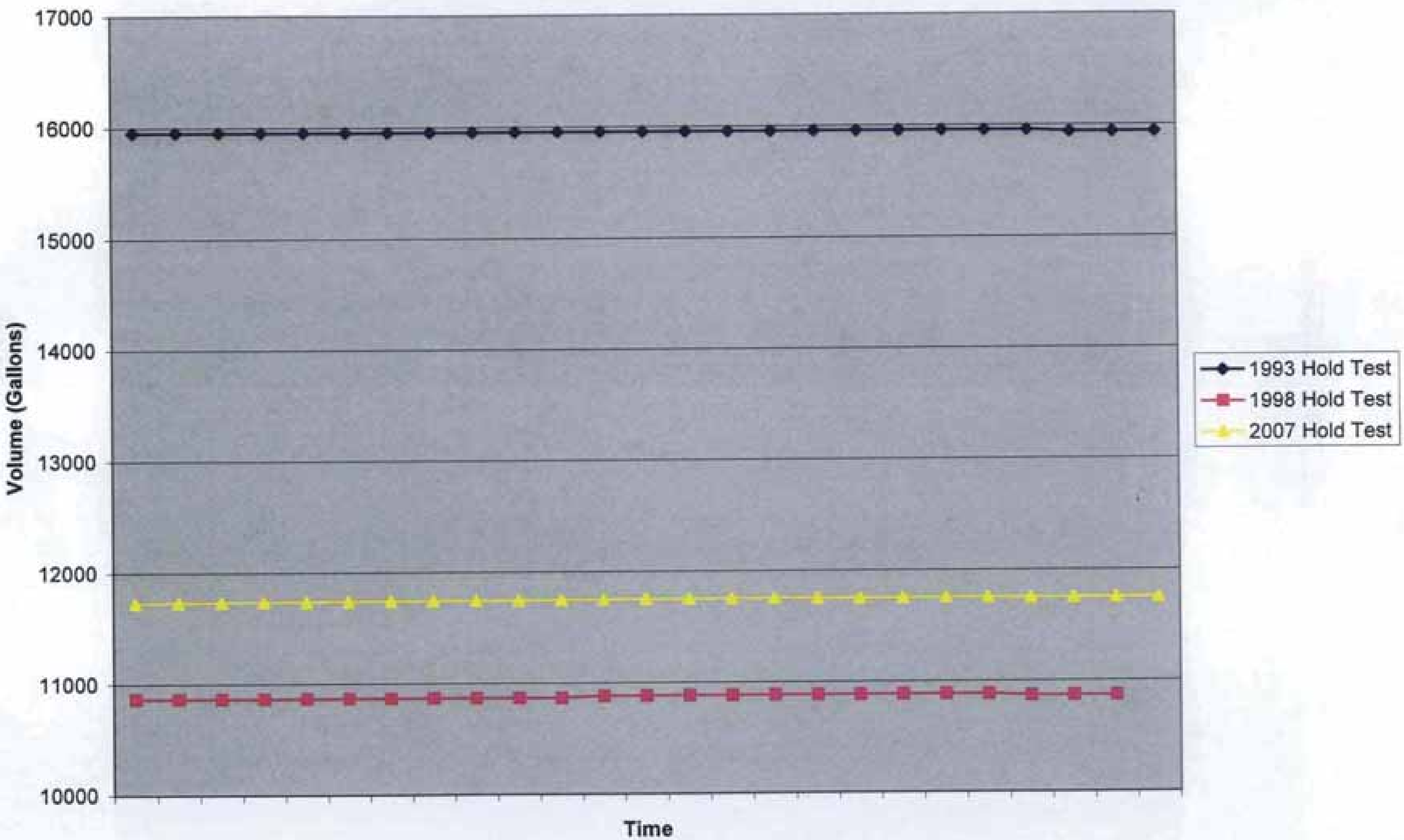


Figure 4B.2 TK-C-100 Hold Tests (1993 - 2007)



ATTACHMENT 5

EVAPORATOR-REBOILER LOOP LEAK TESTING PROCEDURES AND TEST RESULTS

(75 PAGES)

ATTACHMENT 5A

C-A-1 HYDRO TEST WORK INSTRUCTIONS AND TEST RESULTS

(16 PAGES)

Terry Curtis

From: Burke, Christopher A [Christopher_A_Burke@RL.gov]
Sent: Wednesday, December 26, 2007 2:11 PM
To: tcurtis@technogeneral.com
Subject: FW: Evaporator Leak test results

From: Cowgill, Ronnie A (Ron)
Sent: Wednesday, December 26, 2007 12:05 PM
To: 'tcurtis@tecnogeneral.com'
Cc: Faust, Toni L; Burke, Christopher A; Ostrom, Michael J
Subject: Evaporator Leak test results

Gentlemen;

In an effort to clarify the entries on data sheet 1, of WFO-WO-07-1225 Evaporator & Component Leak Test Visual Inspection Results, let it be known that I observed no leakage on any portion of the areas inspected. The entry on data sheet line ...To P-B-1 and data sheet line ...From P-B-1 should be read as no leakage observed.
If I can be of any further assistance let me know.

Ron Cowgill

WFO-WO-07-1225
242A INTEGRITY ASSESSMENT – C-A-1 VESSEL

1.0 SCOPE

- Perform Leak Test of the Evaporator Vessel in support of the Integrity Assessment Plan (IAP) for the 242-A Evaporator System. The Vessel Integrity Test is being conducted under the overview of an Independent Qualified Registered Professional Engineer (IQRPE). It is not necessary for state inspectors to witness the integrity test nor is it necessary to notify the state of the date and time of the test. Results of the integrity test will be documented in the final 242-A Integrity Assessment Report (IAR), which will be retained in the 242-A Evaporator regulatory File.

- The external portions of the components, piping, flanges, welds, and valves will be examined for evidence of leaks. The walk downs will be performed by a qualified inspector in accordance with ASME Section XI (VT-2) and overseen by the IQRPE or designated QC Level II inspector. Visual Inspections in the Evaporator/pump rooms will be performed on WO# WFO-WO-06-002549 **AFTER** this leak test is completed.

- Water will be the process solution in the Evaporator Vessel for testing.

- The acceptance criteria for this test are NO DETECTABLE LEAKS.

- Work will include:
  - Coordinating the hydrostatic testing of the Evaporator Vessel (C-A-1) with Operations after the Deep Flush process.
  - Filling of the vessel to a minimum level of 26,500 gallons.
  - Obtaining weight factor data readings and recording levels hourly during the 24 hour test.
  - Conducting Visual observations every four hours during the 24 hour test.
  - IF leaks are observed, follow-up engineering analysis shall be conducted to identify the type and extent of repairs required.

- The equipment being worked on is general service (GS).

- In accordance with the guidance contained in TFC-ESHQ-RP_RWP-C-03 "ALARA Work Planning", this task has been determined to be LOW radiological risk. (Ref. RWP TF-001, current rev.)

2.0 LIMITATIONS

[✓] 2.1. This work package will utilize radiological limits and controls specified on RWP TF-001 (Current Rev).

[✓] 2.2. Feed and Slurry lines must have been deep flushed and Section 5.10 of Procedure TO-650-140 performed prior to performing this leak test.

[✓] 2.3. Water used will be at ambient temperature.

3.0 PREREQUISITES

[✓] 3.1. FWS shall conduct a Pre-Job Briefing and review the applicable Job Hazards, Limitations and Precautions sections.

[✓] 3.2. Ensure C-A-1 vessel dump valve locking screws are installed to prevent inadvertent loss of vessel contents until integrity assessment has been completed.

[✓] 3.3. The Evaporator Facility SHALL be in OPERATION Mode during this work activity.

NOTE – This note applies to Section 4.0. Ensure Prerequisites have been completed. MULTIPLE ENTRIES may be performed.

4.0 SPECIFIC WORK INSTRUCTIONS

[✓] 4.1. **ENSURE** Feed and Slurry lines have been deep flushed, Section 5.10 of Procedure TO-650-140 has been performed and Hydrostatic testing of the vessel may be performed per the following steps.

[✓] 4.2. **RECORD** beginning Pump Room Sump level (G12, F7) reading on Data Sheet 1.

[✓] 4.3. **RECORD** FQI-RW-1 BOTTOMS FLUSH TOTALIZR (G15, F10) reading on Data Sheet 1.

[✓] 4.3.1. **START** Slurry Line Flush water flow to the Evaporator Pot by performing the following:

[✓] 4.3.1.1. **SELECT** HV-CA1-2 SLURRY FLUSH VALVES (G15/11, G47/0, F9).

[✓] 4.3.1.2. **IF** HV-CA1-2 is in AUTO mode, **PRESS** AUTO/MAN twice to place HV-CA1-2 in MANUAL.

[✓] 4.3.1.3. **PRESS** CMD 2 twice to place HV-CA1-2 to the EVAP FL position and start flush water flow to the Evaporator.

[✓] 4.3.1.4. **CHECK** that HV-CA1-2 status changes to EVAP FL.

[✓] 4.3.2. **MONITOR** FQI-RW-1 BOTTOMS FLUSH TOTALIZR (G15, F10) as the Evaporator fills.

[✓] 4.3.3. **IF** the Evaporator Vessel volume does not show a volume increase after FQI-RW-1 increases 300 gallons, **SHUT DOWN** Flush Water flow to the Evaporator Pot by performing the following:

[✓] 4.3.3.1. **SELECT** HV-CA1-2 SLURRY FLUSH VALVES (G15/11, G47/0, F9).

[ ] 4.3.3.2. **PRESS** CMD 0 twice to place HV-CA1-2 to the BLOCK position and shut down flush water flow to the Evaporator.

[ ] 4.3.3.3. **CHECK** that HV-CA1-2 status changes to BLOCK.

[ ] 4.3.3.4. **NOTIFY** Shift Manager of possible misrouted water.

[✓] 4.3.4. **MONITOR** LIC-CA1-1 EVAP CA1-1 LEVEL CONTROLR (G10/9, F2) **OR** LIC-CA1-2 EVAP CA1-2 LEVEL CONTROLR (G10/10, F2), TK-102-AW, and the Slurry Receiver Tank liquid levels as the Evaporator vessel fills.

[✓] 4.3.5. **AFTER** the lower of LIC-CA1-1 EVAP CA1-1 LEVEL CONTROLR (G10/9, F2) OR LIC-CA1-2 EVAP CA1-2 LEVEL CONTROLR (G10/10, F2) reads a MINIMUM of 26, 500 gallons (not to exceed 27,000 gallons), **SHUT DOWN** flush water flow to the Evaporator Pot by performing the following:

[✓] 4.3.5.1. **SELECT** HV-CA1-2 SLURRY FLUSH VALVES (G15/11, G47/0, F9).

[✓] 4.3.5.2. **PRESS** CMD 0 twice to place HV-CA1-2 to the BLOCK position and shut down flush water flow to the Evaporator.

[✓] 4.3.5.3. **CHECK** that HV-CA1-2 status changes to BLOCK.

[✓] 4.3.6. **SHUT DOWN** PB-1 RECIRC PUMP as follows:

[✓] 4.3.6.1. **SELECT** "PB-1" (G12/6, F5).

[✓] 4.3.6.2. **PRESS** "CMD 0" twice to shut down PB-1.

[✓] 4.3.6.3. **CHECK** PB-1 status changes to CF-OFF.

NOTE - After pump PB-1 is shut down, it is necessary to bypass the PB-1 shut down interlock to prevent the pot from automatically dumping (via Interlock #2) 8 minutes after PB-1 shuts down.

[✓] 4.3.6.4. **ACTIVATE** PB1-BYPAS PB-1 SHUT DOWN BYPASS as follows:

[✓] 4.3.6.5. **SELECT** "PB1-BYPAS" (G12/8, F5).

[✓] 4.3.6.6. **PRESS** "CMD 1" twice to set PB1-BYPAS to BYP ON.

[✓] 4.3.6.7. **CHECK** PB1-BYPAS status changes to BYP ON.

[✓] 4.4. **RECORD** Date/Time and initial level of the pump room sump at the start of the 24 hour hold period as read on LI-SUMP1 and record on Data Sheet 2.

[✓] 4.4.1. **QAT VERIFY** starting level of pump room sump.

9-01-07 / 15:20	[signature]	~~II~~ 430.2 (RJ 9-1-07)
Date/ Time	CH2M HILL QAT Signature	Level

NOTE: After the vessel is filled, the vessel must be left at this condition for a minimum of 24 hours. The liquid level should remain constant throughout the 24 hour hold period and no additional liquid should be required to maintain the level. Small erratic up and down variations in liquid level indication may be due to expansion and contraction due to temperature changes. This would not be cause for concern; however, a slow steady downward trend in level is more likely to be indicative of a leak.

[✓] 4.5. **RECORD** date/time and initial level at the start of the 24 hour hold period as read on either LIC-CA1-1 or LIC-CA1-2 and record on Data Sheet 2. Whichever indicator is used to determine the initial level must be used throughout the Integrity Test and **circled** on the data sheet.

[✓] 4.5.1. **QAT VERIFY** starting level of C-A-1.

Work Instructions

RECORD COPY

RW 9.1.07

9-01-07 / 15:20 [signature] 26728
Date/ Time CH2M HILL QAT Signature Level

[✓] 4.5.2. **CONDUCT** Visual observations every four hours during the hold period. Results will be recorded on the C-A-1 four hour visual inspections Data Sheet 3.

[✓] 4.5.2.1. Visual Observations are to include jumpers, pipes and pumps visible from the Pump Room viewing window.

[✓] 4.5.3. **OBTAIN** weight factor data reading hourly by monitoring either LIC-CA1-1 or LIC-CA1-2 and RECORD on Data Sheet 2.

[✓] 4.5.3.1. **IF** the liquid level begins to drop noticeably, NOTIFY the 242-A System Engineer so an evaluation of the situation may be performed. The System Engineer shall decide whether to continue with the leak test.

[✓] 4.5.3.2. The 24 hour hold period shall be terminated and the System Engineer notified IF:

- Three successive hourly increases in the sump level totaling 1 inch or more, or a cumulative level rise in the sump of 2 inches or more over the entire 24 hour hold period.
- Any visual evidence of a leak as viewed through the viewing window of the pump room.

[✓] 4.6. **QAT VERIFY** ending level of pump room sump.

9-02-07 / 16:06 [signature] 427.3
Date/ Time CH2M HILL QAT Signature Level

[✓] 4.7. **QAT VERIFY** ending level of C-A-1.

9-02-07 / 16:06 [signature] 26722
Date/ Time CH2M HILL QAT Signature Level

[✓] 4.8. **REMOVE** C-A-1 vessel dump valve locking screws to allow vessel contents to be emptied.

[✓] 4.9. **ENSURE** Operations is notified that hydrostatic testing activities have been completed and emptying C-A-1 per TO-600-060 may proceed.

[✓] 4.10. **NOTIFY** QA Level II Inspector that visual inspections on WO# WFO-WO-06-002549 may begin AFTER C-A-1 vessel has been emptied.

[✓] 4.11. **COMPLETE** Data Sheet 4 with inspection results.

[✓] 4.11.1. **AFTER** completion of the Test, the 242-A System Engineer shall review the observations, MARK the appropriate evaluation line and SIGN Data Sheet 4.

5.0 POST MAINTENANCE TESTING

N/A

NOTE - Steps in section 6.0 may be worked concurrently.

6.0 RESTORATION ACTIONS

[✓] 6.1. FWS Ensure work documents/Data Sheets are forwarded to Al Friberg (376-1190) OR Jim Castleberry (373-5011).

[✓] 6.2. FWS to review work package for trends and lessons learned. Conduct a Post Job Review on all fieldwork and mark "X" in Feedback block on work record, where appropriate.

[ ] 6.3. Closeout review.

Work Instructions

RECORD COPY

DATA SHEET 1

242-A EVAPORATOR SUMP READING LI-SUMP-1	(G12, F7)	429.9
FQI-RW-1 BOTTOMS FLUSH TOTALIZR	(Gallons) (G15, F10)	8896 (12112 ①)

① after pot fill

[signature] 1 1200 1 9-1-07

Operators Signature Time Date

Work Instructions

RECORD COPY

DATA SHEET 2

Date	Time	Pump Room Sump Reading LI-SUMP1 Gallons (inches) KJJ 9-1-07	Tank Indicator Reading LIC-CA1-1 / (LIC-CA1-2) Gallons	Recorded By
9-01-07	15:20	430.2	26728	[illegible] QC KJJ
9-01-07	15:30	430.0 (34.8)	26729	[illegible] KJJ
9-1-07	16:30	430.4 (34.8)	26729	[illegible]
9-1-07	17:30	430.2 (34.8)	26728	[illegible] KJJ
9-1-07	1830	430.6 (34.8)	26729	[illegible]
9-1-07	1930	430.0 (34.8)	26730	[illegible]
9-1-07	2000	429.7 (34.8)	26731	[illegible]
9-1-07	2100	429.8 (34.8)	26730	[illegible]
9-1-07	2200	430.2 (34.8)	26729	[illegible]
9-1-07	2300	430.3 (34.8)	26730	[illegible]
9-2-07	0000	429.8 (34.7)	26730	[illegible]
9-2-07	0100	428.6 (34.7)	26727	[illegible]
9-2-07	0200	429.2 (34.8)	26727	[illegible]
9-2-07	0300	428.6 (34.7)	26726	[illegible]
9-2-07	0400	428.4 (34.7)	26726	[illegible]
9-2-07	0500	427.5 (34.7)	26723	[illegible]
9-2-07	0600	427.5 (34.7)	26723	[illegible]
9-2-07	0700	427.6 (34.6)	26721	[illegible]
9-2-07	0800	426.8 (34.6)	26718	[illegible]
9-2-07	0900	426.9 (34.6)	26716	[illegible]
9-2-07	1000	426.4 (34.6)	26717	[illegible]
9-2-07	1100	426.5 (34.6)	26719	[illegible]
9-2-07	1200	426.3 (34.6)	26716	[illegible]
9-2-07	1300	426.2 (34.5)	26719	[illegible]
9-2-07	1400	426.9 (34.6)	26720	[illegible] KJJ
9-2-07	1500	426.6 (34.6)	26721	[illegible] KJJ
9-2-07	1600	427.3 (34.6)	26723	[illegible]
9-2-07	1606	427.3 (34.6)	26722	[illegible] QC

DATA SHEET 3

Date	Time	Observation	Recorded By
9-1-07	1530	ALL GOOD No Leaks observed	[signature] Dabling
9-1-07	1900	NO NEW LEAKS (1) looks like old leak below nozzle E	[signature]
9-1-07	2300	NO NEW LEAKS	[signature]
9-2-07	0300	NO NEW LEAKS	[signature]
9-2-07	0700	Same old leak under nozzle E - nothing new	[signature] Dabling
9-2-07	1100	No New Leaks	[signature] Dabling
9-2-07	1500	No New Leaks	[signature] Dabling

(1) NOTIFIED ENVIRONMENTAL AND S. RINGO OF APPARENT LEAK FROM NOZZLE E. [initials] 9/1/07

Work Instructions

RECORD COPY

DATA SHEET 4

EVAPORATOR VESSEL LEAK TEST INSPECTION

Time and date when Vessel was filled: 15:20 9/1/07

Time and Date when inspection began: 15:20 9/1/07

Operations Manager: [signature]

QC Inspectors: [signature]

Comments: Leak during campaign observed during testing. No water observed leaking during actual test.

________ System is acceptable based on the inspection results. No further evaluation is required.

✓ System requires further evaluation.
Reference: Visual evaluation of pump room discovered a waste leak on the floor below nozzle "E". Nozzle "E" must be evaluated to determine cause of leak & repaired as required.

242-A System Engineer: R.N. DALE / [signature] Date 09/04/07

QC Level II Inspector: [signature] Date 9-2-07

RPP WORK RECORD	1. Document Number: WFO-WO-07-1225

2. Work Item Title: 242-A INTEGRITY ASSESSMENT C-A-1 VESSEL

Date	Turnover, Problem Description, Action Taken	Feed Back (X)	Name	Craft/ Resource Type	Hours
7/30/07	Ops pre work release completed. No LHT.		[signature]	OE	
8/31/07	With concurrence of FWS Steve Ringo (per telecon), removed references in work instruction to "applicable Swess memo" and revised step 4.3.4 for instruments to be read for monitoring water levels.		per telecon Steve Ringo	FWS	
			Pat Sand [signature]	Planner	
9/1/07	Conducted pre job with personnel. Discussed purpose of test and required readings throughout. Test started at 15:20 and should be complete by same time 9/2/07. Locking plates screwed in.		[signature]	FWS	
9/2/07	A leak during campaign was observed. A hardened crust mound of waste was observed leaking from past campaign but was not evident during hold test. The leak appeared to be coming from		[signature]		

Summary by Craft/Resource Type

Craft/Resource Type	Total Hours	Craft/Resource Type	Total Hours

A-6003-243 (11/04)

RPP WORK RECORD

1. Document Number: WFO-WO-07-1225

2. Work Item Title: 242-A INTEGRITY ASSESSMENT C-A-1 VESSEL

Date	Turnover, Problem Description, Action Taken	Feed Back (X)	Name	Craft/ Resource Type	Hours
9/2/07 (Cont'd)	Nozzle E. Test was concluded at 1606 on 9/2/07. No leaks observed during actual test (No water observed leaking) Locking plates removed and notified SOM to continue with shutdown activities. Notified System Engineer Rob Dale and left message with Project Engineer Al Fisberg. Notified M. Kembel regarding planned entry into pump room to perform visual via WFO-WO-00-2549 planned for 9/3/07. Per direction of McHasty, Operators will continue with dumping of CA1 contents to AW102.		[signature]	FWS	
9/3/07	0124 CA1 was emptied to AW102.		[signature]	FWS	

Summary by Craft/Resource Type

Craft/Resource Type	Total Hours	Craft/Resource Type	Total Hours

A-6003-243 (11/04)

2/2/2007 1:46 PM

WORKING COPY TSI Required Data

242-A Evaporator Backside Rounds (Cont.)

Date:	8-27-07		8-28-07		8-29-07		8-30-07		8-31-07		9-01-07		9-02-07	
Day:	Monday		Tuesday		Wednesday		Thursday		Friday		Saturday		Sunday	
Parameter:	D	N	D	N	D	N	D	N	D	N	D	N	D	N
PUMP ROOM INSPECTIONS (use viewing window in AMU Room for inspection)							✓	✓	✓	✓	✓	✓	✓	✓
Inspect process systems for integrity and signs of corrosion. (No leakage from piping, valves, flanges, gaskets, etc. No rust buildup) RCRA	D	①	①	②	①	①	D	①	①	①	①	①	①	①
Inspect room lighting. (No burned out lights, light fixtures intact etc.) SAFETY	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Inspect visible areas within 2 meters of the pump room side of the shielding windows, on the AMU lower and mezzanine levels, for combustible materials. (Report combustibles for removal.) FIRE PROTECTION	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Space for emergency movement of fire, spill and decontamination equipment is maintained. (Clear walkways) RCRA	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	②	②	②
	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
No unsafe conditions exist. Conditions hazardous to personnel and/or environmental equipment. (Wet floors, exposed wiring, housekeeping, belt guards not installed, water leaking onto electrical equipment, etc.) SAFETY	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓

Conversion 1 Meter = 39.37 inches: 2.0 meters = 78.74 inches (6' 6¾")

DL #: (1) WFO-WO-06-0465	Remarks: leak below nozzle E ① NOTIFIED ENVIRONMENTAL & INTEGRITY ASSESSMENT (MGR) MGR 9/2/07
No indications of malfunctioning equipment. (Lack of power to indicating lights, abnormal noises from operating equipment, etc.) RCRA	DL # (2)

Inspect Pump Room Sump for overflows. RCRA

09/29/201

ATTACHMENT 5B

FACTORS POTENTIALLY AFFECTING THE VAPOR-LIQUID SEPARATOR HOLD TEST AND POST TEST ANALYSIS

(52 Pages)

5B.0 FACTORS POTENTIALLY AFFECTING THE VAPOR-LIQUID SEPARATOR HOLD TEST AND POST TEST ANALYSIS

The following sections analyze factors potentially affecting the vapor-liquid separator hold test.

5B.1 INTRODUCTION

In discussions since the preparation of the current IAP (2007), the IQRPE has been alerted to factors that may affect the Evaporator/Reboiler Loop Leak (Hold) test. These factors consist of the following:

1) Level sensor sensitivity.
2) Potential losses from the system by evaporation of the test fluid (water vapor); and
3) Thermal expansion of the text fluid and system components;

The potential impacts of these factors upon the outcome of the Hold Test will be discussed in the following sections, beginning with analysis of previously collected Evaporator/Reboiler Loop Test data.

5B.2 ANALYSIS OF PREVIOUS LEAK TESTS

The Evaporator/Reboiler Loop was previously tested in 1992 and reported in the 1993 IAR (USDOE 1993) and in 1998 and reported in the 1998 IAR (USDOE 1998). Analysis and discussion of results are provided in the following sections.

5B.2.1 1993 Test

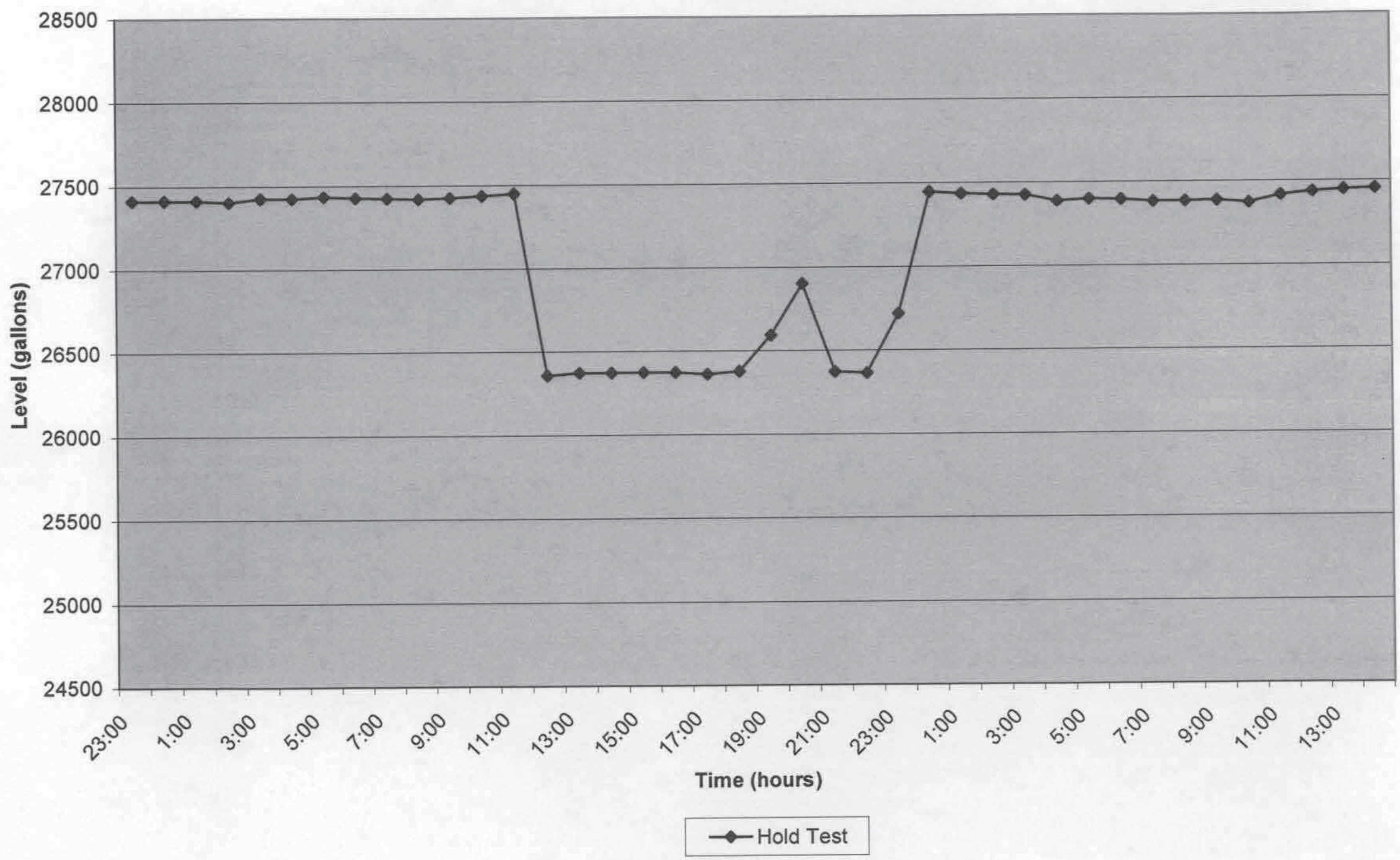
1993 Evaporator hold test data are compiled in Table 5B.2.1 (US and SI units). Figure 5B.2.1 demonstrates that in 1993, the data are relatively flat, maintaining a baseline of approximately 27,400 gallons (103,720 Liters) until the reading taken at 12:00 hours on November 22, 1992 fourteen hours after the test began. At this point, the electronically indicated level dropped approximately 1,000 gallons (3,785 Liters) to a new baseline of approximately 26,400 gallons until 22:00 hours, except for a level spike of up to 26,900 gallons (101,828 Liters) that was recorded between 18:00 and 21:00 hours on November 22, 1992. Level readings resumed the 27,400 gallon (103,720 Liters) baseline at 0:00 hours on November 23, 1992 and maintained this baseline until the termination of the test after 39 hours of testing. In comparing the initial, 27,413 gallons (103,769 Liters), and final levels, 27,454 gallons (103,924 Liters), an apparent gain of 41 gallons (155 Liters) was electronically indicated.

In explanation for the electronically recorded level readings described above, the 1993 IAR postulated that indicated that the 1,000 gallon drop that occurred between 11:00 and 12:00 hours was the result of a change in instrument reference rather than actual liquid leakage. To support this, the 1993 IAR reported that the electronically reported drop between 11:00 and 12:00 hours coincided with the shut down of a cell ventilating fan. It was explained that fan power and liquid level indicator reference leg are on the same electrical motor control center circuit. Further, that the weight factor based level instrument was sensitive to air pressure and that the shutdown of the fan would have

TABLE 5B.2.1
1993 Evaporator Hold Test Data

Date	Time	Level (gallons)	Level (CF)	Level (Liters)	Level (m^3)
11/21/1992	23:00	27413	3664.6	103769	103.77
11/22/1992	0:00	27414	3664.7	103773	103.77
11/22/1992	1:00	27413	3664.6	103769	103.77
11/22/1992	2:00	27403	3663.2	103732	103.73
11/22/1992	3:00	27425	3666.2	103815	103.81
11/22/1992	4:00	27424	3666.1	103811	103.81
11/22/1992	5:00	27435	3667.5	103853	103.85
11/22/1992	6:00	27427	3666.5	103822	103.82
11/22/1992	7:00	27424	3666.1	103811	103.81
11/22/1992	8:00	27419	3665.4	103792	103.79
11/22/1992	9:00	27426	3666.3	103819	103.82
11/22/1992	10:00	27436	3667.7	103857	103.86
11/22/1992	11:00	27450	3669.5	103910	103.91
11/22/1992	12:00	26358	3523.6	99776	99.78
11/22/1992	13:00	26373	3525.6	99833	99.83
11/22/1992	14:00	26373	3525.6	99833	99.83
11/22/1992	15:00	26375	3525.8	99840	99.84
11/22/1992	16:00	26374	3525.7	99836	99.84
11/22/1992	17:00	26363	3524.2	99795	99.79
11/22/1992	18:00	26379	3526.4	99855	99.86
11/22/1992	19:00	26594	3555.1	100669	100.67
11/22/1992	20:00	26903	3596.4	101839	101.84
11/22/1992	21:00	26373	3525.6	99833	99.83
11/22/1992	22:00	26366	3524.6	99806	99.81
11/22/1992	23:00	26721	3572.1	101150	101.15
11/23/1992	0:00	27447	3669.1	103898	103.90
11/23/1992	1:00	27435	3667.5	103853	103.85
11/23/1992	2:00	27429	3666.7	103830	103.83
11/23/1992	3:00	27425	3666.2	103815	103.81
11/23/1992	4:00	27388	3661.2	103675	103.67
11/23/1992	5:00	27399	3662.7	103716	103.72
11/23/1992	6:00	27395	3662.2	103701	103.70
11/23/1992	7:00	27382	3660.4	103652	103.65
11/23/1992	8:00	27383	3660.6	103656	103.66
11/23/1992	9:00	27386	3661.0	103667	103.67
11/23/1992	10:00	27372	3659.1	103614	103.61
11/23/1992	11:00	27417	3665.1	103785	103.78
11/23/1992	12:00	27436	3667.7	103857	103.86
11/23/1992	13:00	27448	3669.3	103902	103.90
11/23/1992	14:00	27454	3670.1	103925	103.92

Figure 5B.2.1 - 1993 Hold Test (Volume vs Time)



affected air pressure in the vessel. However, after establishing the link between the fan shutdown and the drop in level readings, it remained unknown why readings on the level instrument remained low for over 12 hours, when the shutdown of the fan lasted only a few minutes.

However, the 1993 IAR concluded that leakage was unlikely, despite the electronically indicated level fluctuations on the basis of the following:

- No visible leakage was observed during any of the 11 recorded visual inspections during the test;
- No visible leakage was observed during the final VT exam conducted at the conclusion of the test;
- The vapor-liquid separator system is covered by insulation, however, the insulation is not absorbent and the amount of electronically indicated leakage was large (1,000 gallons or 3,785 Liters), which would have been readily observable,
- Boundary drain valves were tested and found to be leak tight prior to testing;
- Sufficient make up water could not have come from the P-B-1 seals,
- No make up water was deliberately added nor could have exactly matched the 1,000 gallon (3,785 Liters) loss electronically indicated.

It was also further explained that the electronically reported level fluctuations in the range of +/- 550 gallons (2082 Liters) were attributable to instrument drift (see Section 5B.3).

5B.2.2 1998 Test

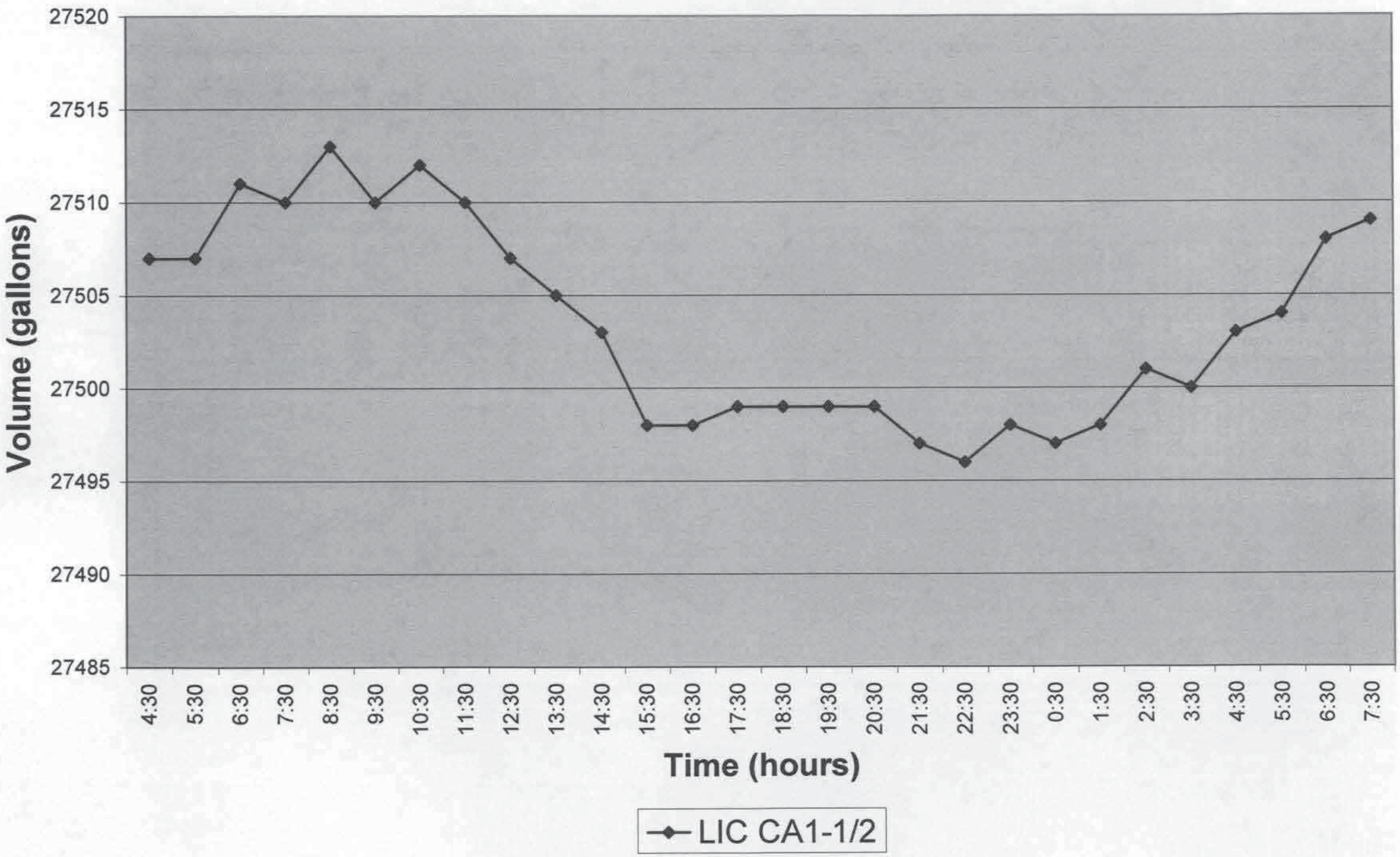
1998 Evaporator hold test data are compiled in Table 5B.2.2 (US and SI units). Figure 5B.2.2 demonstrates that unlike 1993 data, the 1998 data follow a sinusoidal pattern. An analysis of the actual data collected in 1998 (USDOE 1998) shows that the initial volume measurement in 1998 was 27,507 (104,125 liters) at 4:30 hours on June 1st. The maximum volume was 27,513 gallons (104,148 liters) at 8:30 hours and the minimum volume was 27,496 gallons (104,084 liters) at 22:30 hours. The baseline measurement was the reading at 4:30 hours on June 1, 1998, so the greatest positive deviation was 6 gallons (23 liters) at 8:30 hours and the greatest negative deviation was 11 gallons (42 liters) at 22:30 hours on June 1, 1998. For the 6 gallon (23 liters) positive change, this would be approximately a 0.0625 inch (0.159 cm) increase in the apparent height of water in C-A-1. For the 11 gallon (42 liters) negative change, this would be approximately a 0.115 inch (0.291 cm) drop in the apparent height of water in C-A-1.

The 1998 IAR (USDOE 1998) did not detailed analysis of the volume fluctuations observed, however, it acknowledge behavior in the latter half of the explanation for the apparent overall fluctuations of +6 gallons (actually noting this as a change of 5 gallons) and -11 gallons as "...variations within the operating range of the level measuring equipment and the minor temperature fluctuations of the system." Visual inspections during the leak test noted no leaks. During the test, seal water for the recirculation pump P-B1 was routed to tank 241-AW-102, however, the increase in the level of the tank was accounted for by the routing of the seal test water.

TABLE 5B.2.2
1998 Hold Test Data

Date	Time	Level (gallons)	Level (CF)	Level (Liters)	Level (m^3)
6/1/1998	4:30	27507	3677.2	104125	104.1
6/1/1998	5:30	27507	3677.2	104125	104.1
6/1/1998	6:30	27511	3677.7	104140	104.1
6/1/1998	7:30	27510	3677.6	104137	104.1
6/1/1998	8:30	27513	3678.0	104148	104.1
6/1/1998	9:30	27510	3677.6	104137	104.1
6/1/1998	10:30	27512	3677.8	104144	104.1
6/1/1998	11:30	27510	3677.6	104137	104.1
6/1/1998	12:30	27507	3677.2	104125	104.1
6/1/1998	13:30	27505	3676.9	104118	104.1
6/1/1998	14:30	27503	3676.6	104110	104.1
6/1/1998	15:30	27498	3675.9	104091	104.1
6/1/1998	16:30	27498	3675.9	104091	104.1
6/1/1998	17:30	27499	3676.1	104095	104.1
6/1/1998	18:30	27499	3676.1	104095	104.1
6/1/1998	19:30	27499	3676.1	104095	104.1
6/1/1998	20:30	27499	3676.1	104095	104.1
6/1/1998	21:30	27497	3675.8	104087	104.1
6/1/1998	22:30	27496	3675.7	104084	104.1
6/1/1998	23:30	27498	3675.9	104091	104.1
6/2/1998	0:30	27497	3675.8	104087	104.1
6/2/1998	1:30	27498	3675.9	104091	104.1
6/2/1998	2:30	27501	3676.3	104103	104.1
6/2/1998	3:30	27500	3676.2	104099	104.1
6/2/1998	4:30	27503	3676.6	104110	104.1
6/2/1998	5:30	27504	3676.7	104114	104.1
6/2/1998	6:30	27508	3677.3	104129	104.1
6/2/1998	7:30	27509	3677.4	104133	104.1

Figure 5B.2.2 - 1998 Evaporator Hold Test



Variations in instrumentation sensitivity are unlikely to follow a sinusoidal curve but rather to follow small variations around a mean reading. This behavior is more likely attributable to diurnal temperature variations or some other phenomena having a 24 hour cycle or period. For an analysis of level sensor sensitivity, see Section 5B.3 and for an analysis of temperature effects, see Section 5B.5.

5B.2.3 2007 Test – C-A-1 Level

2007 Evaporator hold test data are compiled in Table 5B.2.3 (US and SI units). Figure 5B.2.3 demonstrates the 2007 data follow a similar sinusoidal pattern as the 1998 data, not following a flat or step pattern, as seen in 1993. As in 1998, visual inspections did not indicate leaks. Evidence of an old leak that was attributed to a leak occurring in the previous Evaporator campaign was noted.

An analysis of the actual C-A-1 level data collected in 2007 (Attachment 5A and Table 5B.2.3) shows that the initial volume measurement was 26,728 gallons (101,176 liters) at 15:20 hours on September 1, 2007. The maximum volume was 26,731 gallons (101,188 liters) at 20:00 hours on September 1, 2007 and the minimum volume was 26,716 gallons (101,131 liters) at 9:00 hours on September 2, 2007. The baseline measurement was the reading at 15:20 hours, so the greatest positive deviation was 3 gallons (11 liters) at 20:00 hours on September 1, 2007 and the greatest negative deviation was 12 gallons (45 liters) at 9:00 and 12:00 hours on September 2, 2007. For the 3 gallon positive change, this would be approximately a 0.0313 inch (0.0794 cm) increase in the apparent height of water in C-A-1. For the 12 gallon (45 liter) negative change, this would be approximately a .125 inch (0.318 cm) drop in the apparent height of water in C-A-1.

As noted in Section 5B.2.2, variations in instrumentation sensitivity are unlikely to follow a sinusoidal curve but rather to follow small variations around a mean reading. Instead, this behavior is more likely attributable to diurnal temperature variations or some other phenomena having a 24 hour cycle or period. For an analysis of level sensor sensitivity, see Section 5B.3 and for an analysis of temperature effects, see Section 5B.5.

5B.2.3 2007 Test – L1 Sump Level

L1 Sump level data were also collected in 2007 and are compiled in Table 5B.2.3 (US and SI units) and shown in Figure 5B.2.4. Data are scale corrected to be displayed alongside 242A level data and displayed in Figure 5B.2.5. From observing Figures 5B.2.4 and 5B.2.5, it can be seen that these data demonstrate similar behavior as 1998 and 2007 242A level data, albeit at lesser deviation (i.e. smaller maximums and minimums).

An analysis of the actual L1 Sump level data collected in 2007 (Attachment 5A and Table 5B.2.3) shows that the initial volume measurement was 430.2 gallons (1,628 liters) at 15:20 hours on September 1, 2007. The maximum volume was 430.6 gallons (1,630 liters) at 18:30 hours on September 1, 2007 and the minimum volume was 426.2 gallons (1613 liters) at 13:00 hours on September 2, 2007. The baseline measurement was the reading at 15:20 hours, so the greatest positive deviation was 1 gallon (3 liters) at 18:30 hours on September 1, 2007 and the greatest negative deviation was 4 gallons (13 liters) at 13:00 hours on September 2, 2007. For the 1 gallon positive change, this would be approximately a 0.0662 inch (0.168 cm) increase in the apparent height of water in Sump

TABLE 5B.2.3
2007 Hold Test Data

		242A Level				L1 Sump Level			
Date	Time	(gallons)	(CF)	(Liters)	(m^3)	Gallons	(CF)	(Liters)	(m^3)
9/1/2007	15:20	26728	3573.0	101176	101.2	430.2	57.5	1628	1.6
9/1/2007	15:30	26729	3573.1	101180	101.2	430.0	57.5	1628	1.6
9/1/2007	16:30	26729	3573.1	101180	101.2	430.4	57.5	1629	1.6
9/1/2007	17:30	26728	3573.0	101176	101.2	430.2	57.5	1628	1.6
9/1/2007	18:30	26729	3573.1	101180	101.2	430.6	57.6	1630	1.6
9/1/2007	19:30	26730	3573.3	101184	101.2	430.0	57.5	1628	1.6
9/1/2007	20:00	26731	3573.4	101188	101.2	429.7	57.4	1627	1.6
9/1/2007	21:00	26730	3573.3	101184	101.2	429.8	57.5	1627	1.6
9/1/2007	22:00	26729	3573.1	101180	101.2	430.2	57.5	1628	1.6
9/1/2007	23:00	26730	3573.3	101184	101.2	430.3	57.5	1629	1.6
9/2/2007	0:00	26730	3573.3	101184	101.2	429.8	57.5	1627	1.6
9/2/2007	1:00	26727	3572.9	101173	101.2	428.6	57.3	1622	1.6
9/2/2007	2:00	26727	3572.9	101173	101.2	429.2	57.4	1625	1.6
9/2/2007	3:00	26726	3572.7	101169	101.2	428.6	57.3	1622	1.6
9/2/2007	4:00	26726	3572.7	101169	101.2	428.4	57.3	1622	1.6
9/2/2007	5:00	26723	3572.3	101158	101.2	427.5	57.1	1618	1.6
9/2/2007	6:00	26723	3572.3	101158	101.2	427.5	57.1	1618	1.6
9/2/2007	7:00	26721	3572.1	101150	101.1	427.6	57.2	1619	1.6
9/2/2007	8:00	26718	3571.7	101139	101.1	426.8	57.1	1616	1.6
9/2/2007	9:00	26716	3571.4	101131	101.1	426.9	57.1	1616	1.6
9/2/2007	10:00	26717	3571.5	101135	101.1	426.4	57.0	1614	1.6
9/2/2007	11:00	26719	3571.8	101142	101.1	426.5	57.0	1614	1.6
9/2/2007	12:00	26716	3571.4	101131	101.1	426.3	57.0	1614	1.6
9/2/2007	13:00	26719	3571.8	101142	101.1	426.2	57.0	1613	1.6
9/2/2007	14:00	26720	3571.9	101146	101.1	426.9	57.1	1616	1.6
9/2/2007	15:00	26721	3572.1	101150	101.1	426.6	57.0	1615	1.6
9/2/2007	16:00	26723	3572.3	101158	101.2	427.3	57.1	1618	1.6
9/2/2007	16:06	26722	3572.2	101154	101.2	427.3	57.1	1618	1.6

Figure 5B.2.3 - 2007 Evaporator Hold Test - C-A-1 Level

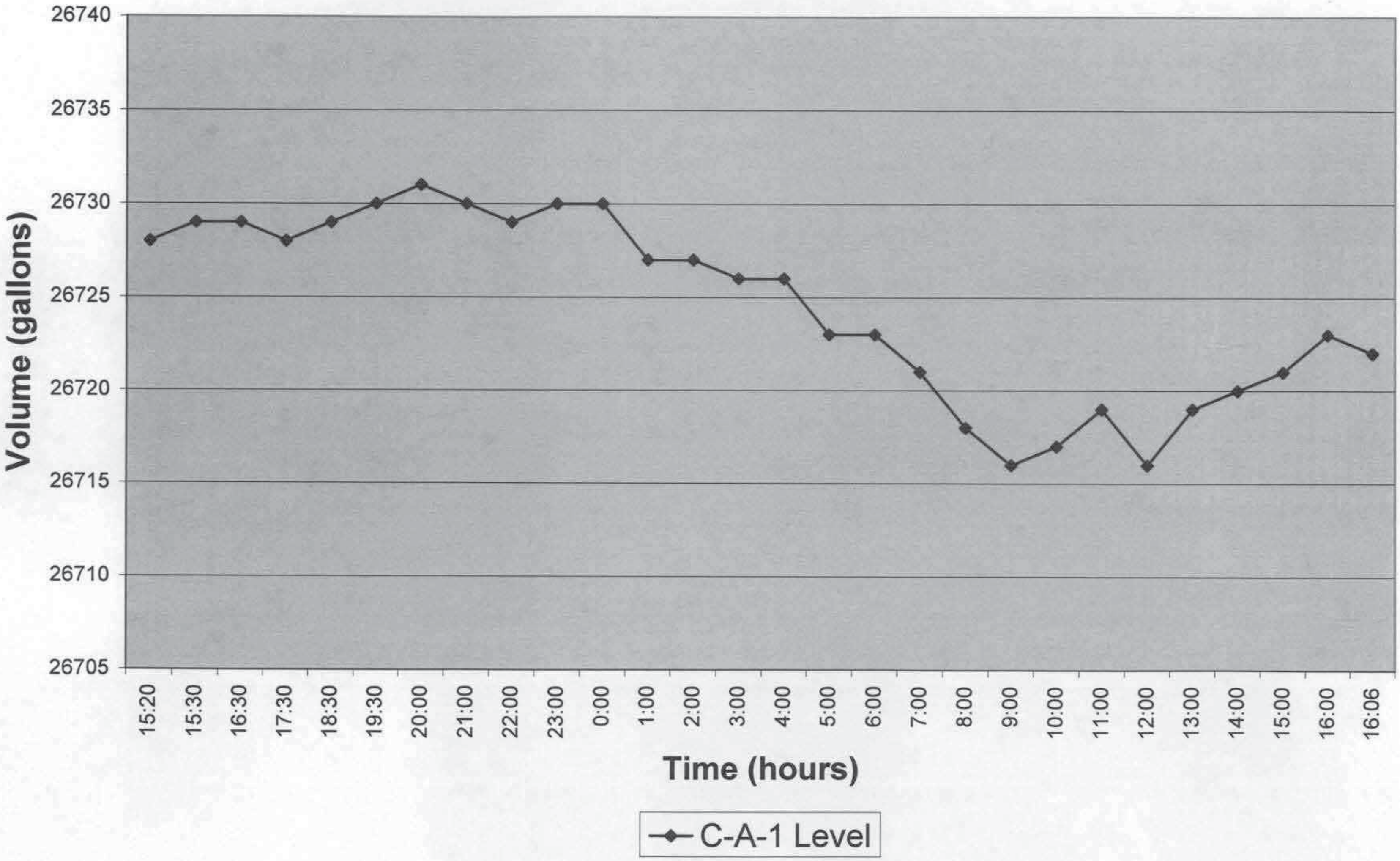


Figure 5B.2.4 - 2007 Evaporator Hold Test - L1 Sump Level

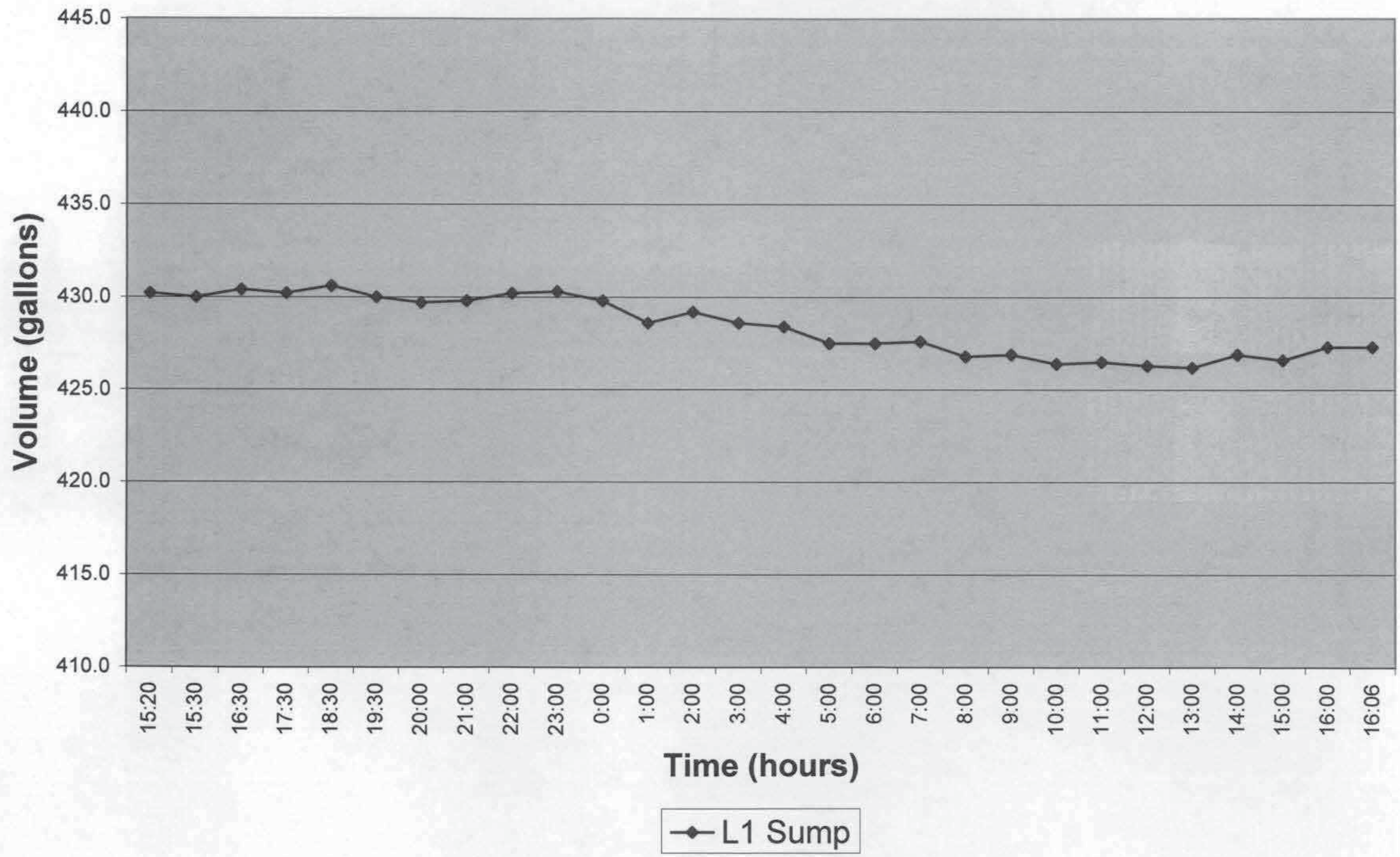


Figure 5B.2.5 - 2007 Evaporator Hold Test - C-A-1 and L1 Sump Change in Level

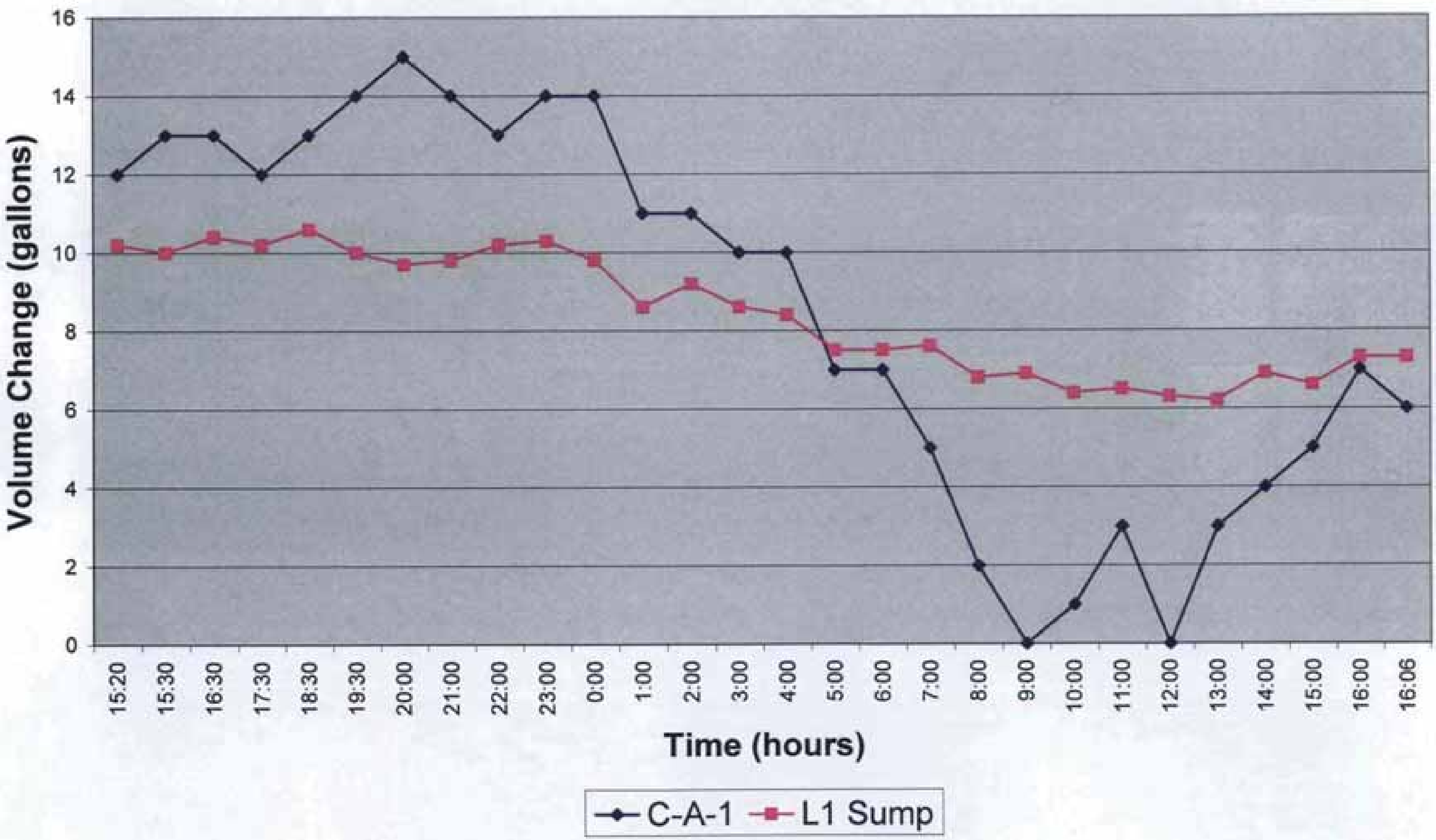
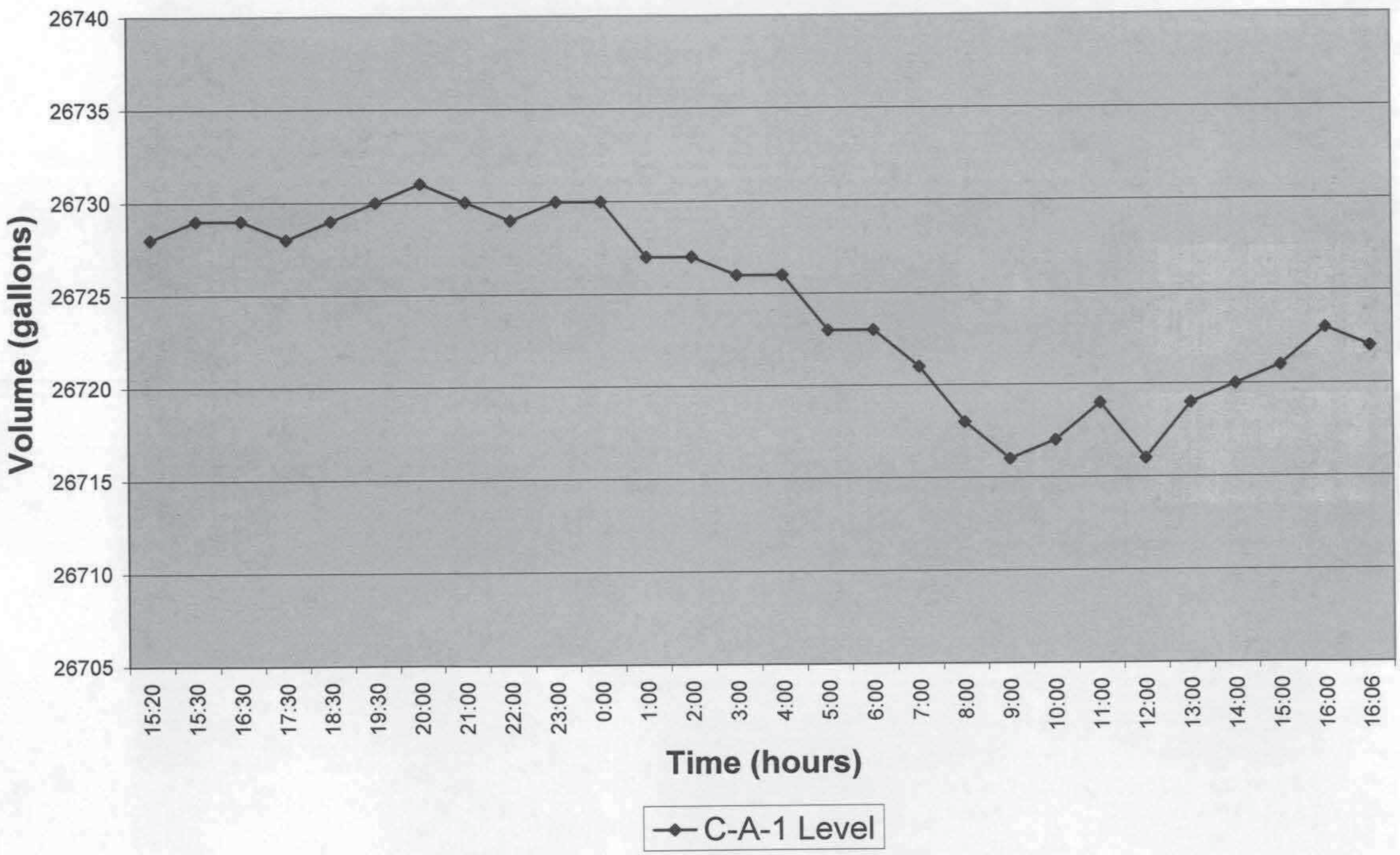


Figure 5B.2.3 - 2007 Evaporator Hold Test - C-A-1 Level



L1. For the 4 gallon (13 liter) negative change, this would be approximately a 0.265 inch (0.673 cm) drop in the apparent height of water in L1.

As noted in Section 5B.2.2 and 5B.2.3, variations in instrumentation sensitivity are unlikely to follow a sinusoidal curve but rather to follow small variations around a mean reading. Instead, this behavior is more likely attributable to diurnal temperature variations or some other phenomena having a 24 hour cycle or period. For an analysis of level sensor sensitivity, see Section 5B.3 and for an analysis of temperature effects, see Section 5B.5.

5B.3 LEVEL SENSOR INSTRUMENTATION

It is desired to determine what effects C-A-1 instrument accuracy may have on determining whether losses from the Vapor-Liquid Separator Loop occur during the hold test.

Level instrument specifications were formally archived in the B100 archive boxes. This information is currently unavailable to the IQRPE. However, two descriptions are provided as being applicable to level sensing instrumentation currently in operation HNF 14755 and CH2 2006 that provide detailed information:

HNF 14755 provides the following:

> WF in vessel C-A-1 is measured using differential pressure information from dip tubes and is controlled to prevent overfilling, prevent tank structural damage, and to preclude the spread of contamination. One dip tube penetrates the bottom of the vessel in the recirculation line and is used for wide-range WF indication. Two dip tubes (to provide redundancy) penetrate to mid-level and are used for narrow range WF indication. Two additional dip tubes (to provide redundancy) are located approximately 100 in. below the narrow range dip tubes. Specific gravity is determined from the differential pressure between these two pairs of dip tubes. A reference tube is located in the vapor space just below the lower deentrainment pad. WF is calculated by measuring the differential pressure between the reference tube and the WF dip tubes. The WF is corrected for density by dividing the height of the WF by specific gravity. This corrected WF is the actual liquid level inches. Vessel calibration data are then used to convert this level from inches to gallons.
>
> The dip tube system is designed and installed to prevent liquid from backflowing into the instrument area. The dip tubes enter the cell 7 m (23 ft) above the operating liquid level in vessel C-A-1. The 242-A Evaporator operates under a vacuum of approximately 6.7 kPa or 50 torr. Assuming that the slurry density is 1.3 g/cc, the pressure in vessel C-A-1 would have to exceed 90 kPa (13 lbf/in.2) above atmospheric pressure to back up liquid into the instrument area. In addition, the dip tubes are slightly pressurized and air flows continuously into the vessel.
>
> High- and low-level vessel C-A-1 alarms signal the operator when the liquid level is approaching liquid levels either below or above the desired range of liquid levels specified by process engineering.
>
> The liquid level in vessel C-A-1 must be controlled to prevent overfilling the vessel and plugging or damaging the deentrainment pads. Vessel C-A-1 overflow

> could reach the process condensate tank TK-C-100, which would cause a significant increase in condenser room radiation levels. Operators and RCTs would be unable to enter the room and perform normal surveillance activities until the tank contents were pumped out and the tank and associated lines decontaminated.
>
> A minimum liquid level is maintained in vessel C-A-1 to control scale formation on the reboiler tubes and prevent cavitation in P-B-1 recirculation pump. The liquid level is maintained just above the outlet pipe that exits from the reboiler into the vessel. The level helps prevent vapor bubbles from forming inside the reboiler tubes, which creates a potential for the upper part of the reboiler tubes to become dry and for scale to deposit on the tube walls. High solution velocity through the reboiler tubes also reduces scale formation.

CH2 2006 provides the following:

> The liquid level of the vessel is continuously monitored via three dip tube assemblies installed within the vessel. The signals from the dip tubes are received by the Monitoring Control System (MCS) and displayed in both graphical and faceplate format. Weight factors and specific gravities are then converted by the MCS to vessel liquid level. Only one of the two narrow range weight factor indicators (WFI CA1 1 or WFI CA1 2) is required to operate the evaporator. If both WFI CA1 1 and WFI CA1 2 are inoperable, the evaporator liquid level can be monitored using WFI CA1 3 (uncorrected weight factor) if the feed pump, slurry pump, and steam to the reboiler are shut off. Control is accomplished by adjustment of the feed rate, reboiler steam rate, vessel operating pressure, slurry rate, or a combination of these. In the event of a high liquid level alarm, the weight factor transmitters (WFT CA1 1, 2) are hardwired to a switch that turns off the feed pump. A software interlock shuts down the recirculation pump, P B 1, and slurry pump, P B 2, on low liquid level.

Both descriptions are essentially the same. In both cases, level sensors are dip tubes that communicate weight factor and specific gravity data that is used to monitor and control the liquid level in C-A-1.

Indirectly, information regarding the probable accuracy of instrumentation used in 1993 is provided in the 1993 IAR (USDOE 1993). Observations during the leak test of the starting liquid inventory in the system as indicated by the LI-CAI-3G level indicator was 27,413 gallons (103,769 Liters). At the conclusion of the test 39 hours later, the final indicated inventory was 27,454 gallons (103,924 Liters). The difference between starting and ending levels reported electronically was an increase of 41 gallons (155 Liters), with both positive and negative differentials occurring during testing (see Sections 5B.2.2 and 5B.5 below). The testers attributed this discrepancy to electronic instrument drift. Per information received from the instrument engineer, the accuracy of the 242A evaporator/reboiler loop level transmitter (Loop AEIOH-1, instrument number WFT-CAI-3, calibrated for 0-800 inches of water, 4-20 mA) was +/- 2 percent. Out of a total water inventory of 27,454 gallons (approximate) in the evaporator reboiler loop, the accuracy of instrumentation used in the 1993 hold test was therefore approximately +/- 550 gallons (2,082 Liters).

A discussion of instrumentation accuracy is not provided in the 1998 IAR, however, LIC CA1-1 and LIC CA1-2 were used in the 1998 evaporator hold test (US DOE 1998). Since these level sensors remain in use, the descriptions found in HNF 14755 and CH2 2006 are applicable. Specifications for these instruments are not currently available to the IQRPE, however, the system engineer describes LIC-CA1-1/LIC-CA1-2 as being accurate to within approximately 2 percent of scale or the equivalent of ½-inch (1.27 cm) drop in the level of CA1. At typical and maximum operating levels, the diameter of C-A-1 is 14 feet (4.27 m) and has an area of 154 square feet (14.3 m^2). If ½-inch (1.27 cm) is taken as the accuracy of LIC-CA1-1/LIC-CA1-2, a loss of ½ inch (1.27 cm) represents 6.4 cubic feet (0.182 m^3) or 48 gallons (182 Liters), giving these instruments an accuracy of +/- 48 gallons (182 Liters) with respect to reading changes in the volume of CA1.

While instrument sensitivity has an impact regarding quantitative readings, qualitative trends, such as steady, sustained losses should still be observable, provided that instrument response . However, it is also possible that transient changes smaller than instrument sensitivity would go undetected. Potential effects of instrument sensitivity are shown on 1993 data in Figure 5B.3.1 as "Y-bars" of +/- 550 gallons on actual data recorded and on Figure 5B.3.2 as "Y bars" of +/- 48 gallons on actual data recorded. Potential effects of instrument sensitivity are shown on Figures 5B.4.1 and 5B.4.2 (see Section 5B.4 below) by using the larger "error bar" of +/- 550 gallons due to the scale of the figures. Because the instrumentation in effect is as described by the system engineer, Figure 5B.3.3, which depicts the potential effects of instrument sensitivity upon the current hold test, includes "Y bars" of 48 gallons.

5B.4 EVAPORATION

It is desired to determine what effects evaporation may have during the Vapor-Liquid Separator Leak Test/Hold Test. Calculations of this rate could be used to separate any losses from the Loop caused by evaporation from losses caused by leaks during the hold test period.

The following boundary conditions and assumptions are relevant for each of the following calculations:

- The hold test is assumed to be 24 hours in duration;
- Previous hold tests indicate that Evaporator C-A-1 will be filled to at or near the maximum operating level. This is approximately 726'2" (H-2-69328, H-2-69340, and other USDOE drawings);
- Evaporation losses will occur primarily from the surface area of the Evaporator (C-A-1) (if the Evaporator is at the operating level or above, the Reboiler is completely full of fluid, therefore, no evaporation losses can occur from anywhere else in the system);
- Ambient temperature is assumed to be 68 degrees Fahrenheit (°F) or 20 degrees Celsius (°C);
- The test fluid in C-A-1 is assumed to be pure water,
- Humidity at Richland, WA assumed to be 58% (typical) http://weather.msn.com/local.aspx?wealocations=wc:USWA0373; and

Figure 5B.3.1 - 1993 Hold Test Showing Instrument Sensitivity (Volume vs Time)

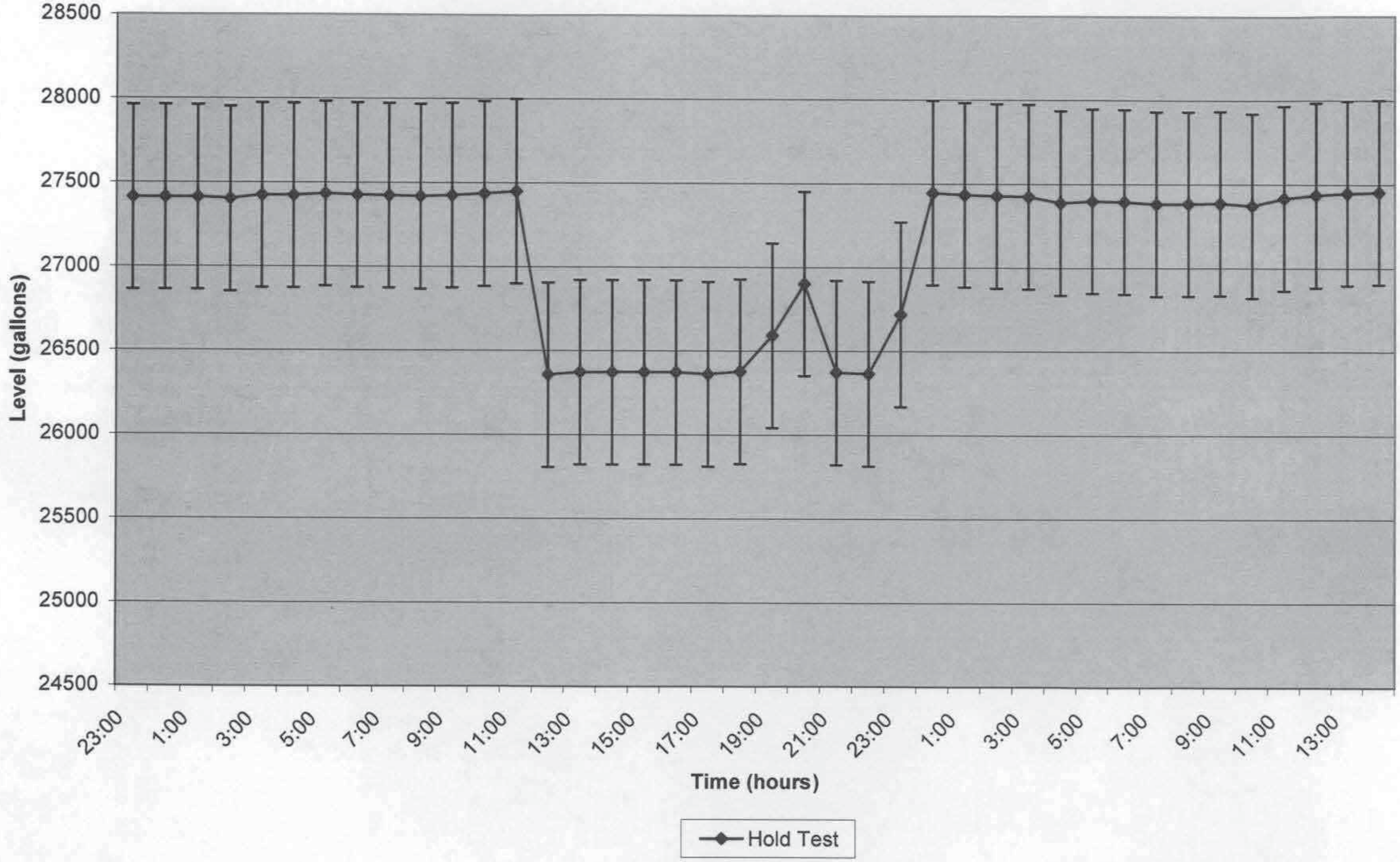


Figure 5B.3.2 - 1998 Evaporator Hold Test Showing Instrument Sensitivity

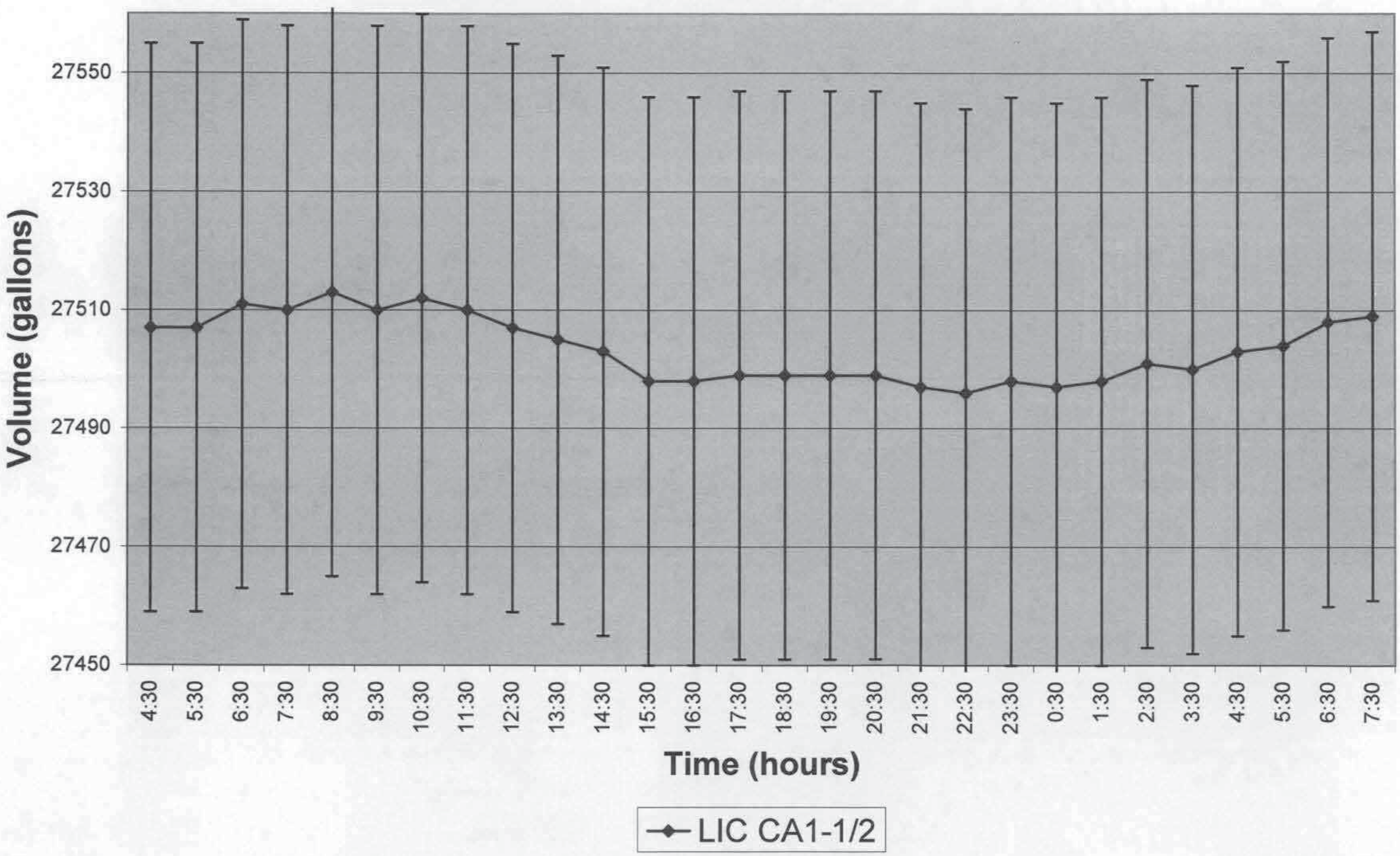
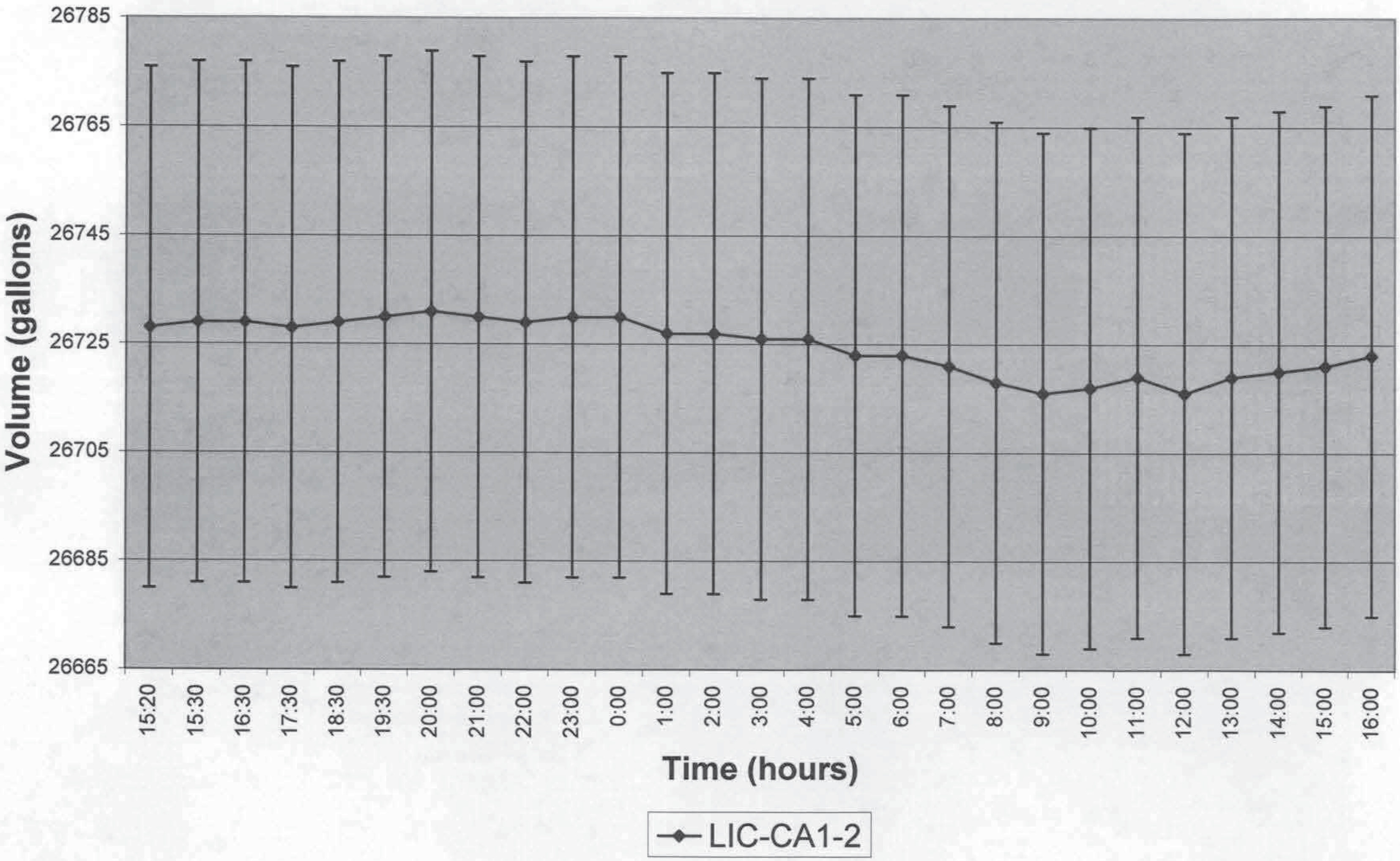


Figure 5B.3.3 - 2007 Evaporator Hold Test Showing Instrument Sensitivity



- Other properties or conditions will be determined by boundary conditions, or determined from physical property tables (i.e. steam tables, etc.), or otherwise calculated in the following sections as needed with results relevant to other sections carried forward or cross-referenced.

Boundary conditions will be changed based on actual field conditions to more accurately estimate evaporation.

Several methods to estimate evaporation losses are presented in the following section, beginning with theoretical methods and progressing through empirical methods.

5B.4.1 Langmuir's Equation

Irving Langmuir developed a way to measure vapor pressure by measuring the evaporation rate. His reasoning is that the rate at which molecules are lost due to evaporation to a gas with no partial pressure of the evaporating substance is the same as the rate at which molecules of the substance would hit the surface if it were in equilibrium with the vapor (because in equilibrium the evaporation rate and re-condensation rate cancel each other out). The theoretical equation developed by Langmuir is:

$$\frac{\Delta m}{A} = \left[P_{vp} \bullet P_a\right]\sqrt{\frac{MW}{2\pi RT}}$$; *Equation 5B.4.1.1* (Zemansky and Dittman 1981)

Where:

$\frac{\Delta m}{A}$ = (mass loss rate) / (unit area)

P_{vp} = vapor pressure of the fluid at temperature T in Pascals (Pa),

P_a = ambient vapor pressure above the fluid in Pa,

MW = molecular weight in kilograms per moles (kg/mol),

T = Temperature of the fluid in Kelvins (K)

R = the gas constant expressed as 8.314 Joules(J)/(mol K)

We be begin to calculate and solve for the values in *Equation 5B.4.1.1* by making use of known values and assumptions.

We assume an ambient temperature, T, of 68°F (20°C) (293.15K) (see boundary conditions in Section 5B.4 above).

The molecular weight, MW, of water (H2O) is 0.018 kg / mol.

The vapor pressure of water, P_{vp} at 68°F (20°C) = $\frac{lb}{ft^2}$ (2,339 Pa) (Lindeburg 1998)

Ambient partial pressure is calculated as follows:

$\phi = \frac{P_w}{P_{sat}}$; or $P_w = \phi P_{sat}$; *Equation 5B.4.1.2* (Lindeburg 1988)

Where:

Φ = Humidity ratio

P_w = Ambient Partial Pressure

P_{sat} = Saturation Pressure

Humidity at Richland, WA assumed to be 58% (typical) (see boundary conditions in Section 5B.4).

P_{sat} = 0.02339 bars (2339 Pa) at 20°C; (Moran and Shapiro 1988). We will retain this result in the following calculations.

Substituting and solving for the above values in *Equation 5B.4.1.2*, gives:

P_w = (0.58)(2339) = 1,356 Pa

We now have all the values we need for *Equation 5B.4.1.1*. By substitution, we write:

$$\frac{\Delta m}{A} = [2{,}339 - 1{,}356]\sqrt{\frac{0.018}{2\pi \cdot 8.314 \cdot 293.15}}$$

Hence, the result of *Equation 5B.4.1.1* gives an evaporation loss rate of 1.07 kg per square meter per second. This is a large rate as will soon be demonstrated. However, Langmuir's equation has the following implicit assumptions: (1) temperature of the fluid is maintained at "*T*," 68°F (20°C) in our case, at the interface and (2) the relative humidity is maintained right up to the interface. Condition (2) carries another third implicit assumption that there must be a high enough air flow rate over the water surface of concern to carry away all of the evaporating water. In a real situation, all three of the implicit assumptions required to correctly use Langmuir's equation are rarely satisfied. In fact, evaporation is a cooling process and condition (1) is actually thermodynamically impossible, so Langmuir's equation is obviously an over simplification.

To get the evaporation rate for the leak test period of 24 hours, we must apply the rate to the surface area exposed. This is assumed to be the operating level of C-A-1, at which level C-A-1 is 14 ft (4.3 m) in diameter (see boundary conditions, Section 5B.4 above):

$A = \frac{1}{4} \pi D^2$, *Equation 5B.4.1.3*

Where D = 14 ft (4.3 m)

Thus, A = 14.3 m^2 (154 ft^2). We will retain this result in the following calculations.

And we now write:

$$Evaporation\ rate\ /\ day = 1.07 \frac{kg}{s \cdot m^2} \cdot 14.3 m^2 \cdot \frac{3{,}600 s}{h} \cdot \frac{24 h}{d}$$

Or, 1,318,300 kg per day. The evaporator loops contains between 85,200 to 94,600 liters. Therefore, the predicted loss would exceed 100% (Tables 5B.4.1A [US] and 5B.4.1B [SI]). The potential effects of evaporation on Evaporator system volume and level

TABLE 5B.4.1A
Comparison of Evaporation Rate Calculations (US)

Method	Loss Flux	Flux Units[1]	Surface Area (sq feet)	Loss Flux lb/s	Total Loss (CF / day)	Total Loss (lb/day)	Total Loss in/hr	Total Loss gph	Total Loss gpd	Total Loss (inches/day)
Langmuir	1.07	kg/s*1/m^2	154	33.6	46521	2902883	151	14500	347997	3626
Dalton	108.00	cm/month	154	0.0144	20.0	1247.4952	0.0582	6.26	150	1.4
USAF	0.001	lb/min*1/ft^2	154	0.00286	3.96	247	0.0129	1.23	30	0.309
US EPA	0.944	lb/min	154	0.0157	21.8	1359	0.0708	6.79	163	1.70
US EPA, Area Correction	836	lb/min	154	13.9	19298	1204195	62.7	6015	144359	1504
Stiver and MacKay	1.33E-05	lb/s*1/ft^2	154	0.00206	2.85	178	0.00924	0.887	21	0.222
ASHRAE	0.0693	lb/h*1/ft^2	154	0.00296	4.10	256	0.0133	1.28	30.7	0.320
Boelter	2.28	lb/h	154	0.097	135	8411	0.438	42.0	1008	10.5

Notes[1]

Flux units are units that are native to the corresponding methods utilized and are used in each table, regardless of US or SI units used elsewhere.

TABLE 5B.4.1A
Comparison of Evaporation Rate Calculations (US)

Method	Loss Flux	Flux Units(1)	Surface Area (sq feet)	Loss Flux lb/s	Total Loss (CF / day)	Total Loss (lb/day)	Total Loss in/hr	Total Loss gph	Total Loss gpd	Total Loss (inches/day)
Langmuir	1.07	kg/s*1/m^2	154	33.6	46521	2902883	151	14500	347997	3626
Dalton	108.00	cm/month	154	0.0144	20.0	1247.4952	0.0582	6.26	150	1.4
USAF	0.001	lb/min*1/ft^2	154	0.00286	3.96	247	0.0129	1.23	30	0.309
US EPA	0.944	lb/min	154	0.0157	21.8	1359	0.0708	6.79	163	1.70
US EPA, Area Correction	836	lb/min	154	13.9	19298	1204195	62.7	6015	144359	1504
Stiver and MacKay	1.33E-05	lb/s*1/ft^2	154	0.00206	2.85	178	0.00924	0.887	21	0.222
ASHRAE	0.0693	lb/h*1/ft^2	154	0.00296	4.10	256	0.0133	1.28	30.7	0.320
Boelter	2.28	lb/h	154	0.097	135	8411	0.438	42.0	1008	10.5

Notes[1]

Flux units are units that are native to the corresponding methods utilized and are used in each table, regardless of US or SI units used elsewhere.

predicted by this equation is show in Figures 5B.4.1 and 5B.4.2. Clearly, this is an impossible rate for the physical situation.

Evaporation is created by a humidity gradient between the humidity near the surface of a fluid and the humidity of the surrounding air. However, as the fluid evaporates, a boundary layer of nearly 100 percent humidity air is created just above the surface. This slows down the rate since the rate of evaporation is proportional to the difference between the vapor pressure and the partial pressure of the fluid. The transport mechanism removing the water from the surface of the fluid is diffusion through air, which also limits the rate of evaporation. Further, as the fluid evaporates, the partial pressure of the fluid over the surface is nearly equal to the fluid below and drops off in a gradient away from the surface. The steepness of the gradient depends on air flow rate above the fluid, as well as temperature. These effects, taken together, are non-linear and are not reliably predictable by theoretical equations. Rigorous, complex computer algorithms have been developed that account for these effects (for instance, Lee and Dalpiaz). However, these algorithms can be cumbersome. Further, while more accurate predictions may be made detailed knowledge of multiple parameters (i.e. boundary layer conditions) is required. Several relatively simple empirical equations have been developed, beginning with the earliest, Dalton's Law, which can provide useful estimates of evaporation.

5B.4.2 Dalton's Law

Most empirical equations are in the form of Dalton's Law, who proposed the following simple equation in 1802:

$E = f(u)\cdot(e_s - e_a)$; *Equation 5B.4.2.1*

f(u) is a function of air speed and height of above the water surface. *Equation 5B.3.1* can be estimated as

$E = a\cdot(e_s - e_a)$*Equation 5B.4.2.2*;

Where

E = Free water surface evaporation (cm per month),

e_s = the saturation vapor pressure at the temperature of the water surface, millibars (mbar) (equivalent to P_s above or 23.39 mbar)

e_a = the vapor pressure in the air; the term e_a is also equal to the saturation vapour pressure at the dew point temperature (equivalent to P_w above or 1,356 mbar).

a = 5 for small, shallow water, and

a =11 for large deep water, Singh and Xu (1997).

However, additional sources (Ohio University 2004) recommend calculating the vapor pressure deficit term (e_s-e_a) in *Equation 5B.4.2.2* above, by estimating saturation vapor pressure e_s, in kilo Pascals (kPa), as follows:

$e_s = e^{\left[\frac{16.78T - 116.9}{T + 237.3}\right]}$; *Equation 5B.4.2.3*

Figure 5B.4.1 - Potential Evaporation Effects (Volumetric)

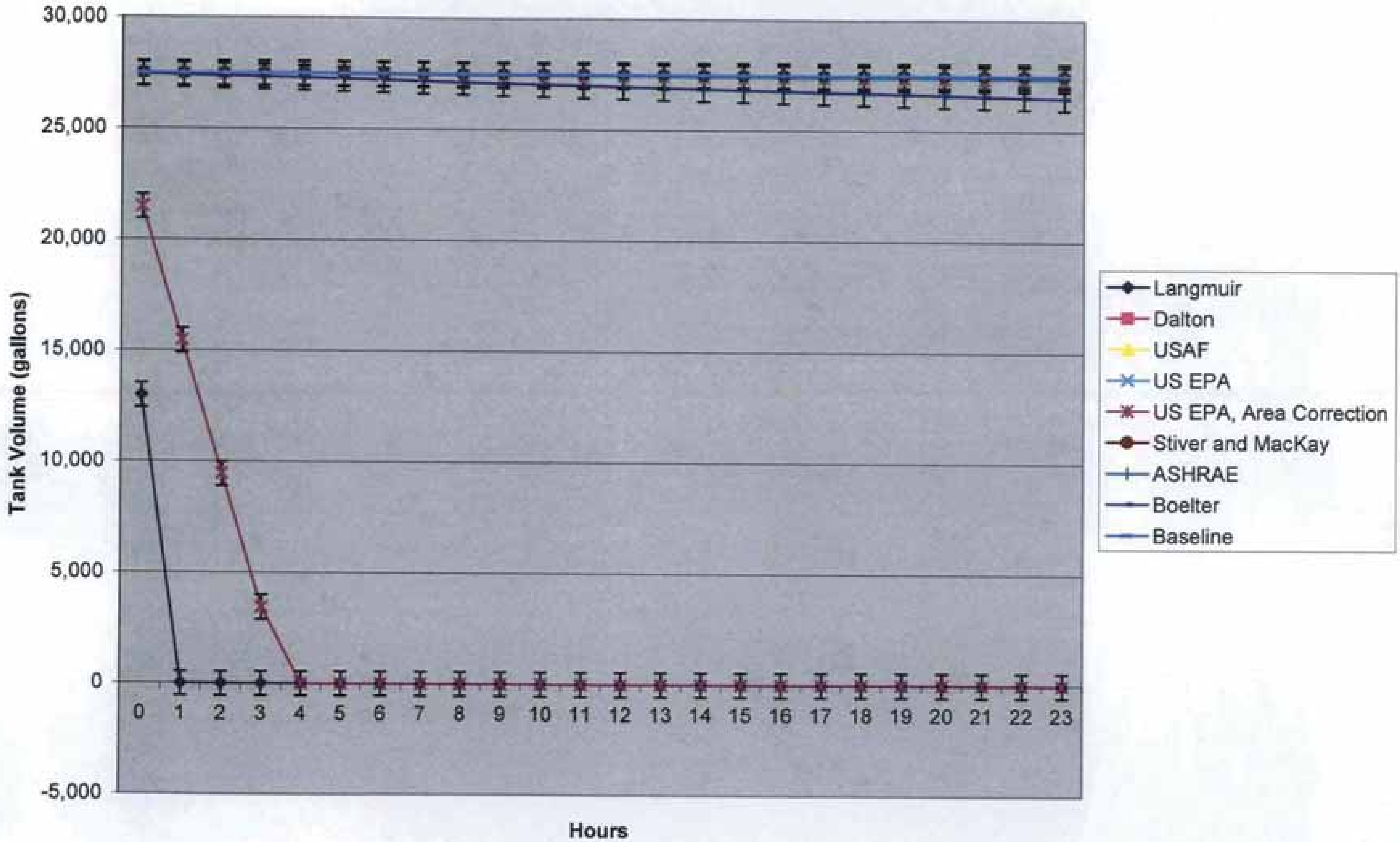
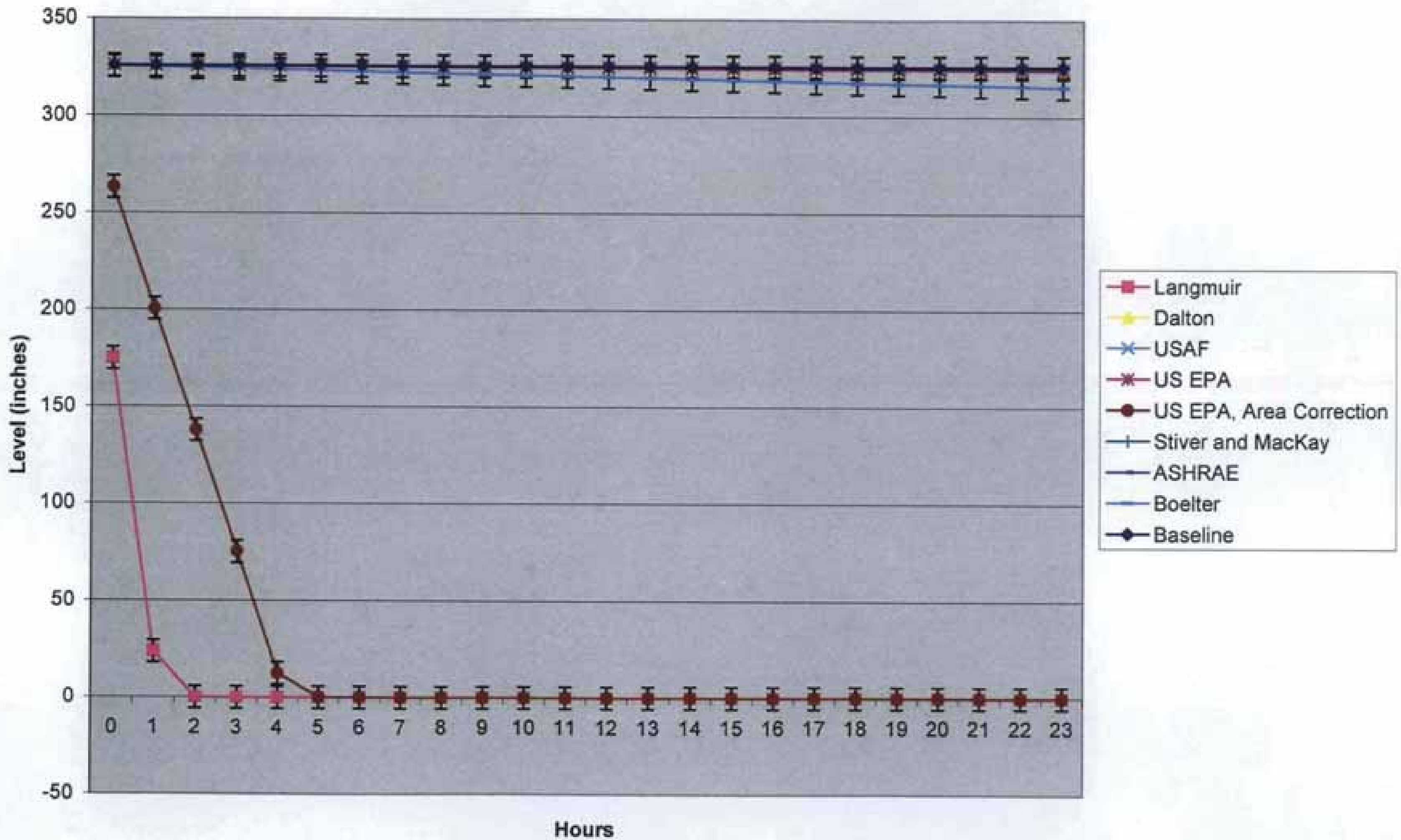


Figure 5B.4.2 - Potential Evaporation Effects (Level)



And estimating actual vapor, e_a, as:

$e_a = e_s \frac{RH}{100}$; *Equation 5B.4.2.4*

And where

T = is the temperature, in Celsius, and

RH = the relative humidity (percent)

For saturation vapor pressure, we solve *Equation 5B.4.2.3* as follows:

$$e_s = e^{\left[\frac{16.78 \cdot 20 - 116.9}{20 + 237.3}\right]}$$

And we solve *Equation 5B.4.2.4* as follows:

$$e_a = e_s \frac{RH}{100}$$

Thus, e_s is 2.34 kPa or 23.4 mbar and e_a is 13.6 mbar. This pressure is essentially identical to what is found by looking up this value in steam tables (see Section 5B.4.1). So, equations ,are, in fact, good estimates.

We have all the terms we need for *Equation 5B.4.2.2*, so we write:

$E = 11 \cdot (23.4 - 13.6)$, assuming that for Dalton's Law (generally concerning large water bodies) that a small value for a is appropriate.

Thus, the evaporation rate, E, is 108 centimeters per month, in the common units of Dalton's equation (Tables 5B.4.1A and 5B.4.1B, US and SI units). The potential effects of evaporation on Evaporator system volume and level predicted by this equation is show in Figures 5B.4.1 and 5B.4.2.

5B.4.3 United States Air Force Empirical Evaporation Equations

The United States Air Force developed the following equations for predicting the rate at which liquid evaporates from the surface of a pool of liquid which is at or near the ambient temperature. The equations were derived from field tests performed by the U.S. Air Force with pools of liquid hydrazine. http://www.air-dispersion.com/usource.html#Non-Boiling%20Liquid%20Pool

$E = (4.66X10^{-6}) \cdot U^{0.75} \cdot T_F \cdot MW \cdot \left(\frac{P_S}{P_H}\right)$; *Equation 5B.4.3.1*

Where

E = evaporation flux, $\frac{lb}{\min}$ per ft^2 of pool surface

u = windspeed just above the liquid surface, $\frac{miles}{hour}$

T_A = ambient temperature, K

T_F = pool liquid temperature correction factor

T_P = pool liquid temperature, °F

MW = pool liquid molecular weight

P_S = pool liquid vapor pressure at ambient temperature, mmHg

P_H = hydrazine vapor pressure at ambient temperature, mmHg

If T_P is 32°F or less, then $T_F = 1.0$

If $T_P > 32$°F, then $T_F = 1.0 + 0.00133\ (T_P - 32)^2$; *Equation 5B.4.3.2*

$$P_H = 760 \cdot e^{\left[65.3319 - \left(\frac{7245}{T_A}\right) - (8.22 \cdot \ln T_A) + (6.1557 X 10^{-3}) T_A\right]}$$; *Equation 5B.4.3.3*

We be begin to calculate and solve for the values in *Equation 5B.4.3.1* by making use of known values and assumptions.

We assume an ambient temperature, T_A, of 68°F (20°C) (293.15K), as before.

The molecular weight, MW, of water (H2O) is 18 grams / mol.

We assume the temperature of the pool is also 68°F.

The vapor pressure of water, P_S at 68°F (20°C) = 17.56 mmHg (Lindeburg 1998).

We must substitute and solve *Equations 5B.4.2.2* and *5B.4.2.3* prior to *5B.4.3.1*, so we write:

For *Equation 5B.3.2.2*, $T_P > 32$°F, then $T_F = 1.0 + 0.00133\ (68 - 32)^2$

So, $T_F = 2.724$°F

For *Equation 5B.4.2.3*,

$$P_H = 760 \cdot e^{\left[65.3319 - \left(\frac{7245}{293.15}\right) - (8.22 \cdot \ln 293.15) + (6.1557 X 10^{-3}) 293.15\right]}$$

So, P_H =10.60 mmHg

However, the airflow over the water in C-A-1 is still needed (i.e. a value for U). The Facility RCRA permit (WA7890008967) states that:

> During waste processing, the airflow is about 20.5 cubic meters per minute, with about 4.3 cubic meters per minute ventilated from tank C-100 and the remainder from the vapor-liquid separator and air inleakage.

This leaves approximately 16.2 cubic meters per minute ventilated from C-A-1. Using the following relationship:

$Q = VA$, or $V = \frac{Q}{A}$; *Equation 5B.4.3.4*

Where

Q = volumetric flow rate (m_3/min)

V = velocity (m/s); and

A = Area (m_2).

The area is already known to be 14.3 m^2 (see Section 5B.4). We write the following,

$$V = \frac{16.2}{14.3m^2} \cdot \frac{m^3}{\min} \cdot \frac{\min}{60s}$$

So, V is 1.888 meters per second or 4.22 mph.

And now, inserting these values into *Equation 5B.4.3.1*, we may write,

$$E = \left(4.66X10^{-6}\right) \cdot 4.22^{0.75} \cdot 2.724 \cdot 18 \cdot \left(\frac{17.56}{10.59}\right)$$

Thus, our evaporation flux, using the USAF formulas, is $1.11X10^{-3} \frac{lb}{\min}$ per ft^2 of fluid surface or 0.1716 pounds per minute from the surface of C-A-1. The total lost over 24 hours is then:

$$Evaporation\ rate\ /\ day = 0.0011 \frac{lb}{\min \cdot ft^2} \cdot 154 ft^2 \cdot \frac{60 \min}{h} \cdot \frac{24h}{d}$$

Or 247 lb lost per day due to evaporation (Tables 5B.4.1A and 5B.4.1B, US and SI units). The potential effects of evaporation on Evaporator system volume and level predicted by this equation is show in Figures 5B.4.1 and 5B.4.2.

5B.4.4 United States EPA

The following equations are for predicting the rate at which liquid evaporates from the surface of a pool of liquid which is at or near the ambient temperature. The equations were developed by the United States Environmental Protection Agency (U.S. EPA). http://www.air-dispersion.com/usource.html#Non-Boiling%20Liquid%20Pool

$$E = \frac{0.284 \cdot U^{0.78} \cdot MW \cdot A \cdot P}{RT}; \textit{ Equation 5B.4.4.1}$$

Where:

E = evaporation rate, lb / minute

U = windspeed just above the pool liquid surface, m / second (calculated as 1.888 m/s above)

MW = molecular weight of the pool liquid (18 g/mol for water)

A = surface area of the pool liquid, ft^2 (154 square feet)

P = vapor pressure of the pool liquid at the pool temperature, mm Hg (17.56 mmHg)

T = pool liquid temperature, K (assumed to be 293.15K)

R = the Universal Gas Law constant expressed as 82.05 (atm * cm^3) / (gmol · °K)

The U.S. EPA also defined the pool depth as 0.033 ft (i.e., 1 cm) so that the surface area of the pool liquid could be calculated as:

A = (cubic feet of pool liquid) / (0.033 ft); *Equation 5B.4.4.2*

However, for deep pools, including the relation in *Equation 5B.4.4.2* predicts large evaporation rates (see below and Tables 5B.4.1A and 5B.4.1B, US and SI units).

Since we know all the values we need for *Equation 5B.4.4.1*, substituting into this equation, we write:

$$E = \frac{0.284 \cdot 1.888^{0.78} \cdot 18 \cdot 154 \cdot 17.56}{82.05 \cdot 293.15}$$

Giving an evaporation flux of 0.944 pounds per minute and 1,359 pounds per day lost by evaporation. (Tables 5B.4.1A and 5B.4.1B, US and SI units).

Returning to *Equation 5B.4.4.2*, the volume of C-A-1, at the typical operating level, is 2,660 cubic feet. Applying the divisor of 0.033 ft as required by *Equation 5B.4.4.2*, the area becomes 81,076 square feet and the resulting evaporative flux is 836 pounds per minute (Tables 5B.4.1A and 5B.4.1B, US and SI units). It is likely that the area correction factor is incorrect or misapplied to the equation. The potential effects of evaporation on Evaporator system volume and level predicted by this equation is show in Figures 5B.4.1 and 5B.4.2.

5B.4.5 Stiver and Mackay

The following equations are for predicting the rate at which liquid evaporates from the surface of a pool of liquid which is at or near the ambient temperature. The equations were developed by Warren Stiver and Dennis Mackay of the Chemical Engineering Department at the University of Toronto. http://www.air-dispersion.com/usource.html#Non-Boiling%20Liquid%20Pool

$E = \frac{k \cdot P \cdot MW}{RT_A}$; *Equation 5B.4.5.1*; and

$k = 0.00293\ U$; *Equation 5B.4.5.2*

Where

E = evaporation flux, (lb / s) / ft 2 of pool surface,

k = mass transfer coefficient, ft / s,

T_A = ambient temperature, °R (assumed to be 527.7°R),

MW = pool liquid molecular weight (18 g/mol for water),

P = pool liquid vapor pressure at ambient temperature, mmHg (17.56 mmHg, from above),

R = the Universal Gas Law constant = 555 (mmHg * ft 3) / (lbmol * °R),

U = wind speed just above the liquid surface, miles / hour (4.22 mph, from above),

We have only to calculate k from the simple relationship of *Equation 5B.4.5.2*. However, U is known, so, substituting for k into *Equation 5B.5.1*, we write,

$$E = \frac{0.00293 \cdot 4.22 \cdot 17.56 \cdot 18}{555 \cdot 527.7}$$

Thus, E, our evaporation flux, is $1.33X10^{-5}$ pounds per second per square foot of surface area or 2.06 pounds per second (utilizing the previously calculated surface area of 154 square feet). Thus the total loss by evaporation is 178 pounds per day (Tables 5B.4.1A and 5B.4.1B, US and SI units). The potential effects of evaporation on Evaporator system volume and level predicted by this equation is show in Figures 5B.4.1 and 5B.4.2.

5B.4.6 American Society of Heating, Refrigeration and Air-conditioning Engineers

American Society of Heating, Refrigeration and Air-conditioning Engineers (ASHRAE) provides the most commonly used equation for estimating evaporation loss in the following equation:

$$W = \frac{[A + B \cdot V](P_W - P_a)}{H_V}; \textit{ Equation 5B.4.6.1}$$

Where

W = water evaporation rate, (lb/hr) per sq.ft. of pond surface area

A = a constant = 95

B = a constant = 37.4

V = air velocity over the pond surface, miles/hr (4.22 mph, from above)

P_w = vapor pressure of water at the pond water temperature, inHg (17.56 mmHg or 0.6913 inHg, from above)

P_a = vapor pressure of water at the air dewpoint temperature, inHg

H_v = heat of vaporization of water at the pond water temperature, Btu/lb

We have only to find P_a and H_v.

We calculate P_a using *Equation 5B.4.1.2* or (*Equation 5B.4.2.4*) with slightly different terms, as in Section 5B.2.1:

$$P_a = \phi P_w; \textit{ Equation 5B.4.6.2}$$

And so we write:

$$P_a = 0.58 \cdot 0.6913$$

So, P_a = 0.40095 inHg

H_v is 1,059.6 Btu/lb at 68°F (Moran and Shapiro 1988).

Substituting into *Equation 5B.4.6.1*, we write,

$$W = \frac{[95 + 37.4 \cdot 4.22](0.6913 - 0.40095)}{1{,}059.6}$$

Thus, the water loss rate, W, is 0.0693 pounds per hour per square foot, or 10.7 pounds per hour. A total loss of 256 pounds per day is predicted by the ASHRAE equation (Tables 5B.4.1A and 5B.4.1B, US and SI units). The potential effects of evaporation on Evaporator system volume and level predicted by this equation is show in Figures 5B.4.1 and 5B.4.2.

5B.4.7 Boelter's Equation

Another commonly used equation to predict evaporation rates, especially from tanks, is Boelter's equation. Boelter et al (1946) developed the following equation to predict the amount of the water vapor transferred from a pure water surface to the bulk air based on the experimental data.

$W = 0.00129 \cdot A \cdot (P_i - P_b)^{1.22}$; *Equation 5B.4.7.1*

Where:

W = Amount of water vapor transferred (lb/hr)

A = surface area (ft2), (154 square feet, from above)

P_i = surface water vapor pressure (mm Hg) (17.56 mmHg from above)

P_b = bulk phase water vapor pressure (mm Hg) (10.18 mmHg from above)

We apply these values to the Boelter equation and write:

$$W = 0.00129 \cdot 154 \cdot (17.56 - 10.18)^{1.22}$$

Thus, the evaporation flux rate is 2.28 pounds per hour or a total loss rate of 54.7 pounds through evaporation (Tables 5B.4.1A and 5B.4.1B, US and SI units). The potential effects of evaporation on Evaporator system volume and level predicted by this equation is show in Figures 5B.4.1 and 5B.4.2.

It should be noted that the validity of applying the Boelter equation to large tanks has been questioned, since Boelter et al developed the empirical equation based on experimental data using a small pan (Young and Lee 2003).

5B.5 THERMAL EXPANSION

It is desired to determine what effects thermal expansion and/or contraction may have during the Vapor-Liquid Separator Leak Test/Hold Test. Calculations of this rate could be used to separate any losses from the Loop caused by evaporation from losses caused by leaks during the hold test period.

The following boundary conditions and assumptions are relevant for each of the following calculations and for each test campaign analyzed:

- The level of C-A-1 will initially be at the typical operating level of C-A-1, 721'2" (H-2-69328, H-2-69340, and other USDOE drawings),

- The diameter of C-A-1 is 14 feet (ft) or 4.3 meters (m) at this location (H-2-69328, H-2-69340, other USDOE drawings, and WA7890008967),
- The test fluid in C-A-1 is assumed to be pure water,
- Humidity at Richland, WA assumed to be 58% (typical) http://weather.msn.com/local.aspx?wealocations=wc:USWA0373; and
- Other properties or conditions will be determined by boundary conditions, or determined from physical property tables (i.e. steam tables, etc.), or otherwise calculated in the following sections as needed with results relevant to other sections carried forward or cross-referenced.

Thermal expansion is calculated by the following equation:

$\Delta V = V_0 \beta (T_2 - T_1)$; *Equation 5B.5.1*

Where

ΔV = change in volume,

V_0 = initial volume,

β = Bulk coefficient of thermal expansion,

T_1 = initial temperature, and

T_2 = final temperature

And

$\beta = 3\alpha$

Where

α = Liner coefficient of thermal expansion

The linear thermal coefficient of thermal expansion for stainless steel (α) is commonly $9.6X10^{-6}$/°F, giving a bulk coefficient of expansion (β) of $2.9X10^{-5}$/°F (Perry's 1984).

The bulk thermal coefficient of thermal expansion for water varies significantly by temperature (see Table 5B.5.1, US and SI units).

5B.5.1 1993 Test

There is no apparent sinusoidal pattern in the hold test data collected in 1993. Therefore, attempting to determine whether thermal expansion was a factor in these data was not attempted. Given the disruption of 1993 data by the step drop mid-test (see Figure 5B.2.1 and Section 5B.2.1), it is possible that this effect may have been observed had this not occurred. However, it is indicated that level indicating instrumentation may have been less sensitive in 1993 (sensitive to +/- 550 gallons vs +/- 48 for the 1998 and 2007 tests), so it is also possible, if not probable that small changes observed either would not have been detected during this test or would have been masked by larger variations in level measurement.

5B.5.2 1998 Test

The 1998 IAR (USDOE 1998) described a gain and loss in the volume of the Vapor-Liquid Separator Loop that were described as within the operating range of the level measuring equipment and attributable to minor temperature fluctuations during the test. The system measured a gain of 5 gallons and a loss of 11 gallons during the test (Table 5B.2.2, US and SI units).

The volume fluctuations observed in 1998 are shown in Figure 5B.2.2. These fluctuations most nearly follow a sinusoidal pattern. A likely explanation is thermal expansion and contraction caused by diurnal temperature fluctuations. To test this explanation, the following analysis was performed.

Thermal expansion is largely contingent upon the temperature of the fluid. (Typically, fluid expansion coefficients are much higher than that of the enclosure. Since water is the working fluid of the hold test, the thermal expansion coefficient is much higher than that of the shell of the evaporator and this assumption holds.) However, neither ambient nor C-A-1 temperatures were recorded during the previous hold test. Volume data were recorded hourly as gallons. Concerning water, the volumetric coefficient of expansion is temperature dependent (Table 5B.5.2.1, US and SI units). This material property, together with an iterative approach, was used to determine the most likely conditions of the water in the evaporator loop during the hold test. Tables 5B.5.2.2A and 5B.5.2.2B show initial conditions attempted for loop fill water (50°F and 68°F or 10°C, and 20°C). Figure 5B.5.2.1 shows the various expansion and contraction curves predicted by these initial conditions. It can be seen that the 68°F (20°C) condition best matches actual conditions. From this, an idealized sinusoidal temperature distribution (Table 5B.5.2.3, US and SI units) and inferred CA1 temperature curve (Figure 5B.5.2.2) were predicted. However, using this curve directly resulted in incorrectly predicting volumetric expansion. The best fit to actual volumetric data was another diurnal 6 hours out of phase from the idealized curve (Table 5B.5.2.3) and ("Idealized Curve," Figure 5B.5.2.1). This result was arrived at by matching the volumetric output.

The 68°F (20°C) prediction and idealized curve on Figure 5B.5.2.1 show excellent agreement to actual data, albeit these deviations are small. Arguably, such behavior is, perhaps, attributable to instrument drift, as postulated in the 1993 hold test, however, the above analysis show that the data seem to best fit a 24 hour periodic fluctuation. Such a fluctuation is best explained by external temperature effects (such diurnal temperature cycles) or some other daily phenomena. Therefore, it is most likely that the volume fluctuations observed in 1998 were either caused by diurnal temperature fluctuations or some other daily phenomena associated with a 24 hour period or cycle. However, these affects have been of small magnitude, less than 17 gallons, and therefore within known accuracy of level sensing instrumentation (+/- 48 gallons). Therefore, the actual magnitude of these fluctuations is not likely to be accurately represented by the current sensors due to their small magnitude (i.e. the temperature effects are represented qualitatively rather than quantitatively).

5B.5.3 2007 Test – C-A-1

Analyses similar to those performed in Section 5B.5.2 were performed on 2007 data. Sinusoidal forcing functions presumed to be diurnal temperature fluctuations similar to

TABLE 5B.5.2.1
Coefficients of Thermal Expansion of Water

°C	°F	α (SI) 1μm/(m°C)	β (SI) 1μm³/(m³°C)	α (US) 1/°F	β (US) 1/°F
0	32	-23.1	-69.3	-1.28333E-05	-0.0000385
1	33.8	-50	-150	-2.77778E-05	-8.33333E-05
4	39.2	0	0	0	0
10	50	29.3	88	1.63E-05	4.88E-05
20	68	69	207	3.83E-05	1.15E-04
30	86	101	303	5.61E-05	1.68E-04
40	104	128	385	7.12963E-05	2.14E-04
50	122	153	457	8.50E-05	2.55E-04
100	212	250	750	1.39E-04	4.17E-04

Sources:

CRC Handbook of Chemistry and Physics, David R. Lide, Ed. 79th Edition, CRC Press, Boca Raton, FL, 1998.

CRC Handbook of Chemistry and Physics, Robert C. Weast, Ed. 62 Edition, CRC Press, Boca Raton, FL, 1981.

TABLE 5B.5.2.2A
1998 Hold Test
Modeled and Actual Diurnal Temperatures and Volumetric Expansions (US)

Actual Data					68°F Iteration					50°F Iteration					Idealized					Actual		Predicted	
Date	Time	Level (gal)	Level (CF)	Actual ΔV (gal)	Derived ΔT (°F)	Predicted T (°F)	Recalculated Bulk Coeff (β) (1/°F)	Predicted ΔV (gal)	Predicted Level (gal)	Derived ΔT (°F)	Predicted T (°F)	Recalculated Bulk Coeff (β) (1/°F)	Predicted ΔV (gal)	Predicted Level (gal)	Predicted T (°F)	Bulk Coeff (β) (1/°F)	Predicted ΔV (gal)	Predicted Level (gal)	Heat Change (Btu)	Actual Height in Evap Loop (inches)	Net Rise/Fall C-A-1 (inch)	Predicted Height in Evap Loop (inches)	Net Rise/Fall C-A-1 (inch)
6/1/1998	4:30	27507	3677.2	0	0.0000	68.00	1.15E-04	0.00	27507.0		50.0	4.88E-05	0.00	27507.0	64.72	1.05E-04				286.5	0.00		
6/1/1998	5:30	27507	3677.2	0	0.0000	68.00	1.15E-04	0.00	27507.0	0.0000	50.0	4.88E-05	0.00	27507.0	65.07	1.06E-04	1.02	27508.0	60.83	286.5	0.00	286.6	-0.031
6/1/1998	6:30	27511	3677.7	4	1.2645	69.26	1.19E-04	4.13	27511.1	2.9778	53.0	5.98E-05	4.90	27511.9	65.57	1.08E-04	1.47	27508.5	86.03	286.6	0.04	286.6	-0.035
6/1/1998	7:30	27510	3677.6	3	0.9484	68.95	1.18E-04	3.07	27510.1	2.2334	52.2	5.70E-05	3.50	27510.5	66.17	1.10E-04	1.83	27508.8	105.36	286.6	0.03	286.6	-0.039
6/1/1998	8:30	27513	3678.0	6	1.8968	69.90	1.21E-04	6.29	27513.3	4.4668	54.5	6.53E-05	8.02	27515.0	66.85	1.12E-04	2.07	27509.1	117.51	286.6	0.06	286.6	-0.042
6/1/1998	9:30	27510	3677.6	3	0.9484	68.95	1.18E-04	3.07	27510.1	2.2334	52.2	5.70E-05	3.50	27510.5	67.55	1.14E-04	2.19	27509.2	121.66	286.6	0.03	286.6	-0.043
6/1/1998	10:30	27512	3677.8	5	1.5806	69.58	1.20E-04	5.20	27512.2	3.7223	53.7	6.25E-05	6.40	27513.4	68.23	1.16E-04	2.15	27509.2	117.51	286.6	0.05	286.6	-0.042
6/1/1998	11:30	27510	3677.6	3	0.9484	68.95	1.18E-04	3.07	27510.1	2.2334	52.2	5.70E-05	3.50	27510.5	68.83	1.17E-04	1.96	27509.0	105.36	286.6	0.03	286.6	-0.040
6/1/1998	12:30	27507	3677.2	0	0.0000	68.00	1.15E-04	0.00	27507.0	0.0000	50.0	4.88E-05	0.00	27507.0	69.33	1.19E-04	1.62	27508.6	86.03	286.5	0.00	286.6	-0.037
6/1/1998	13:30	27505	3676.9	-2	-0.6323	67.37	1.13E-04	-1.96	27505.0	-1.4889	48.5	4.21E-05	-1.72	27505.3	69.68	1.20E-04	1.15	27508.2	60.83	286.5	-0.02	286.6	-0.032
6/1/1998	14:30	27503	3676.6	-4	-1.2645	66.74	1.10E-04	-3.84	27503.2	-2.9778	47.0	3.54E-05	-2.90	27504.1	69.86	1.22E-04	0.61	27507.6	31.49	286.5	-0.04	286.6	-0.026
6/1/1998	15:30	27498	3675.9	-9	-2.8451	65.15	1.05E-04	-8.18	27498.8	-6.7001	43.3	1.85E-05	-3.42	27503.6	69.86	1.22E-04	0.00	27507.0	0.00	286.4	-0.09	286.6	-0.020
6/1/1998	16:30	27498	3675.9	-9	-2.8451	65.15	1.05E-04	-8.18	27498.8	-6.7001	43.3	1.85E-05	-3.42	27503.6	69.68	1.21E-04	-0.60	27506.4	-31.49	286.4	-0.09	286.5	-0.014
6/1/1998	17:30	27499	3676.1	-8	-2.5290	65.47	1.06E-04	-7.35	27499.6	-5.9557	44.0	2.19E-05	-3.59	27503.4	69.33	1.20E-04	-1.15	27505.8	-60.83	286.4	-0.08	286.5	-0.008
6/1/1998	18:30	27499	3676.1	-8	-2.5290	65.47	1.06E-04	-7.35	27499.6	-5.9557	44.0	2.19E-05	-3.59	27503.4	68.83	1.18E-04	-1.61	27505.4	-86.03	286.4	-0.08	286.5	-0.003
6/1/1998	19:30	27499	3676.1	-8	-2.5290	65.47	1.06E-04	-7.35	27499.6	-5.9557	44.0	2.19E-05	-3.59	27503.4	68.23	1.16E-04	-1.93	27505.1	-105.36	286.4	-0.08	286.5	0.000
6/1/1998	20:30	27499	3676.1	-8	-2.5290	65.47	1.06E-04	-7.35	27499.6	-5.9557	44.0	2.19E-05	-3.59	27503.4	67.55	1.13E-04	-2.11	27504.9	-117.51	286.4	-0.08	286.5	0.002
6/1/1998	21:30	27497	3675.8	-10	-3.1613	64.84	1.03E-04	-8.99	27498.0	-7.4446	42.6	1.52E-05	-3.11	27503.9	66.85	1.11E-04	-2.13	27504.9	-121.66	286.4	-0.10	286.5	0.002
6/1/1998	22:30	27496	3675.7	-11	-3.4774	64.52	1.02E-04	-9.78	27497.2	-8.1890	41.8	1.18E-05	-2.66	27504.3	66.17	1.08E-04	-2.01	27505.0	-117.51	286.4	-0.11	286.5	0.001
6/1/1998	23:30	27498	3675.9	-9	-2.8451	65.15	1.05E-04	-8.18	27498.8	-6.7001	43.3	1.85E-05	-3.42	27503.6	65.57	1.06E-04	-1.77	27505.2	-105.36	286.4	-0.09	286.5	-0.002
6/2/1998	0:30	27497	3675.8	-10	-3.1613	64.84	1.03E-04	-8.99	27498.0	-7.4446	42.6	1.52E-05	-3.11	27503.9	65.07	1.04E-04	-1.42	27505.6	-86.03	286.4	-0.10	286.5	-0.005
6/2/1998	1:30	27498	3675.9	-9	-2.8451	65.15	1.05E-04	-8.18	27498.8	-6.7001	43.3	1.85E-05	-3.42	27503.6	64.72	1.03E-04	-0.99	27506.0	-60.83	286.4	-0.09	286.5	-0.010
6/2/1998	2:30	27501	3676.3	-6	-1.8968	66.10	1.08E-04	-5.64	27501.4	-4.4668	45.5	2.86E-05	-3.52	27503.5	64.54	1.02E-04	-0.51	27506.5	-31.49	286.5	-0.06	286.5	-0.015
6/2/1998	3:30	27500	3676.2	-7	-2.2129	65.79	1.07E-04	-6.50	27500.5	-5.2112	44.8	2.53E-05	-3.62	27503.4	64.54	1.02E-04	0.00	27507.0	0.00	286.5	-0.07	286.6	-0.020
6/2/1998	4:30	27503	3676.6	-4	-1.2645	66.74	1.10E-04	-3.84	27503.2	-2.9778	47.0	3.54E-05	-2.90	27504.1	64.72	1.05E-04	0.52	27507.5	31.49	286.5	-0.04	286.6	-0.025
6/2/1998	5:30	27504	3676.7	-3	-0.9484	67.05	1.12E-04	-2.91	27504.1	-2.2334	47.8	3.87E-05	-2.38	27504.6	65.07	1.06E-04	1.02	27508.0	60.83	286.5	-0.03	286.6	-0.031
6/2/1998	6:30	27508	3677.3	1	0.3161	68.32	1.16E-04	1.01	27508.0	0.7445	50.7	5.16E-05	1.06	27508.1	65.57	1.08E-04	1.47	27508.5	86.03	286.5	0.01	286.6	-0.035
6/2/1998	7:30	27509	3677.4	2	0.6323	68.63	1.17E-04	2.03	27509.0	1.4889	51.5	5.43E-05	2.22	27509.2	66.17	1.10E-04	1.83	27508.8	105.36	286.6	0.02	286.6	-0.039

TABLE 5B.5.2.2B
1998 Hold Test
Modeled and Actual Diurnal Temperatures and Diurnal Expansions (SI)

Actual Data					20°C Iteration					10°C Iteration					Idealized					Actual		Predicted	
Date	Time	Level (Liters)	Level (m^3)	Actual ΔV (Liters)	Derived ΔT (°C)	Predicted T (°C)	Recalculated Bulk Coeff (β) (1/°C)	Predicted ΔV (Liters)	Predicted Level (Liters)	Derived ΔT (°C)	Predicted T (°C)	Recalculated Bulk Coeff (β) (1/°C)	Predicted ΔV (Liters)	Predicted Level (Liters)	Predicted T (°C)	Bulk Coeff (β) (1/°C)	Predicted ΔV (Liters)	Predicted Level (Liters)	Heat Change (KJ)	Actual Height in Evap Loop (cm)	Net Rise/Fall C-A-1 (cm)	Predicted Height in Evap Loop (cm)	Net Rise/Fall C-A-1 (cm)
6/1/1998	4:30	104125	104.1	0	0.00	20.0	2.07E-04	0.00	104125.3	0.00	10.0	8.79E-05	0.00	104125.3	18.2	1.90E-04				727.8	0.00		
6/1/1998	5:30	104125	104.1	0	0.00	20.0	2.07E-04	0.00	104125.3	0.00	10.0	8.79E-05	0.00	104125.3	18.4	1.91E-04	3.87	104129	64.18	727.8	0.00	728	-0.078
6/1/1998	6:30	104140	104.1	15	0.70	20.7	2.14E-04	15.63	104141.0	1.65	11.7	1.08E-04	18.54	104143.9	18.6	1.94E-04	5.56	104131	90.76	727.9	0.11	728	-0.089
6/1/1998	7:30	104137	104.1	11	0.53	20.5	2.12E-04	11.63	104137.0	1.24	11.2	1.03E-04	13.27	104138.6	19.0	1.97E-04	6.92	104132	111.16	727.9	0.08	728	-0.099
6/1/1998	8:30	104148	104.1	23	1.05	21.1	2.17E-04	23.82	104149.1	2.48	12.5	1.17E-04	30.35	104155.7	19.4	2.01E-04	7.85	104133	123.98	727.9	0.16	728	-0.105
6/1/1998	9:30	104137	104.1	11	0.53	20.5	2.12E-04	11.63	104137.0	1.24	11.2	1.03E-04	13.27	104138.6	19.7	2.05E-04	8.28	104134	128.36	727.9	0.08	728	-0.108
6/1/1998	10:30	104144	104.1	19	0.88	20.9	2.15E-04	19.69	104145.0	2.07	12.1	1.13E-04	24.23	104149.6	20.1	2.08E-04	8.14	104133	123.98	727.9	0.13	728	-0.107
6/1/1998	11:30	104137	104.1	11	0.53	20.5	2.12E-04	11.63	104137.0	1.24	11.2	1.03E-04	13.27	104138.6	20.5	2.11E-04	7.41	104133	111.16	727.9	0.08	728	-0.102
6/1/1998	12:30	104125	104.1	0	0.00	20.0	2.07E-04	0.00	104125.3	0.00	10.0	8.79E-05	0.00	104125.3	20.7	2.14E-04	6.13	104131	90.76	727.8	0.00	728	-0.093
6/1/1998	13:30	104118	104.1	-8	-0.35	19.6	2.03E-04	-7.42	104117.9	-0.83	9.2	7.58E-05	-6.53	104118.8	20.9	2.16E-04	4.37	104130	64.18	727.7	-0.05	728	-0.081
6/1/1998	14:30	104110	104.1	-15	-0.70	19.3	1.99E-04	-14.53	104110.8	-1.65	8.3	6.37E-05	-10.97	104114.4	21.0	2.19E-04	2.30	104128	33.22	727.7	-0.11	728	-0.067
6/1/1998	15:30	104091	104.1	-34	-1.58	18.4	1.88E-04	-30.97	104094.4	-3.72	6.3	3.34E-05	-12.93	104112.4	21.0	2.19E-04	0.00	104125	0.00	727.6	-0.24	728	-0.051
6/1/1998	16:30	104091	104.1	-34	-1.58	18.4	1.88E-04	-30.97	104094.4	-3.72	6.3	3.34E-05	-12.93	104112.4	20.9	2.18E-04	-2.28	104123	-33.22	727.6	-0.24	728	-0.035
6/1/1998	17:30	104095	104.1	-30	-1.41	18.6	1.90E-04	-27.84	104097.5	-3.31	6.7	3.94E-05	-13.58	104111.7	20.7	2.16E-04	-4.37	104121	-64.18	727.6	-0.21	728	-0.020
6/1/1998	18:30	104095	104.1	-30	-1.41	18.6	1.90E-04	-27.84	104097.5	-3.31	6.7	3.94E-05	-13.58	104111.7	20.5	2.13E-04	-6.08	104119	-90.76	727.6	-0.21	728	-0.008
6/1/1998	19:30	104095	104.1	-30	-1.41	18.6	1.90E-04	-27.84	104097.5	-3.31	6.7	3.94E-05	-13.58	104111.7	20.1	2.08E-04	-7.31	104118	-111.16	727.6	-0.21	728	0.000
6/1/1998	20:30	104095	104.1	-30	-1.41	18.6	1.90E-04	-27.84	104097.5	-3.31	6.7	3.94E-05	-13.58	104111.7	19.7	2.04E-04	-7.98	104117	-123.98	727.6	-0.21	728	0.005
6/1/1998	21:30	104087	104.1	-38	-1.76	18.2	1.86E-04	-34.03	104091.3	-4.14	5.9	2.73E-05	-11.76	104113.6	19.4	1.99E-04	-8.07	104117	-128.36	727.5	-0.26	728	0.006
6/1/1998	22:30	104084	104.1	-42	-1.93	18.1	1.84E-04	-37.01	104088.3	-4.55	5.5	2.13E-05	-10.07	104115.3	19.0	1.95E-04	-7.62	104118	-123.98	727.5	-0.29	728	0.003
6/1/1998	23:30	104091	104.1	-34	-1.58	18.4	1.88E-04	-30.97	104094.4	-3.72	6.3	3.34E-05	-12.93	104112.4	18.6	1.91E-04	-6.69	104119	-111.16	727.6	-0.24	728	-0.004
6/2/1998	0:30	104087	104.1	-38	-1.76	18.2	1.86E-04	-34.03	104091.3	-4.14	5.9	2.73E-05	-11.76	104113.6	18.4	1.88E-04	-5.37	104120	-90.76	727.5	-0.26	728	-0.013
6/2/1998	1:30	104091	104.1	-34	-1.58	18.4	1.88E-04	-30.97	104094.4	-3.72	6.3	3.34E-05	-12.93	104112.4	18.2	1.85E-04	-3.75	104122	-64.18	727.6	-0.24	728	-0.024
6/2/1998	2:30	104103	104.1	-23	-1.05	18.9	1.94E-04	-21.34	104104.0	-2.48	7.5	5.15E-05	-13.32	104112.0	18.1	1.84E-04	-1.93	104123	-33.22	727.6	-0.16	728	-0.037
6/2/1998	3:30	104099	104.1	-26	-1.23	18.8	1.92E-04	-24.62	104100.7	-2.90	7.1	4.55E-05	-13.71	104111.6	18.1	1.84E-04	0.00	104125	0.00	727.6	-0.19	728	-0.051
6/2/1998	4:30	104110	104.1	-15	-0.70	19.3	1.99E-04	-14.53	104110.8	-1.65	8.3	6.37E-05	-10.97	104114.4	18.2	1.90E-04	1.99	104127	33.22	727.7	-0.11	728	-0.064
6/2/1998	5:30	104114	104.1	-11	-0.53	19.5	2.01E-04	-11.01	104114.3	-1.24	8.8	6.97E-05	-9.01	104116.3	18.4	1.91E-04	3.88	104129	64.18	727.7	-0.08	728	-0.078
6/2/1998	6:30	104129	104.1	4	0.18	20.2	2.09E-04	3.82	104129.1	0.41	10.4	9.28E-05	4.00	104129.3	18.6	1.94E-04	5.56	104131	90.76	727.8	0.03	728	-0.089
6/2/1998	7:30	104133	104.1	8	0.35	20.4	2.10E-04	7.69	104133.0	0.83	10.8	9.78E-05	8.42	104133.7	19.0	1.97E-04	6.92	104132	111.16	727.8	0.05	728	-0.099

TABLE 5B.5.2.3
1998 Hold Test
Predicted Hold Test Temperatures

Date	Time	Volumetric Predicted Temperature (°F)	Volumetric Predicted Temperature (°C)	Best Fit To Actual Volume Data (°F)	Best Fit To Actual Volume Data (°C)
6/1/1998	4:30	68.23	20.13	64.72	18.18
6/1/1998	5:30	68.83	20.46	65.07	18.37
6/1/1998	6:30	69.33	20.74	65.57	18.65
6/1/1998	7:30	69.68	20.93	66.17	18.99
6/1/1998	8:30	69.86	21.03	66.85	19.36
6/1/1998	9:30	69.86	21.03	67.55	19.75
6/1/1998	10:30	69.68	20.93	68.23	20.13
6/1/1998	11:30	69.33	20.74	68.83	20.46
6/1/1998	12:30	68.83	20.46	69.33	20.74
6/1/1998	13:30	68.23	20.13	69.68	20.93
6/1/1998	14:30	67.55	19.75	69.86	21.03
6/1/1998	15:30	66.85	19.36	69.86	21.03
6/1/1998	16:30	66.17	18.99	69.68	20.93
6/1/1998	17:30	65.57	18.65	69.33	20.74
6/1/1998	18:30	65.07	18.37	68.83	20.46
6/1/1998	19:30	64.72	18.18	68.23	20.13
6/1/1998	20:30	64.54	18.08	67.55	19.75
6/1/1998	21:30	64.54	18.08	66.85	19.36
6/1/1998	22:30	64.72	18.18	66.17	18.99
6/1/1998	23:30	65.07	18.37	65.57	18.65
6/2/1998	0:30	65.57	18.65	65.07	18.37
6/2/1998	1:30	66.17	18.99	64.72	18.18
6/2/1998	2:30	66.85	19.36	64.54	18.08
6/2/1998	3:30	67.55	19.75	64.54	18.08
6/2/1998	4:30	68.23	20.13	64.72	18.18
6/2/1998	5:30	68.83	20.46	65.07	18.37
6/2/1998	6:30	69.33	20.74	65.57	18.65
6/2/1998	7:30	69.68	20.93	66.17	18.99

Figure 5B.5.2.1 - 1998 Hold Test - Actual Volume and Modeled Expansions

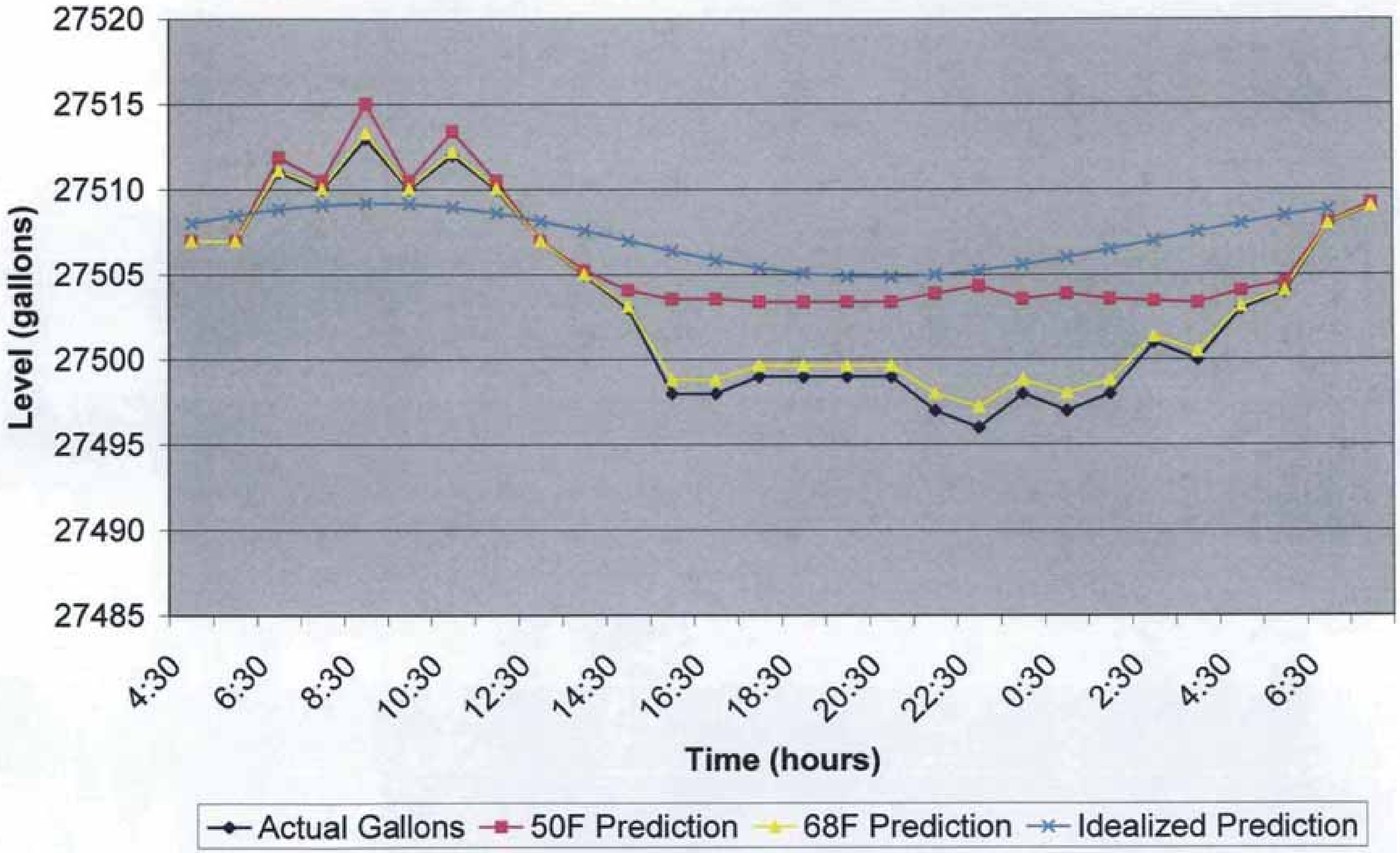
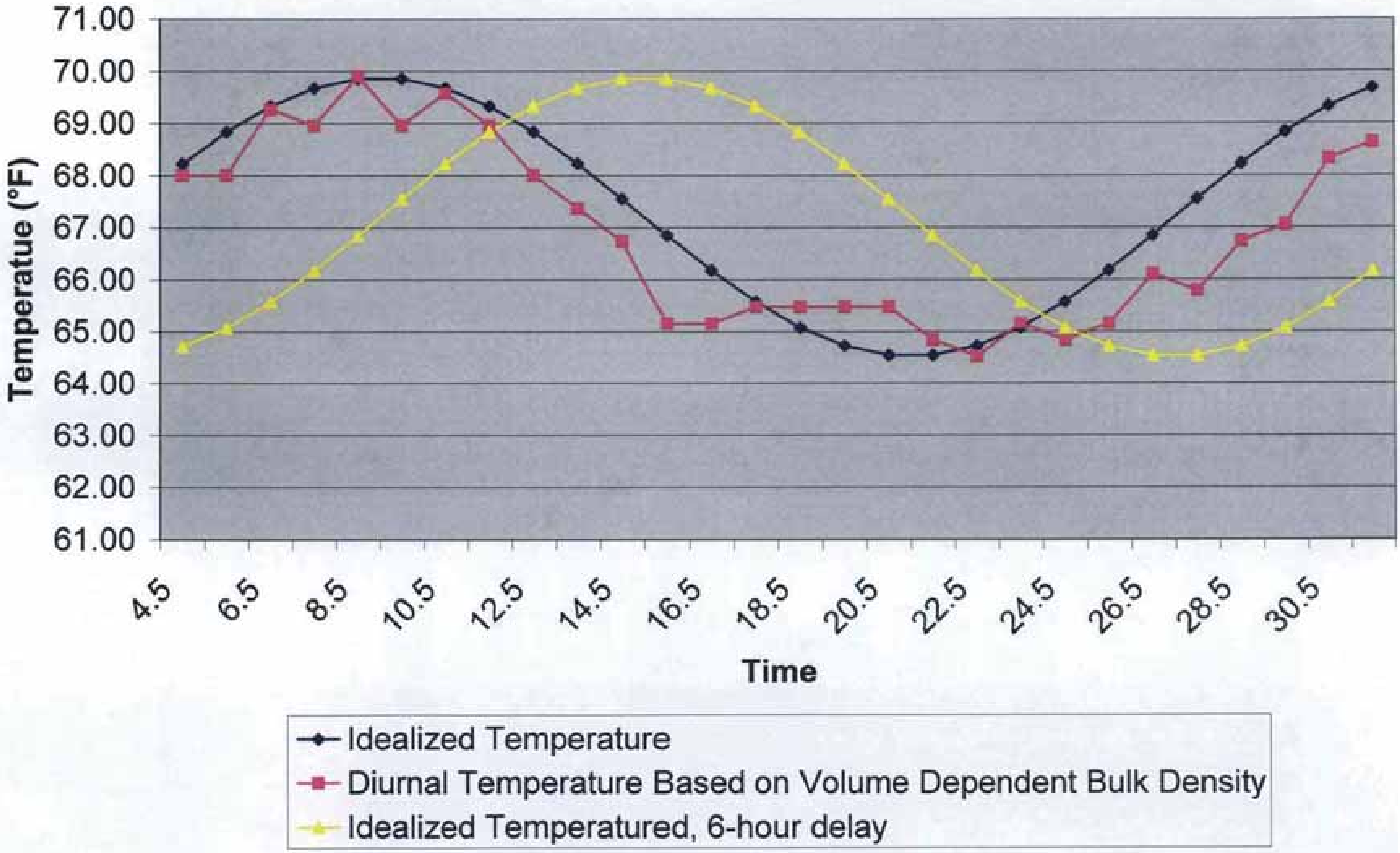


Figure 5B.5.2.2 - 1998 Hold Test - Estimated Temperature Behavior (C-A-1)



the form of $x = F_0 - X\cos(\omega_n t - \beta)$ were attempted as above. As with 1998 data, Tables 5B.5.3.1A and 5B.5.3.1B show initial conditions attempted for loop fill water (50°F and 68°F or 10°C, and 20°C). Figure 5B.5.3.1 shows the various expansion and contraction curves predicted by these initial conditions. It can be seen that the 68°F (20°C) condition best matches actual conditions. From this, an idealized sinusoidal temperature distribution (Table 5B.5.3.2) and inferred CA1 temperature curve (Figure 5B.5.2.2) were predicted. However, as with 1998 C-A-1 level data, using this curve directly resulted in incorrectly predicting volumetric expansion. As with 1998 data, the best fit to actual volumetric data was another diurnal 6 hours out of phase from the idealized curve (Table 5B.5.3.2) and ("Idealized Curve," Figure 5B.5.3.1). This result was arrived at by matching the volumetric output.

The 68°F (20°C) prediction and idealized curve on Figure 5B.5.3.1 show good agreement to actual data, albeit these deviations are small, as seen in the 1998 data. However, in the case of the 2007 analysis, real data show an apparent greater volumetric contraction than the idealized data. This may be caused by Arguably, such behavior is, perhaps, attributable to instrument drift, as postulated in the 1993 hold test, however, the above analysis show that the data seem to best fit a 24 hour periodic fluctuation. Such a fluctuation is best explained by external temperature effects (such diurnal temperature cycles) or some other daily phenomena. Therefore, it is most likely that the C-A-1 volume fluctuations observed in 2007 were also either caused by diurnal temperature fluctuations or some other daily phenomena associated with a 24 hour period or cycle. However, it should be noted that these affects are of small magnitude, less 15 gallons, and therefore within known accuracy of level sensing instrumentation (+/- 48 gallons). Therefore, the actual magnitude of these fluctuations is not likely to be accurately represented by the current sensors due to their small magnitude (i.e. the temperature effects are represented qualitatively rather than quantitatively).

5B.5.4 2007 Test – L1 Sump

L1 Sump level data were also collected in 2007. These data are included in Attachment 5A and tabulated for analysis in Table 5B.2.3. To determine whether the L1 sump might be affected by temperature fluctuations, these data were subjected to the same analyses as 1998 and 2007 Evaporator / Boiler Loop data as measured in C-A-1 (see Tables 5B.5.4.1A, 5B.5.4.2B, and Figure 5B.5.4.1). The same forcing function with adjusted constants was used for the L1 Sump for the idealized expansion shown in Figure 5B.5.4.1. It can be readily seen actual data closely mirror the idealized volumetric expansion/contraction curve developed for the Evaporator/Reboiler Loop. Therefore, whatever is affecting the Evaporator/Reboiler Loop system (most likely temperature) is also affecting the L1 Sump. However, it should also be noted here that these affects have are of small magnitude, less than 5 gallons, and therefore within known accuracy of level sensing instrumentation (+/- 48 gallons). Therefore, the actual magnitude of these fluctuations is not likely to be accurately represented by the current sensors due to their small magnitude.

5B.6 CONCLUSIONS

Analysis of 1993 data indicated that fluctuations observed in electronically indicated level data were most likely caused by either the level instrument being located on the

TABLE 5B.5.3.1A
2007 Hold Test
C-A-1
Modeled and Actual Diurnal Temperatures and Volumetric Expansions (US)

Actual Data					68°F Iteration					50°F Iteration					Idealized					Actual		Predicted	
Date	Time	Level (gal)	Level (CF)	Actual ΔV (gal)	Derived ΔT (°F)	Predicted T (°F)	Recalculated Bulk Coeff (β) (1/°F)	Predicted ΔV (gal)	Predicted Level (gal)	Derived ΔT (°F)	Predicted T (°F)	Recalculated Bulk Coeff (β) (1/°F)	Predicted ΔV (gal)	Predicted Level (gal)	Predicted T (°F)	Bulk Coeff (β) (1/°F)	Predicted ΔV (gal)	Predicted Level (gal)	Heat Change (Btu)	Actual Height in Evap Loop (inches)	Net Rise/Fall C-A-1 (inch)	Predicted Height in Evap Loop (inches)	Net Rise/Fall C-A-1 (inch)
9/1/2007	15:20	26728	3573.0	0	0.0000	68.00	1.15E-04	0.00	26728.0		50.0	4.88E-05	0.00	26728.0	64.21	1.01E-04				278.4	0		
9/1/2007	15:30	26729	3573.1	1	0.3253	68.33	1.16E-04	1.01	26729.0	0.7662	50.77	5.16E-05	1.06	26729.1	64.22	1.01E-04	0.03	26728.0	1.90	278.4	0.01	278.4	-0.020
9/1/2007	16:30	26729	3573.1	1	0.3253	68.33	1.16E-04	1.01	26729.0	0.7662	50.77	5.16E-05	1.06	26729.1	64.38	1.02E-04	0.42	26728.4	27.02	278.4	0.01	278.4	-0.024
9/1/2007	17:30	26728	3573.0	0	0.0000	68.00	1.15E-04	0.00	26728.0	0.0000	50.00	4.88E-05	0.00	26728.0	64.68	1.03E-04	0.82	26728.8	52.20	278.4	0.00	278.4	-0.028
9/1/2007	18:30	26729	3573.1	1	0.3253	68.33	1.16E-04	1.01	26729.0	0.7662	50.77	5.16E-05	1.06	26729.1	65.10	1.04E-04	1.18	26729.2	73.83	278.4	0.01	278.4	-0.032
9/1/2007	19:30	26730	3573.3	2	0.6507	68.65	1.17E-04	2.03	26730.0	1.5323	51.53	5.45E-05	2.23	26730.2	65.62	1.06E-04	1.48	26729.5	90.42	278.4	0.02	278.5	-0.035
9/1/2007	20:00	26731	3573.4	3	0.9760	68.98	1.18E-04	3.07	26731.1	2.2985	52.30	5.73E-05	3.52	26731.5	65.90	1.07E-04	0.82	26728.8	49.54	278.4	0.03	278.4	-0.028
9/1/2007	21:00	26730	3573.3	2	0.6507	68.65	1.17E-04	2.03	26730.0	1.5323	51.53	5.45E-05	2.23	26730.2	66.50	1.09E-04	1.74	26729.7	103.52	278.4	0.02	278.5	-0.038
9/1/2007	22:00	26729	3573.1	1	0.3253	68.33	1.16E-04	1.01	26729.0	0.7662	50.77	5.16E-05	1.06	26729.1	67.10	1.12E-04	1.78	26729.8	103.52	278.4	0.01	278.5	-0.038
9/1/2007	23:00	26730	3573.3	2	0.6507	68.65	1.17E-04	2.03	26730.0	1.5323	51.53	5.45E-05	2.23	26730.2	67.65	1.14E-04	1.69	26729.7	96.46	278.4	0.02	278.5	-0.037
9/2/2007	0:00	26730	3573.3	2	0.6507	68.65	1.17E-04	2.03	26730.0	1.5323	51.53	5.45E-05	2.23	26730.2	68.13	1.15E-04	1.47	26729.5	82.83	278.4	0.02	278.5	-0.035
9/2/2007	1:00	26727	3572.9	-1	-0.3253	67.67	1.14E-04	-0.99	26727.0	-0.7662	49.23	4.54E-05	-0.93	26727.1	68.49	1.17E-04	1.14	26729.1	63.56	278.4	-0.01	278.4	-0.031
9/2/2007	2:00	26727	3572.9	-1	-0.3253	67.67	1.14E-04	-0.99	26727.0	-0.7662	49.23	4.54E-05	-0.93	26727.1	68.72	1.18E-04	0.72	26728.7	39.96	278.4	-0.01	278.4	-0.027
9/2/2007	3:00	26726	3572.7	-2	-0.6507	67.35	1.13E-04	-1.96	26726.0	-1.5323	48.47	4.19E-05	-1.72	26726.3	68.80	1.18E-04	0.25	26728.2	13.63	278.4	-0.02	278.4	-0.022
9/2/2007	4:00	26726	3572.7	-2	-0.6507	67.35	1.13E-04	-1.96	26726.0	-1.5323	48.47	4.19E-05	-1.72	26726.3	68.72	1.18E-04	-0.25	26727.8	-13.63	278.4	-0.02	278.4	-0.017
9/2/2007	5:00	26723	3572.3	-5	-1.6267	66.37	1.09E-04	-4.74	26723.3	-3.8308	46.17	3.15E-05	-3.23	26724.8	68.49	1.17E-04	-0.72	26727.3	-39.96	278.4	-0.05	278.4	-0.012
9/2/2007	6:00	26723	3572.3	-5	-1.6267	66.37	1.09E-04	-4.74	26723.3	-3.8308	46.17	3.15E-05	-3.23	26724.8	68.13	1.15E-04	-1.13	26726.9	-63.56	278.4	-0.05	278.4	-0.008
9/2/2007	7:00	26721	3572.1	-7	-2.2774	65.72	1.07E-04	-6.49	26721.5	-5.3631	44.64	2.46E-05	-3.52	26724.5	67.65	1.14E-04	-1.45	26726.6	-82.83	278.3	-0.07	278.4	-0.004
9/2/2007	8:00	26718	3571.7	-10	-3.2534	64.75	1.03E-04	-8.96	26719.0	-7.6616	42.34	1.42E-05	-2.91	26725.1	67.10	1.12E-04	-1.66	26726.3	-96.46	278.3	-0.10	278.4	-0.002
9/2/2007	9:00	26716	3571.4	-12	-3.9041	64.10	1.01E-04	-10.50	26717.5	-9.1939	40.81	7.26E-06	-1.78	26726.2	66.50	1.09E-04	-1.74	26726.3	-103.52	278.3	-0.12	278.4	-0.001
9/2/2007	10:00	26717	3571.5	-11	-3.5787	64.42	1.02E-04	-9.74	26718.3	-8.4277	41.57	1.07E-05	-2.42	26725.6	65.90	1.07E-04	-1.71	26726.3	-103.52	278.3	-0.11	278.4	-0.002
9/2/2007	11:00	26719	3571.8	-9	-2.9280	65.07	1.04E-04	-8.16	26719.8	-6.8954	43.10	1.77E-05	-3.25	26724.7	65.35	1.05E-04	-1.56	26726.4	-96.46	278.3	-0.09	278.4	-0.003
9/2/2007	12:00	26716	3571.4	-12	-3.9041	64.10	1.01E-04	-10.50	26717.5	-9.1939	40.81	7.26E-06	-1.78	26726.2	64.87	1.04E-04	-1.32	26726.7	-82.83	278.3	-0.12	278.4	-0.006
9/2/2007	13:00	26719	3571.8	-9	-2.9280	65.07	1.04E-04	-8.16	26719.8	-6.8954	43.10	1.77E-05	-3.25	26724.7	64.51	1.02E-04	-1.00	26727.0	-63.56	278.3	-0.09	278.4	-0.009
9/2/2007	14:00	26720	3571.9	-8	-2.6027	65.40	1.05E-04	-7.33	26720.7	-6.1292	43.87	2.11E-05	-3.46	26724.5	64.28	1.01E-04	-0.62	26727.4	-39.96	278.3	-0.08	278.4	-0.013
9/2/2007	15:00	26721	3572.1	-7	-2.2774	65.72	1.07E-04	-6.49	26721.5	-5.3631	44.64	2.46E-05	-3.52	26724.5	64.20	1.01E-04	-0.21	26727.8	-13.63	278.3	-0.07	278.4	-0.017
9/2/2007	16:00	26723	3572.3	-5	-1.6267	66.37	1.09E-04	-4.74	26723.3	-3.8308	46.17	3.15E-05	-3.23	26724.8	64.28	1.01E-04	0.21	26728.2	13.63	278.4	-0.05	278.4	-0.022
9/2/2007	16:06	26722	3572.2	-6	-1.9520	66.05	1.08E-04	-5.63	26722.4	-4.5969	45.40	2.80E-05	-3.45	26724.6	64.29	1.01E-04	0.04	26728.0	2.84	278.4	-0.06	278.4	-0.020

TABLE 5B.5.3.1B
2007 Hold Test
C-A-1
Modeled and Actual Diurnal Temperatures and Volumetric Expansions (SI)

Actual Data					20°C Iteration					10°C Iteration					Idealized					Actual		Predicted	
Date	Time	Level (Liters)	Level (m^3)	Actual ΔV (Liters)	Derived ΔT (°C)	Predicted T (°C)	Recalculated Bulk Coeff (β) (1/°C)	Predicted ΔV (Liters)	Predicted Level (Liters)	Derived ΔT (°C)	Predicted T (°C)	Recalculated Bulk Coeff (β) (1/°C)	Predicted ΔV (Liters)	Predicted Level (Liters)	Predicted T (°C)	Bulk Coeff (β) (1/°C)	Predicted ΔV (Liters)	Predicted Level (Liters)	Heat Change (KJ)	Actual Height in Evap Loop (cm)	Net Rise/Fall C-A-1 (cm)	Predicted Height in Evap Loop (cm)	Net Rise/Fall C-A-1 (cm)
9/1/2007	15:20	101176	101.2	0	0.00	20.0	2.07E-04	0.00	101176.5	0.00	10.0	8.79E-05	0.00	101176.5	17.9	1.82E-04				707	0.000		
9/1/2007	15:30	101180	101.2	4	0.18	20.2	2.09E-04	3.82	101180.3	0.43	10.4	9.30E-05	4.00	101180.5	17.9	1.82E-04	0.11	101177	2.00	707	0.026	707.2	-0.05
9/1/2007	16:30	101180	101.2	4	0.18	20.2	2.09E-04	3.82	101180.3	0.43	10.4	9.30E-05	4.00	101180.5	18.0	1.83E-04	1.60	101178	28.51	707	0.026	707.2	-0.06
9/1/2007	17:30	101176	101.2	0	0.00	20.0	2.07E-04	0.00	101176.5	0.00	10.0	8.79E-05	0.00	101176.5	18.2	1.85E-04	3.12	101180	55.08	707	0.000	707.2	-0.07
9/1/2007	18:30	101180	101.2	4	0.18	20.2	2.09E-04	3.82	101180.3	0.43	10.4	9.30E-05	4.00	101180.5	18.4	1.88E-04	4.48	101181	77.89	707	0.026	707.3	-0.08
9/1/2007	19:30	101184	101.2	8	0.36	20.4	2.10E-04	7.70	101184.2	0.85	10.9	9.80E-05	8.44	101184.9	18.7	1.91E-04	5.59	101182	95.40	707	0.053	707.3	-0.09
9/1/2007	20:00	101188	101.2	11	0.54	20.5	2.12E-04	11.64	101188.1	1.28	11.3	1.03E-04	13.32	101189.8	18.8	1.93E-04	3.09	101180	52.27	707	0.079	707.2	-0.07
9/1/2007	21:00	101184	101.2	8	0.36	20.4	2.10E-04	7.70	101184.2	0.85	10.9	9.80E-05	8.44	101184.9	19.2	1.97E-04	6.59	101183	109.21	707	0.053	707.3	-0.10
9/1/2007	22:00	101180	101.2	4	0.18	20.2	2.09E-04	3.82	101180.3	0.43	10.4	9.30E-05	4.00	101180.5	19.5	2.01E-04	6.73	101183	109.21	707	0.026	707.3	-0.10
9/1/2007	23:00	101184	101.2	8	0.36	20.4	2.10E-04	7.70	101184.2	0.85	10.9	9.80E-05	8.44	101184.9	19.8	2.05E-04	6.38	101183	101.77	707	0.053	707.3	-0.09
9/2/2007	0:00	101184	101.2	8	0.36	20.4	2.10E-04	7.70	101184.2	0.85	10.9	9.80E-05	8.44	101184.9	20.1	2.08E-04	5.56	101182	87.39	707	0.053	707.3	-0.09
9/2/2007	1:00	101173	101.2	-4	-0.18	19.8	2.05E-04	-3.75	101172.7	-0.43	9.6	8.17E-05	-3.52	101173.0	20.3	2.10E-04	4.32	101181	67.06	707	-0.026	707.3	-0.08
9/2/2007	2:00	101173	101.2	-4	-0.18	19.8	2.05E-04	-3.75	101172.7	-0.43	9.6	8.17E-05	-3.52	101173.0	20.4	2.12E-04	2.74	101179	42.16	707	-0.026	707.2	-0.07
9/2/2007	3:00	101169	101.2	-8	-0.36	19.6	2.03E-04	-7.41	101169.1	-0.85	9.1	7.54E-05	-6.50	101170.0	20.4	2.12E-04	0.94	101177	14.38	707	-0.053	707.2	-0.06
9/2/2007	4:00	101169	101.2	-8	-0.36	19.6	2.03E-04	-7.41	101169.1	-0.85	9.1	7.54E-05	-6.50	101170.0	20.4	2.12E-04	-0.93	101176	-14.38	707	-0.053	707.2	-0.04
9/2/2007	5:00	101158	101.2	-19	-0.90	19.1	1.96E-04	-17.94	101158.5	-2.13	7.9	5.67E-05	-12.21	101164.3	20.3	2.10E-04	-2.72	101174	-42.16	707	-0.132	707.2	-0.03
9/2/2007	6:00	101158	101.2	-19	-0.90	19.1	1.96E-04	-17.94	101158.5	-2.13	7.9	5.67E-05	-12.21	101164.3	20.1	2.08E-04	-4.27	101172	-67.06	707	-0.132	707.2	-0.02
9/2/2007	7:00	101150	101.1	-26	-1.27	18.7	1.92E-04	-24.57	101151.9	-2.98	7.0	4.43E-05	-13.34	101163.1	19.8	2.05E-04	-5.48	101171	-87.39	707	-0.185	707.2	-0.01
9/2/2007	8:00	101139	101.1	-38	-1.81	18.2	1.85E-04	-33.92	101142.6	-4.26	5.7	2.55E-05	-11.00	101165.5	19.5	2.01E-04	-6.27	101170	-101.77	707	-0.265	707.2	-0.01
9/2/2007	9:00	101131	101.1	-45	-2.17	17.8	1.81E-04	-39.76	101136.7	-5.11	4.9	1.31E-05	-6.76	101169.7	19.2	1.97E-04	-6.59	101170	-109.21	707	-0.317	707.2	0.00
9/2/2007	10:00	101135	101.1	-42	-1.99	18.0	1.83E-04	-36.88	101139.6	-4.68	5.3	1.93E-05	-9.15	101167.3	18.8	1.93E-04	-6.46	101170	-109.21	707	-0.291	707.2	0.00
9/2/2007	11:00	101142	101.1	-34	-1.63	18.4	1.88E-04	-30.88	101145.6	-3.83	6.2	3.18E-05	-12.32	101164.2	18.5	1.89E-04	-5.91	101171	-101.77	707	-0.238	707.2	-0.01
9/2/2007	12:00	101131	101.1	-45	-2.17	17.8	1.81E-04	-39.76	101136.7	-5.11	4.9	1.31E-05	-6.76	101169.7	18.3	1.86E-04	-4.99	101171	-87.39	707	-0.317	707.2	-0.01
9/2/2007	13:00	101142	101.1	-34	-1.63	18.4	1.88E-04	-30.88	101145.6	-3.83	6.2	3.18E-05	-12.32	101164.2	18.1	1.84E-04	-3.78	101173	-67.06	707	-0.238	707.2	-0.02
9/2/2007	14:00	101146	101.1	-30	-1.45	18.6	1.90E-04	-27.76	101148.7	-3.41	6.6	3.80E-05	-13.10	101163.4	17.9	1.82E-04	-2.36	101174	-42.16	707	-0.212	707.2	-0.03
9/2/2007	15:00	101150	101.1	-26	-1.27	18.7	1.92E-04	-24.57	101151.9	-2.98	7.0	4.43E-05	-13.34	101163.1	17.9	1.82E-04	-0.80	101176	-14.38	707	-0.185	707.2	-0.04
9/2/2007	16:00	101158	101.2	-19	-0.90	19.1	1.96E-04	-17.94	101158.5	-2.13	7.9	5.67E-05	-12.21	101164.3	17.9	1.82E-04	0.80	101177	14.38	707	-0.132	707.2	-0.05
9/2/2007	16:06	101154	101.2	-23	-1.08	18.9	1.94E-04	-21.30	101155.2	-2.55	7.4	5.05E-05	-13.05	101163.4	17.9	1.82E-04	0.17	101177	3.00	707	-0.159	707.2	-0.05

TABLE 5B.5.3.2
2007 Hold Test
Predicted Hold Test Temperatures

Date	Time	Volumetric Predicted Temperature (°F)	Volumetric Predicted Temperature (°C)	Best Fit To Actual Volume Data (°F)	Best Fit To Actual Volume Data (°C)
9/1/2007	15:20	66.70	19.28	64.21	17.89
9/1/2007	15:30	66.80	19.33	64.22	17.90
9/1/2007	16:30	67.38	19.66	64.38	17.99
9/1/2007	17:30	67.90	19.94	64.68	18.15
9/1/2007	18:30	68.32	20.18	65.10	18.39
9/1/2007	19:30	68.62	20.35	65.62	18.68
9/1/2007	20:00	68.72	20.40	65.90	18.84
9/1/2007	21:00	68.80	20.44	66.50	19.17
9/1/2007	22:00	68.72	20.40	67.10	19.50
9/1/2007	23:00	68.49	20.27	67.65	19.81
9/2/2007	0:00	68.13	20.07	68.13	20.07
9/2/2007	1:00	67.65	19.81	68.49	20.27
9/2/2007	2:00	67.10	19.50	68.72	20.40
9/2/2007	3:00	66.50	19.17	68.80	20.44
9/2/2007	4:00	65.90	18.84	68.72	20.40
9/2/2007	5:00	65.35	18.53	68.49	20.27
9/2/2007	6:00	64.87	18.26	68.13	20.07
9/2/2007	7:00	64.51	18.06	67.65	19.81
9/2/2007	8:00	64.28	17.93	67.10	19.50
9/2/2007	9:00	64.20	17.89	66.50	19.17
9/2/2007	10:00	64.28	17.93	65.90	18.84
9/2/2007	11:00	64.51	18.06	65.35	18.53
9/2/2007	12:00	64.87	18.26	64.87	18.26
9/2/2007	13:00	65.35	18.53	64.51	18.06
9/2/2007	14:00	65.90	18.84	64.28	17.93
9/2/2007	15:00	66.50	19.17	64.20	17.89
9/2/2007	16:00	67.10	19.50	64.28	17.93
9/2/2007	16:06	67.15	19.53	64.29	17.94

Figure 5B.5.3.1 - 2007 Hold Test - C-A-1 - Actual Volume and Modeled Expansions

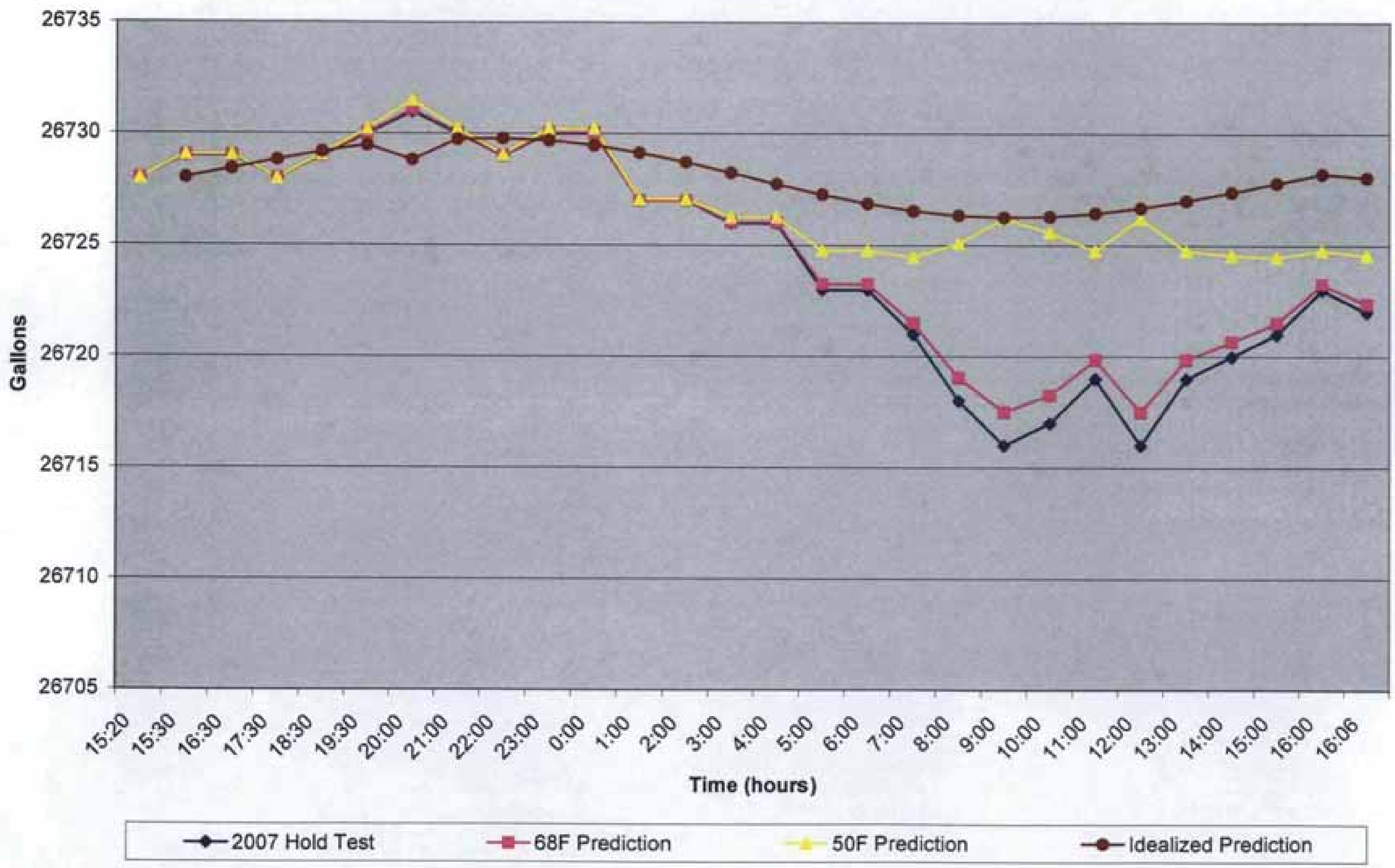


Figure 5B.5.3.2 - Estimated Temperature Behaviour (C-A-1)

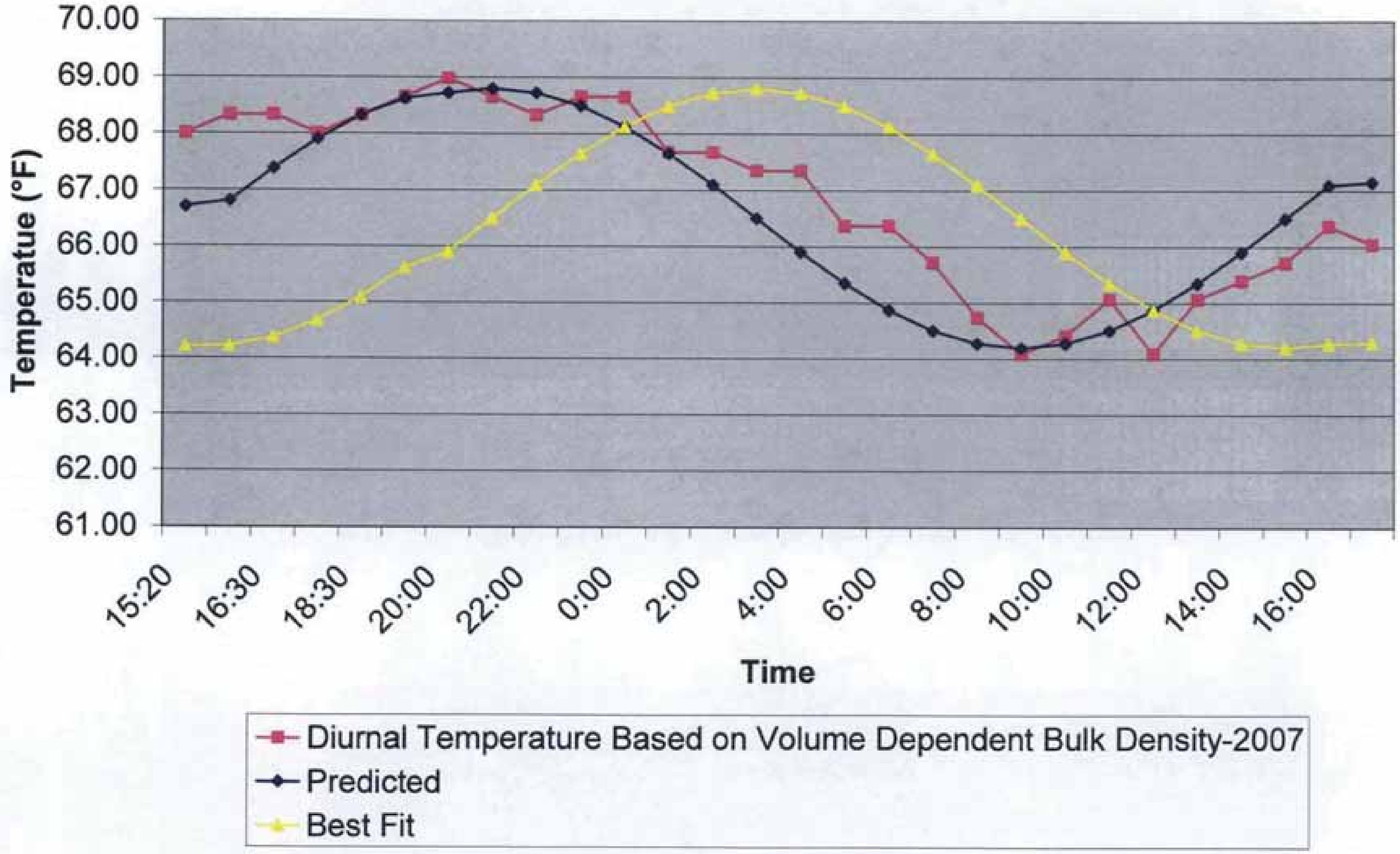


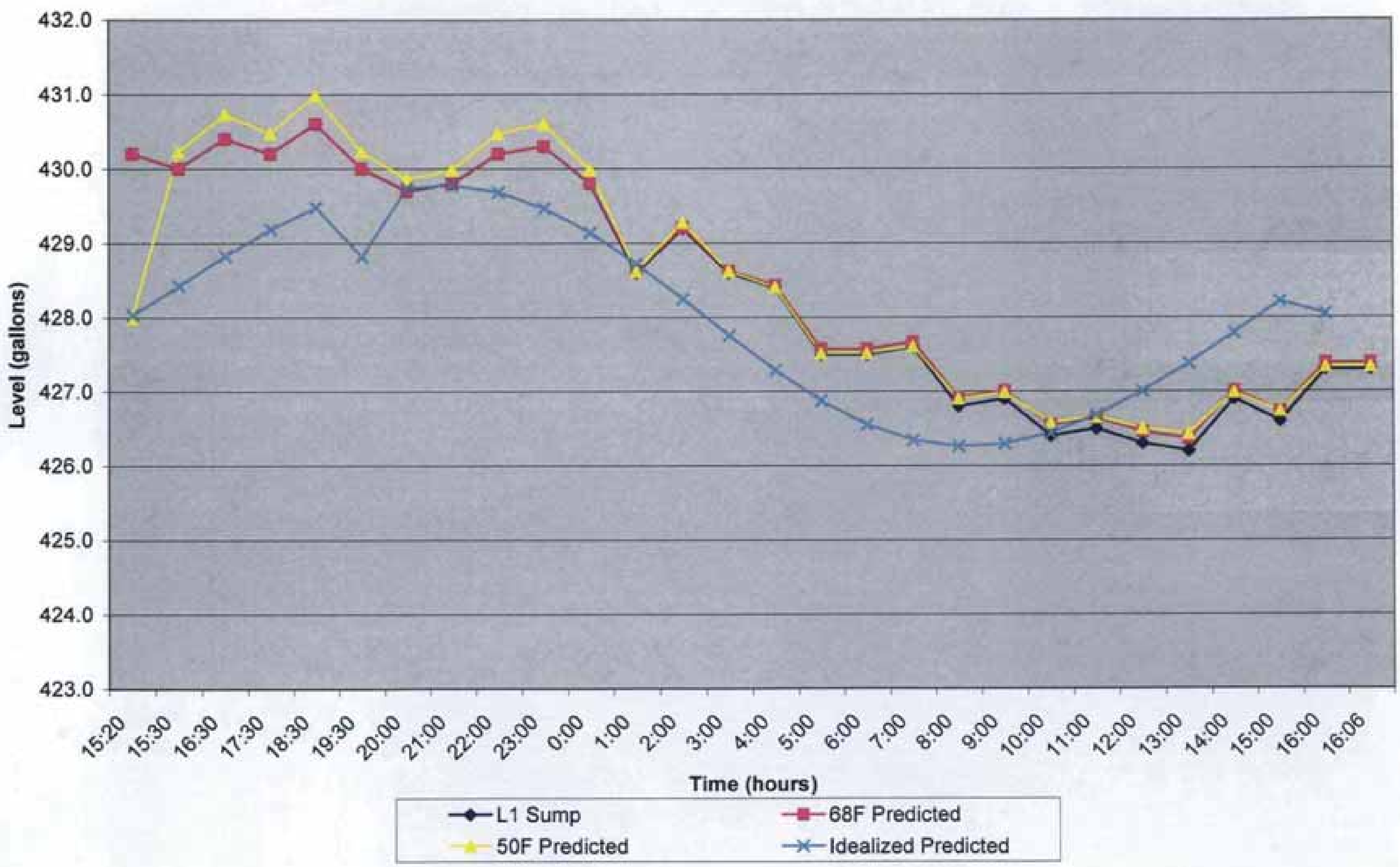
TABLE 5B.5.4.1A
2007 Hold Test
L1 Sump
Modeled and Actual Diurnal Temperatures and Volumetric Expansions (US)

Actual Data					68°F Iteration					50°F Iteration					Idealized					Actual		Predicted	
Date	Time	Actual Level (gallons)	Level (CF)	Actual ΔV (gal)	Derived ΔT (°F)	Predicted T (°F)	Recalculated Bulk Coeff (β) (1/°F)	Predicted ΔV (gal)	Predicted Level (gal)	Derived ΔT (°F)	Predicted T (°F)	Recalculated Bulk Coeff (β) (1/°F)	Predicted ΔV (gal)	Predicted Level (gal)	Predicted T (°F)	Bulk Coeff (β) (1/°F)	Predicted ΔV (gal)	Predicted Level (gal)	Heat Change (Btu)	Actual Height in L1 Sump (inches)	Net Rise/Fall L1 Sump (inch)	Predicted Height in L1 Sump (inches)	Net Rise/Fall L1 Sump (inch)
9/1/2007	15:20	430.2	57.5	0	0.0000	68.00	1.15E-04	0.00	430.20		50.00	4.88E-05	0.00	428.00	64.21	1.01E-04				28.49	0.00		
9/1/2007	15:30	430.0	57.5	0	-0.0651	67.93	1.15E-04	-0.20	430.00	1.5323	51.53	5.45E-05	2.23	430.23	64.22	1.01E-04	0.03	430.23	1.90	28.48	-0.01	28.50	-0.004
9/1/2007	16:30	430.4	57.5	0	0.0651	68.07	1.15E-04	0.20	430.40	1.8388	51.84	5.56E-05	2.73	430.73	64.38	1.02E-04	0.42	430.62	27.02	28.51	0.01	28.52	-0.043
9/1/2007	17:30	430.2	57.5	0	0.0000	68.00	1.15E-04	0.00	430.20	1.6855	51.69	5.50E-05	2.48	430.48	64.68	1.03E-04	0.82	431.02	52.20	28.49	0.00	28.55	-0.043
9/1/2007	18:30	430.6	57.6	0	0.1301	68.13	1.15E-04	0.40	430.60	1.9920	51.99	5.62E-05	2.99	430.99	65.10	1.04E-04	1.18	431.38	73.83	28.52	0.03	28.58	-0.080
9/1/2007	19:30	430.0	57.5	0	-0.0651	67.93	1.15E-04	-0.20	430.00	1.5323	51.53	5.45E-05	2.23	430.23	65.62	1.06E-04	1.48	431.68	90.42	28.48	-0.01	28.59	-0.073
9/1/2007	20:00	429.7	57.4	-1	-0.1627	67.84	1.14E-04	-0.50	429.70	1.3025	51.30	5.36E-05	1.87	429.87	65.90	1.07E-04	0.82	431.02	49.54	28.46	-0.03	28.55	-0.069
9/1/2007	21:00	429.8	57.5	0	-0.1301	67.87	1.15E-04	-0.40	429.80	1.3791	51.38	5.39E-05	1.99	429.99	66.50	1.09E-04	1.74	431.94	103.52	28.47	-0.03	28.61	-0.150
9/1/2007	22:00	430.2	57.5	0	0.0000	68.00	1.15E-04	0.00	430.20	1.6855	51.69	5.50E-05	2.48	430.48	67.10	1.12E-04	1.78	431.98	103.52	28.49	0.00	28.61	-0.146
9/1/2007	23:00	430.3	57.5	0	0.0325	68.03	1.15E-04	0.10	430.30	1.7622	51.76	5.53E-05	2.61	430.61	67.65	1.14E-04	1.69	431.89	96.46	28.50	0.01	28.61	-0.114
9/2/2007	0:00	429.8	57.5	0	-0.1301	67.87	1.15E-04	-0.40	429.80	1.3791	51.38	5.39E-05	1.99	429.99	68.13	1.15E-04	1.47	431.67	82.83	28.47	-0.03	28.59	-0.093
9/2/2007	1:00	428.6	57.3	-2	-0.5205	67.48	1.13E-04	-1.57	428.63	0.4597	50.46	5.05E-05	0.62	428.62	68.49	1.17E-04	1.14	431.34	63.56	28.39	-0.11	28.57	-0.104
9/2/2007	2:00	429.2	57.4	-1	-0.3253	67.67	1.14E-04	-0.99	429.21	0.9194	50.92	5.22E-05	1.28	429.28	68.72	1.18E-04	0.72	430.92	39.96	28.43	-0.07	28.54	-0.156
9/2/2007	3:00	428.6	57.3	-2	-0.5205	67.48	1.13E-04	-1.57	428.63	0.4597	50.46	5.05E-05	0.62	428.62	68.80	1.18E-04	0.25	430.45	13.63	28.39	-0.11	28.51	-0.085
9/2/2007	4:00	428.4	57.3	-2	-0.5856	67.41	1.13E-04	-1.77	428.43	0.3065	50.31	5.00E-05	0.41	428.41	68.72	1.18E-04	-0.25	429.95	-13.63	28.38	-0.12	28.48	-0.092
9/2/2007	5:00	427.5	57.1	-3	-0.8783	67.12	1.12E-04	-2.62	427.58	-0.3831	49.62	4.71E-05	-0.48	427.52	68.49	1.17E-04	-0.72	429.48	-39.96	28.32	-0.18	28.45	-0.074
9/2/2007	6:00	427.5	57.1	-3	-0.8783	67.12	1.12E-04	-2.62	427.58	-0.3831	49.62	4.71E-05	-0.48	427.52	68.13	1.15E-04	-1.13	429.07	-63.56	28.32	-0.18	28.42	-0.106
9/2/2007	7:00	427.6	57.2	-3	-0.8458	67.15	1.12E-04	-2.53	427.67	-0.3065	49.69	4.74E-05	-0.39	427.61	67.65	1.14E-04	-1.45	428.75	-82.83	28.32	-0.17	28.40	-0.085
9/2/2007	8:00	426.8	57.1	-3	-1.1061	66.89	1.11E-04	-3.28	426.92	-0.9194	49.08	4.47E-05	-1.10	426.90	67.10	1.12E-04	-1.66	428.54	-96.46	28.27	-0.23	28.39	-0.065
9/2/2007	9:00	426.9	57.1	-3	-1.0735	66.93	1.11E-04	-3.19	427.01	-0.8428	49.16	4.50E-05	-1.01	426.99	66.50	1.09E-04	-1.74	428.46	-103.52	28.28	-0.22	28.38	-0.112
9/2/2007	10:00	426.4	57.0	-4	-1.2362	66.76	1.10E-04	-3.65	426.55	-1.2258	48.77	4.33E-05	-1.42	426.58	65.90	1.07E-04	-1.71	428.49	-103.52	28.24	-0.25	28.38	-0.107
9/2/2007	11:00	426.5	57.0	-4	-1.2037	66.80	1.11E-04	-3.56	426.64	-1.1492	48.85	4.36E-05	-1.34	426.66	65.35	1.05E-04	-1.56	428.64	-96.46	28.25	-0.25	28.39	-0.150
9/2/2007	12:00	426.3	57.0	-4	-1.2687	66.73	1.10E-04	-3.74	426.46	-1.3025	48.70	4.29E-05	-1.49	426.51	64.87	1.04E-04	-1.32	428.88	-82.83	28.24	-0.26	28.41	-0.160
9/2/2007	13:00	426.2	57.0	-4	-1.3012	66.70	1.10E-04	-3.83	426.37	-1.3791	48.62	4.26E-05	-1.57	426.43	64.51	1.02E-04	-1.00	429.20	-63.56	28.23	-0.26	28.43	-0.194
9/2/2007	14:00	426.9	57.1	-3	-1.0735	66.93	1.11E-04	-3.19	427.01	-0.8428	49.16	4.50E-05	-1.01	426.99	64.28	1.01E-04	-0.62	429.58	-39.96	28.28	-0.22	28.46	-0.226
9/2/2007	15:00	426.6	57.0	-4	-1.1711	66.83	1.11E-04	-3.47	426.73	-1.0726	48.93	4.40E-05	-1.26	426.74	64.20	1.01E-04	-0.21	429.99	-13.63	28.26	-0.24	28.48	-0.207
9/2/2007	16:00	427.3	57.1	-3	-0.9434	67.06	1.12E-04	-2.81	427.39	-0.5363	49.46	4.64E-05	-0.67	427.33	64.28	1.01E-04	0.21	430.41	13.63	28.30	-0.19	28.51	-0.254
9/2/2007	16:06	427.3	57.1	-3	-0.9434	67.06	1.12E-04	-2.81	427.39	-0.5363	49.46	4.64E-05	-0.67	427.33	64.29	1.01E-04	0.04	430.24	2.84	28.30	-0.19	28.50	-0.197

TABLE 5B.5.4.1B
2007 Hold Test
L1 Sump
Modeled and Actual Diurnal Temperatures and Volumetric Expansions (SI)

Actual Data					20°C Iteration					10°C Iteration					Idealized					Actual		Predicted	
Date	Time	Actual Level (Liters)	Level (m^3)	Actual ΔV (Liters)	Derived ΔT (°C)	Predicted T (°C)	Recalculated Bulk Coeff (β) (1/°C)	Predicted ΔV (Liters)	Predicted Level (Liters)	Derived ΔT (°C)	Predicted T (°C)	Recalculated Bulk Coeff (β) (1/°C)	Predicted ΔV (Liters)	Predicted Level (Liters)	Predicted T (°C)	Bulk Coeff (β) (1/°C)	Predicted ΔV (Liters)	Predicted Level (Liters)	Heat Change (KJ)	Actual Height in L1 Sump (cm)	Net Rise/Fall L1 Sump (cm)	Predicted Height in L1 Sump (cm)	Net Rise/Fall L1 Sump (cm)
9/1/2007	15:20	1628	1.628	8	0.00	20.0	2.07E-04	0.00	1620.16	0.00	10.0	8.79E-05	0.00	1620.16	17.9	1.82E-04				72.4	0.00		
9/1/2007	15:30	1628	1.628	8	-0.04	20.0	2.07E-04	-0.76	1619.40	0.85	10.9	9.80E-05	8.44	1628.60	17.9	1.82E-04	0.1118	1628.6	2.004	72.3	-0.03	72.39	-0.010
9/1/2007	16:30	1629	1.629	9	0.04	20.0	2.07E-04	0.76	1620.91	1.02	11.0	1.00E-04	10.34	1630.50	18.0	1.83E-04	1.5986	1630.1	28.511	72.4	0.03	72.45	-0.110
9/1/2007	17:30	1628	1.628	8	0.00	20.0	2.07E-04	0.00	1620.16	0.94	10.9	9.91E-05	9.38	1629.54	18.2	1.85E-04	3.1218	1631.6	55.078	72.4	0.00	72.52	-0.110
9/1/2007	18:30	1630	1.630	10	0.07	20.1	2.08E-04	1.52	1621.68	1.11	11.1	1.01E-04	11.32	1631.47	18.4	1.88E-04	4.4820	1633.0	77.892	72.4	0.07	72.58	-0.204
9/1/2007	19:30	1628	1.628	8	-0.04	20.0	2.07E-04	-0.76	1619.40	0.85	10.9	9.80E-05	8.44	1628.60	18.7	1.91E-04	5.5898	1634.1	95.398	72.3	-0.03	72.63	-0.186
9/1/2007	20:00	1627	1.627	6	-0.09	19.9	2.06E-04	-1.88	1618.27	0.72	10.7	9.65E-05	7.07	1627.22	18.8	1.93E-04	3.0928	1631.6	52.267	72.3	-0.08	72.52	-0.176
9/1/2007	21:00	1627	1.627	7	-0.07	19.9	2.06E-04	-1.51	1618.65	0.77	10.8	9.70E-05	7.52	1627.68	19.2	1.97E-04	6.5942	1635.1	109.214	72.3	-0.07	72.68	-0.382
9/1/2007	22:00	1628	1.628	8	0.00	20.0	2.07E-04	0.00	1620.16	0.94	10.9	9.91E-05	9.38	1629.54	19.5	2.01E-04	6.7260	1635.2	109.214	72.4	0.00	72.68	-0.371
9/1/2007	23:00	1629	1.629	9	0.02	20.0	2.07E-04	0.38	1620.54	0.98	11.0	9.96E-05	9.86	1630.02	19.8	2.05E-04	6.3821	1634.9	101.771	72.4	0.02	72.67	-0.289
9/2/2007	0:00	1627	1.627	7	-0.07	19.9	2.06E-04	-1.51	1618.65	0.77	10.8	9.70E-05	7.52	1627.68	20.1	2.08E-04	5.5648	1634.0	87.393	72.3	-0.07	72.63	-0.236
9/2/2007	1:00	1622	1.622	2	-0.29	19.7	2.04E-04	-5.96	1614.20	0.26	10.3	9.09E-05	2.35	1622.51	20.3	2.10E-04	4.3197	1632.8	67.059	72.1	-0.27	72.57	-0.264
9/2/2007	2:00	1625	1.625	5	-0.18	19.8	2.05E-04	-3.75	1616.41	0.51	10.5	9.40E-05	4.86	1625.01	20.4	2.12E-04	2.7351	1631.2	42.155	72.2	-0.17	72.50	-0.396
9/2/2007	3:00	1622	1.622	2	-0.29	19.7	2.04E-04	-5.96	1614.20	0.26	10.3	9.09E-05	2.35	1622.51	20.4	2.12E-04	0.9352	1629.4	14.378	72.1	-0.27	72.42	-0.215
9/2/2007	4:00	1622	1.622	2	-0.33	19.7	2.03E-04	-6.69	1613.47	0.17	10.2	8.99E-05	1.55	1621.71	20.4	2.12E-04	-0.9329	1627.6	-14.378	72.1	-0.30	72.34	-0.233
9/2/2007	5:00	1618	1.618	-2	-0.49	19.5	2.01E-04	-9.93	1610.22	-0.21	9.8	8.48E-05	-1.83	1618.33	20.3	2.10E-04	-2.7155	1625.8	-42.155	71.9	-0.45	72.26	-0.187
9/2/2007	6:00	1618	1.618	-2	-0.49	19.5	2.01E-04	-9.93	1610.22	-0.21	9.8	8.48E-05	-1.83	1618.33	20.1	2.08E-04	-4.2700	1624.2	-67.059	71.9	-0.45	72.19	-0.269
9/2/2007	7:00	1619	1.619	-2	-0.47	19.5	2.01E-04	-9.58	1610.58	-0.17	9.8	8.54E-05	-1.47	1618.69	19.8	2.05E-04	-5.4804	1623.0	-87.393	71.9	-0.44	72.14	-0.216
9/2/2007	8:00	1616	1.616	-5	-0.61	19.4	2.00E-04	-12.42	1607.74	-0.51	9.5	8.04E-05	-4.16	1616.00	19.5	2.01E-04	-6.2676	1622.2	-101.771	71.8	-0.57	72.10	-0.164
9/2/2007	9:00	1616	1.616	-4	-0.60	19.4	2.00E-04	-12.06	1608.09	-0.47	9.5	8.10E-05	-3.84	1616.32	19.2	1.97E-04	-6.5942	1621.9	-109.214	71.8	-0.56	72.09	-0.284
9/2/2007	10:00	1614	1.614	-6	-0.69	19.3	1.99E-04	-13.82	1606.34	-0.68	9.3	7.79E-05	-5.37	1614.79	18.8	1.93E-04	-6.4624	1622.0	-109.214	71.7	-0.64	72.09	-0.273
9/2/2007	11:00	1614	1.614	-6	-0.67	19.3	1.99E-04	-13.47	1606.69	-0.64	9.4	7.85E-05	-5.07	1615.08	18.5	1.89E-04	-5.9076	1622.6	-101.771	71.8	-0.62	72.12	-0.382
9/2/2007	12:00	1614	1.614	-6	-0.70	19.3	1.99E-04	-14.16	1605.99	-0.72	9.3	7.73E-05	-5.66	1614.50	18.3	1.86E-04	-4.9886	1623.5	-87.393	71.7	-0.66	72.16	-0.406
9/2/2007	13:00	1613	1.613	-7	-0.72	19.3	1.98E-04	-14.51	1605.64	-0.77	9.2	7.67E-05	-5.94	1614.21	18.1	1.84E-04	-3.7782	1624.7	-67.059	71.7	-0.67	72.21	-0.493
9/2/2007	14:00	1616	1.616	-4	-0.60	19.4	2.00E-04	-12.06	1608.09	-0.47	9.5	8.10E-05	-3.84	1616.32	17.9	1.82E-04	-2.3554	1626.1	-42.155	71.8	-0.56	72.28	-0.573
9/2/2007	15:00	1615	1.615	-5	-0.65	19.3	1.99E-04	-13.12	1607.04	-0.60	9.4	7.92E-05	-4.77	1615.38	17.9	1.82E-04	-0.8011	1627.7	-14.378	71.8	-0.61	72.35	-0.525
9/2/2007	16:00	1618	1.618	-3	-0.52	19.5	2.01E-04	-10.65	1609.51	-0.30	9.7	8.35E-05	-2.52	1617.64	17.9	1.82E-04	0.8034	1629.3	14.378	71.9	-0.49	72.42	-0.646
9/2/2007	16:06	1618	1.618	-3	-0.52	19.5	2.01E-04	-10.65	1609.51	-0.30	9.7	8.35E-05	-2.52	1617.64	17.9	1.82E-04	0.1676	1628.7	2.999	71.9	-0.49	72.39	-0.500

Figure 5B.5.4.1 - 2007 Hold Test - L1 Sump - Actual Volume and Modeled Expansions



same circuit as a ventilation fan motor control center or that the weight factor based instrument was impacted by the change in air pressure caused by the shutdown of the fan. It is unknown if the system wiring configuration that existed in 1993 continues to exist, however, if system ventilation changes during testing, level measurement will be impacted, since weight factor based instrumentation is still in use. It should be ensured that system ventilation remain on and constant during testing, if at all possible.

Evaporation losses may also have occurred and may occur in future hold tests. However, evaporation losses, if significant, would take a similar form to leaks from the system (a steady loss over the test period). Based on analysis of data collected in 1993 and 1998, this effect, if it has occurred, does not appear to be significant or detectable with current process instrumentation. Depending on actual test conditions, especially airflow within the vapor-liquid separator, evaporation loss may be too small to be detected. If at all possible, airflow in the system should be quantified to best understand and quantify the potential impact of evaporation, if measurable or significant, during the hold test.

Given the excellent fit between predicted and actual system fluctuations in measured volumes (see Section 5B.5), it is most likely that variations in the vapor-liquid separator system were caused by temperature fluctuations as stated in the 1998 IAR. If not caused by temperature fluctuations, then some other phenomena that occurs in a 24 period or cycle. If temperature data are available in future integrity assessments it might be used to account for volume fluctuations in the Evaporator/Reboiler Loop as well as in Sump L1. In the absence of collecting collaborating temperature data and observing similar sinusoidal volume fluctuations in future integrity assessments, it may be reliably concluded such effects are caused by temperature fluctuations based on the forgoing analysis. However, these affects have been of small magnitude, less than 15 to 17 gallons (or only 5 gallons for the L1 sump), and therefore within known accuracy of level sensing instrumentation (+/- 48 gallons). Therefore, the actual magnitude of these fluctuations is not likely to be accurately represented by the current sensors due to their small magnitude.

5B.7 REFERENCES

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ATTACHMENT 5C

EVAPORATOR AND PUMP ROOM WALKDOWN WORK INSTRUCTIONS AND RESULTS

(7 Pages)

STEP 002

WFO-WO-06-002549, Walkdown of Evaporator and Pump Rooms

1.0 SCOPE

- Supplemental work instructions to STEP 001 to perform visual inspection of the C-A-1 vessel and associated components **AFTER** a 24 hour leak test has been performed under work package # WFO-WO-07-1225. The intent of this step is visual inspection of equipment and supporting photographs as required, as well as data sheet documentation of the inspection. Entry into the Evaporator/Pump rooms will be as soon as possible after the vessel has been emptied and will be coordinated with Shift Manager and Safety personnel.

- The external portions of the components, piping, flanges, welds, and valves will be examined for evidence of leaks. The walk-downs will be performed by a qualified inspector in accordance with ASME Section XI (VT-2) and overseen by the IQRPE or designated QC Level II inspector.

- If any leaks are observed, follow-up engineering analysis shall be conducted.

- Acceptance Criteria for this visual test is NO DETECTABLE LEAKS.

- Multiple entries may be performed to obtain pictures & data.

2.0 LIMITATIONS & PRECAUTIONS:

[ ] 2.1. **ENSURE** limitations and precautions identified in Step 001 are observed.

[ ] 2.2. **AVOID** disturbing any and all areas where indications of leakage may have occurred until surveyed by HPT.

3.0 PREREQUISITES

[ ] 3.1. **CONDUCT** a Pre-Job Briefing.

[ ] 3.2. **ENSURE** prerequisites stipulated in Step 001 have been performed.

NOTE: Steps in Section 4.0 may be worked repeatedly. Multiple Entries may be performed.

4.0 SPECIFIC WORK INSTRUCTIONS

NOTE: Entry into the Evaporator/Pump rooms will be as soon as possible after the vessel has been emptied and will be coordinated with Shift Manager and Safety personnel.

NOTE: All indications of leakage are considered radiologically uncharacterized and are to be avoided until surveyed by HPT.

[ ] 4.1. ENSURE WO# WFO-WO-07-1225 has completed the leak test and the vessel has been drained prior to any entries into the evaporator/pump rooms.

[ ] 4.2. HPT perform pre-job General Area survey at work locations.

[ ] 4.2.1. Record the Pre-Job Survey RSR (Radiological Survey Report) Number on RSR Log in the work package.

Pen+Ink 01 9/4/07

~~[ ] 4.3. ENSURE Caution tape is installed 6 ft from Pump Room sump prior to performing other work activities in the Pump Room.~~

[ ] 4.4. ENSURE any scaffolding/ladder to be used is inspected by a designated competent person prior to use.

NOTE: Components may be examined in whatever sequence is most convenient to minimize exposure time in the radiation zone. Items to be inspected and photographed are listed in Attachment B-1.

[ ] 4.5. QC Level II Inspector shall examine/photograph the exposed sections of the Evaporator Vessel and Reboiler and all connecting piping, flanges, welds, fittings and valves for signs of leakage.

[ ] 4.5.1. EXAMINE the SPC floor coating for signs of water accumulation.

NOTE: It may not be possible or practical to photograph every piece of equipment.

[ ] 4.5.2. ENSURE items listed in Attachment B-1 are photographed as required.

[ ] 4.5.2.1. ENSURE photographs are taken which clearly show any source of leak and its location.

[ ] 4.6. COMPLETE Data Sheet 1 with visual inspection results.

[ ] 4.7. AFTER completion of the visual examination, the 242-A System Engineer shall review the observations, MARK the appropriate evaluation line and SIGN Data Sheet 1.

5.0 POST MAINTENANCE TESTING

N/A

6.0 RESTORATION ACTIONS

[ ] 6.1. FWS Ensure Data Sheet documentation and picture file is forwarded to Al Friberg (376-1190) OR Jim Castleberry (373-5011).

[ ] 6.2. Restoration Actions will be performed per Step 001.

Work Instruction Record Copy

DATA SHEET 1

EVAPORATOR & COMPONENT LEAK TEST VISUAL INSPECTION RESULTS

Time and Date when inspection began: 8:30 PM 9-4-07

Connections:

From C-A-1: TO PUMP ROOM WALL - NO LEAKAGE OBSERVED

To P-B-1: REFERENCE 9-4-07 WP RECORD - NO

From P-B-1: LEAKAGE OBSERVED

To E-A-1: FROM PUMP WALL TO EA-1 - NO LEAKAGE OBSERVED

From E-A-1: NO LEAKAGE OBSERVED

To C-A-1: NO LEAKAGE OBSERVED

_______________ / _______________
Operations Manager Date:

[signature] / 9-4-07
QA Inspector Date

Comments: _______________

✓ System and components are acceptable based on the inspection results. No further evaluation is required.

_____ System and components require further evaluation.
Reference:

_______________ / _______________
242-A System Engineer Date:

[signature] / 9-4-07
QC Level II Inspector Date:

RPP JCS WORK RECORD

Document Number: WFO-WO-06-2549

2. Work Item Title:

Date	Turnover, Problem Description, Action Taken	Feed Back (X)	Name	Craft/ Resource Type	Hours
9/04	Held pre-job, HPT and Operator				
	Entered EVAP at 0'20:26				
	2 FWS and 1 QC Entered EVAP				
	Room on the 4th floor at 20:35.				
	1-FWS Exited HRA, 21:20, QC, Exited				
	HRA 21:26. 1-FWS Exited HRA				
	21:30. Operator Exited HRA At				
	21:32, HPT Exited HRA 21:35				
	All personnel out of HRA and				
	EVAporator Air locks. Verified				
	Highrad Doors secured.		[signature]	FWS	
	All waste properly disposed of.		[signature]	FWS	
9/4/07	VERIFIED WITH QC NO NOTICABLE		[signature]	FWS	
	leaks observed.				

Summary by Craft/Resource Type

Craft/Resource Type	Total Hours	Craft/Resource Type	Total Hours

A-6003-243 (12/02)

ATTACHMENT 5

EVAPORATOR-REBOILER LOOP LEAK TESTING PROCEDURES

AND TEST RESULTS

(75 PAGES)

ATTACHMENT 5A

C-A-1 HYDRO TEST WORK INSTRUCTIONS AND TEST RESULTS

(16 PAGES)

Terry Curtis

From: Burke, Christopher A [Christopher_A_Burke@RL.gov]
Sent: Wednesday, December 26, 2007 2:11 PM
To: tcurtis@technogeneral.com
Subject: FW: Evaporator Leak test results

From: Cowgill, Ronnie A (Ron)
Sent: Wednesday, December 26, 2007 12:05 PM
To: 'tcurtis@tecnogeneral.com'
Cc: Faust, Toni L; Burke, Christopher A; Ostrom, Michael J
Subject: Evaporator Leak test results

Gentlemen;

In an effort to clarify the entries on data sheet 1, of WFO-WO-07-1225 Evaporator & Component Leak Test Visual Inspection Results, let it be known that I observed no leakage on any portion of the areas inspected. The entry on data sheet line ...To P-B-1 and data sheet line ...From P-B-1 should be read as no leakage observed.
If I can be of any further assistance let me know.

Ron Cowgill

WFO-WO-07-1225
242A INTEGRITY ASSESSMENT – C-A-1 VESSEL

1.0 SCOPE

- Perform Leak Test of the Evaporator Vessel in support of the Integrity Assessment Plan (IAP) for the 242-A Evaporator System. The Vessel Integrity Test is being conducted under the overview of an Independent Qualified Registered Professional Engineer (IQRPE). It is not necessary for state inspectors to witness the integrity test nor is it necessary to notify the state of the date and time of the test. Results of the integrity test will be documented in the final 242-A Integrity Assessment Report (IAR), which will be retained in the 242-A Evaporator regulatory File.

- The external portions of the components, piping, flanges, welds, and valves will be examined for evidence of leaks. The walk downs will be performed by a qualified inspector in accordance with ASME Section XI (VT-2) and overseen by the IQRPE or designated QC Level II inspector. Visual Inspections in the Evaporator/pump rooms will be performed on WO# WFO-WO-06-002549 **AFTER** this leak test is completed.

- Water will be the process solution in the Evaporator Vessel for testing.

- The acceptance criteria for this test are NO DETECTABLE LEAKS.

- Work will include:
  - Coordinating the hydrostatic testing of the Evaporator Vessel (C-A-1) with Operations after the Deep Flush process.
  - Filling of the vessel to a minimum level of 26,500 gallons.
  - Obtaining weight factor data readings and recording levels hourly during the 24 hour test.
  - Conducting Visual observations every four hours during the 24 hour test.
  - IF leaks are observed, follow-up engineering analysis shall be conducted to identify the type and extent of repairs required.

- The equipment being worked on is general service (GS).

- In accordance with the guidance contained in TFC-ESHQ-RP_RWP-C-03 "ALARA Work Planning", this task has been determined to be LOW radiological risk. (Ref. RWP TF-001, current rev.)

2.0 LIMITATIONS

[✓] 2.1. This work package will utilize radiological limits and controls specified on RWP TF-001 (Current Rev).

[✓] 2.2. Feed and Slurry lines must have been deep flushed and Section 5.10 of Procedure TO-650-140 performed prior to performing this leak test.

[✓] 2.3. Water used will be at ambient temperature.

3.0 PREREQUISITES

[✓] 3.1. FWS shall conduct a Pre-Job Briefing and review the applicable Job Hazards, Limitations and Precautions sections.

[✓] 3.2. Ensure C-A-1 vessel dump valve locking screws are installed to prevent inadvertent loss of vessel contents until integrity assessment has been completed.

[✓] 3.3. The Evaporator Facility SHALL be in OPERATION Mode during this work activity.