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Preliminary Engineering Report for the 241-S-102 Waste Retrieval System

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PRELIMINARY ENGINEERING REPORT FOR THE 241-S-102 WASTE RETRIEVAL SYSTEM

Submitted by Holmes and Narver/DMJM Inc.
for CH2M HILL Hanford Group, Inc.
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PRELIMINARY ENGINEERING REPORT FOR THE 241-S-102 WASTE RETRIEVAL SYSTEM

EXECUTIVE SUMMARY

This Preliminary Engineering Report establishes a programmatic planning basis for the initial waste retrieval of radioactive waste from Single-Shell Tank 241-S-102, located in the 200 West Area of the U. S. Department of Energy's Hanford Site. The recently renegotiated Hanford Federal Facility Agreement and Consent Order establishes milestones for life-cycle activities required to complete the initial waste retrieval from 241-S-102 by September 30, 2006. The preliminary project schedule developed for this effort indicates that the 241-S-102 waste retrieval systems can be deployed, tested, and operated to support the M-45-05A completion milestone of September 30, 2006.

The Single-Shell Tank, 241-S-102, contains an estimated 472,000 gallons of waste, mainly in the form of saltcake with some insoluble sludge. Dissolution retrieval of this waste has been identified as the preferred mechanism to recover the 241-S-102 Constituents of Concern, thereby reducing the risk of tank leaks resulting in further contamination of the Hanford soil column, groundwater, and Columbia River.

The specific retrieval method selected for deployment in 241-S-102 is based on the fluidic mixing and transfer pumping technology. The fluidic systems available through AEA Technology have been used as the pre-conceptual engineering basis for developing the 241-S-102 waste retrieval system. This retrieval method allows the tank contents to be mobilized and recovered with no moving parts having to be installed within the tank.

The 241-S-102 waste retrieval operations will be performed in two phases. Phase I retrieval operations will rely solely upon dissolution of saltcake to mobilize the tank waste. A 4-diode pump installed in the central 42-inch riser will transfer solution in batches, through a temporary over-ground transfer line, directly to 241-SY-102. Water will be introduced to 241-S-102 by means of back flushing through the transfer line from 241-SY-102 to 241-S-102. Phase I retrieval operations will recover approximately 500,000 gallons of solution, representing approximately 225,000 gallons of 241-S-102 waste. Phase II retrieval operations will commence following Phase I retrieval, the

installation of three fluidic mixers, and a cross-site transfer from 241-SY Farm to accommodate the receipt of additional waste.

Phase II retrieval will utilize three fluidic mixers to mobilize the waste for recovery from 241-S-102. The same 4-diode pump used in Phase I retrieval operations will be used to recover the resultant waste slurry. Water additions will be made through back flushes from 241-SY Farm, as during Phase I retrieval operations.

The preliminary project schedule developed for this effort indicates that the 241-S-102 waste retrieval project can be accomplished to support the M-45-05A completion milestone of September 30, 2006. The preliminary estimate indicates that the project can be completed for the Multi-Year Work Plan (MYWP) baseline cost of $50.3M.

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ACRONYM LIST

AB	authorization basis
AEAT	AEA Technologies
AUR	Air Utilization Ration
BBI	Best-Basis Inventory
c/s	counts per second
CCTV	Closed Circuit Television
CHG	CH2M Hill Hanford Group, Inc.
Ci	Curie
COC	constituents of concern
DOE	U.S. Department of Energy
DQO	data quality objective
DST	Double-Shell Tank
Ecology	State of Washington Department of Ecology
EPDM	ethylene propylene diene monomer
FAT	Factory Acceptance Test
FY	Fiscal Year
HDW	High-Pressure Demineralized Waste
ILL	Interstitial Liquid Level
LDMM	Leak Detection, Monitoring, and Mitigation
LFL	lower flammability limit
LOW	Liquid Observation Well
MCS	Monitoring and Control System
MYWP	Multi-Year Work Plan
OGT	over-ground transfer
ORP	Office of River Protection
P&ID	Piping and Instrumentation Diagram
pCi	Picocurie
PER	Preliminary Engineering Report
PFD	Process Flow Diagram
PLC	Programmable Logic Controllers
REDOX	Reduction-Oxidation
RFD	reverse flow diverter
ROM	rough-order-of-magnitude
RPE	Retrieval Performance Evaluation
RPP	River Protection Project
SSC	structures, systems, and components
SST	Single-Shell Tank
TEP	Test and Evaluation Plan
TFA	Tank Focus Area
TMS	Topographical Mapping System
TOC	total organic carbon
TPA	*Hanford Federal Facility Agreement and Consent Order*, Tri-Party Agreement
VE	Value Engineering
WAC	Washington Administrative Code
WBS	work breakdown structure

WRS	Waste Retrieval System

1.0 INTRODUCTION

1.1 Mission

The mission of the River Protection Project (RPP) includes the retrieval, immobilization, storage, and disposal of Hanford Site tank waste. In support of the RPP mission, and to achieve compliance with federal and state dangerous waste requirements as enforced by the *Hanford Federal Facility Agreement and Consent Order,* Tri-Party Agreement (TPA), the Single-Shell Tank (SST) Retrieval Project has developed several initiatives to implement the recently renegotiated TPA strategy for near-term waste retrieval activities. This new strategy places an emphasis on scheduling the retrieval of wastes from those SSTs with a high volume of constituents of concern (COCs), rather than focusing on maximizing the number of tanks entered for retrieval. The COCs are defined as mobile, long-lived radionuclides that have a potential of reaching the groundwater and the Columbia River. A comprehensive list of contaminants under consideration in the Retrieval Performance Evaluation is included in Table 1-3. The near-term retrieval strategy also focuses on the performance of key retrieval technology demonstrations in a variety of different waste forms and tank farm locations to establish a technical basis for future work. Specific TPA milestones have been established, consistent with the new strategy, for demonstrating SST waste retrieval technologies in 241-S-112 and 241-C-104, and for completing initial waste retrieval from 241-S-102.

The mission of the 241-S-102 Initial Waste Retrieval Project, as defined in RPP-8367, *241-S-102 Waste Retrieval Project Definition Criteria*, is to retrieve radioactive waste from 241-S-102 and to transfer the waste to the double-shell tank (DST) system for staging in support of eventual processing at the future Waste Treatment Complex. Goals established in the TPA for this initial waste retrieval include the retrieval to safe storage of approximately 490 curies of mobile, long-lived radioisotopes and 99% of the tank contents by volume (per the U. S. Department of Energy's (DOE) Best-Basis Inventory (BBI) data, dated August 1, 2000). The 241-S-102 Initial Waste Retrieval Project will demonstrate an integrated retrieval and leak detection, monitoring, and mitigation (LDMM) system to safely retrieve combined saltcake and sludge waste. The goal of the system developed will be to improve upon the performance of past practice sluicing in the areas of retrieval efficiency, leak loss potential, and suitability for use in potentially leaking tanks.

In accordance with TPA Milestone M-45-05A, the initial waste retrieval from 241-S-102 shall be completed by September 30, 2006. A full listing of the TPA milestones associated with this project, including interim target milestones is provided in Table 13-1 (see Section 13.0).

1.2 Purpose/Objective

The programmatic basis and needs are established for the 241-S-102 Initial Waste Retrieval Project by the renegotiated M-45-05 series milestones contained in the TPA. The purpose of this Preliminary Engineering Report (PER) is to develop a pre-conceptual design and supporting engineering, cost, and schedule basis for deployment of a waste

retrieval system (WRS) for 241-S-102 based on application of existing fluidic technology. This report is prepared to meet the Project Hanford Management Contract requirements established in HNF-IP-0842, Volume IV, *Engineering*.

Objectives of the PER include development of a clear and complete description of the 241-S-102 Waste Retrieval Project scope, reflecting the project's pre-conceptual design, and development of preliminary acquisition and operating strategy for the 241-S-102 retrieval system consistent with the established regulatory (i.e., TPA) requirements and RPP mission. The PER is intended to establish scoping-level project interface descriptions and to identify any significant issues, assumptions and technical uncertainties requiring resolution during latter design phases of the project. To the extent possible, technical uncertainties, assumptions and major issues identified during the pre-conceptual design phase will be resolved and documented in this report. Where these issues/uncertainties cannot be resolved due to insufficient information, the PER will provide recommended resolution/risk mitigation strategies to be implemented during latter stages of project execution. Cost and schedule-related objectives associated with this PER include documentation of technically sound, rough-order-of--magnitude (ROM) cost and schedule estimates, consistent with the pre-conceptual design concept and schedule commitments defined in the TPA, that can be used to support initial project baseline development.

This PER provides the scope, cost, and schedule basis to support Critical Decision 0 (CD-0) approval from the DOE Office of River Protection (ORP) to proceed with development of the conceptual design for the 241-S-102 Waste Retrieval Project.

1.3 Scope

The 241-S-102 Waste Retrieval Project scope includes engineering, design, procurement, installation/construction, integrated full-scale testing, and turnover to Operations of a fully functional WRS for 241-S-102. The proposed technology to support the initial waste retrieval of 241-S-102 includes a fluidic mixing and transfer pumping system, consisting of a 4-diode pump and three reverse flow diverter (RFD) mixers installed inside the tank. The fluidic system will introduce relatively small quantities of solvent (water) to dissolve, mix, and mobilize the waste within 241-S-102 and transfer the recovered waste into the DST system.

In addition to the installation of the fluidic mixing and pumping systems in 241-S-102, the project scope includes the waste transfer system and receiver tank modifications, as necessary, to transfer the 241-S-102 waste to the designated DST receiver, 241-SY-102 and/or 241-SY-101. Waste transfers within the DST system will be required before, during, and after the recovery of waste from 241-S-102.

As discussed in RPP-8367, the new structures, systems, and components (SSCs), and modifications to existing tank farm SSCs, provided by this project will include the following general scope elements:

- 241-S-102 Waste Retrieval System
- 241-S-102 Ventilation System
- Transfer System
- 241-S-102 Utilities
- 241-S-102 Instrumentation and Control System
- 241-S-102 Waste Mapping System
- Receiver Tank Modifications
- SY-Farm Flush System
- Leak Detection, Monitoring and Mitigation System(s)

Technical requirements associated with the project SSCs are defined in RPP-7512, *Tank 241-S-102 Waste Retrieval System Level 2 Specification*. A description of the planned project scope elements, based on the current stage of project design development, is provided in Section 2.0 of this PER. A requirements compliance matrix is included in Appendix E.

The scope of the project includes all operational activities associated with recovery of the waste from 241-S-102 to 241-SY-102, as well as subsequent post retrieval activities including a technology evaluation and isolation of 241-S-102 from the 241-S and 241-SY transfer systems. The project scope does not include activities associated with post-retrieval tank closure requirements. Fluidic retrieval has been selected for evaluation in determining the potential application for future retrieval or closure efforts. An evaluation of the technology performance and applicability for future application will be completed by the Project.

1.4 Description of Generic Fluidics Retrieval System

This section is intended to introduce fluidic systems as they have and are generally deployed in a variety of applications. The arrangement represents a generic application of fluidics, not necessarily configured for retrieval at Hanford. The component descriptions, names, and general functions, are taken from the current baseline system as proposed by AEA Technologies. The generic "system" described in this section has been used as the basic platform for the development of the 241-S-102 Initial Waste Retrieval System. The system description proposed for the mobilization and retrieval of 241-S-102 is described in Section 2.0.

The fluidic system uses compressed air flow through a series of eductors to create a pressure differential in a charge vessel. This pressure differential can be used to force liquid out of the charge vessel through a nozzle to mix the waste, and to draw liquid into the vessel for mixing or recovery and transfer. A charge vessel is a hollow pipe section which acts like a positive displacement pump when air force is placed upon the internal fluid.

Fluidic mixing and retrieval systems are used for mixing and pumping of liquids and solids in a variety of applications. The primary advantage of a fluidic system(s) when compared to more conventional retrieval systems is that no moving parts are located inside the tank thereby reducing potential failures requiring, maintenance, and worker exposure. The mixers/pumps use a similar configuration and common support infrastructure components that include:

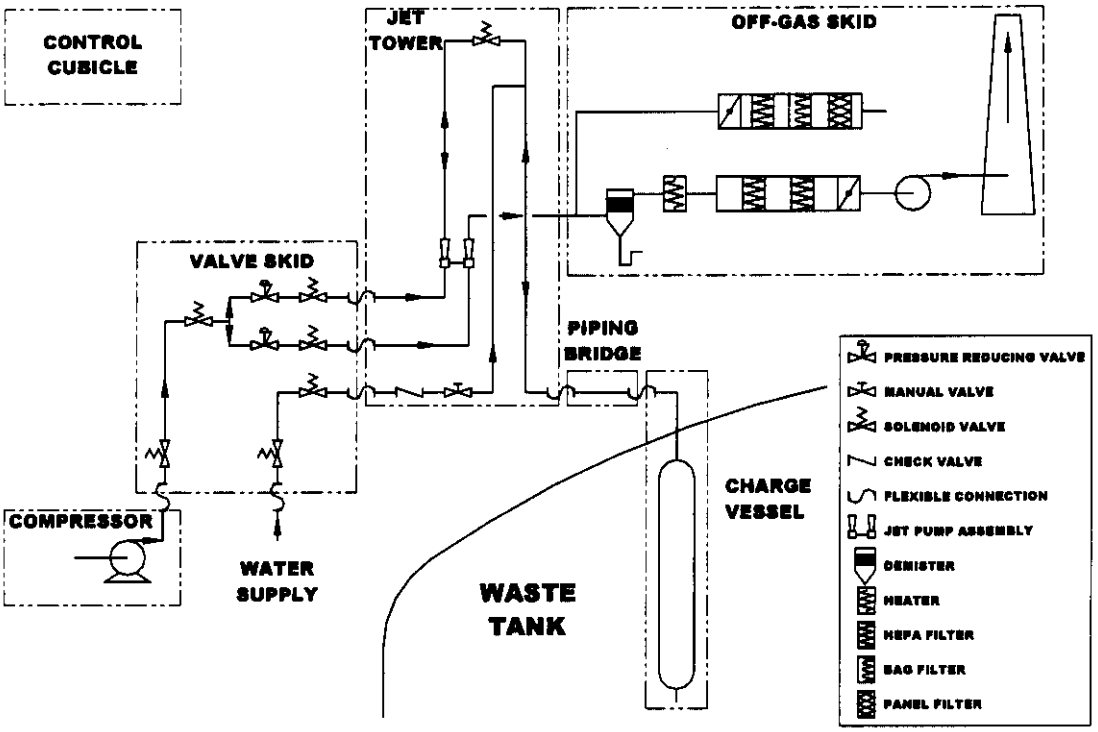
- Air compressor with or without accumulator/surge tank,
- Ventilation (or off-gas) skid,
- Valve skid,
- Jet skid (or jet tower),
- Pipe bridge,
- Charge vessel, and
- Control cubicle.

A simplified schematic showing the arrangement and interrelationship of these components, as they would be arranged for a typical application is provided in Figure 1-1.

Figure 1-1 shows only the charge vessel assembly, or portions thereof, inserted into the tank. While the system does incorporate moving parts, none are introduced into the dangerous waste environment. Components that contain moving parts (i.e., those with potentially greater failure frequency, or requiring routine maintenance or surveillance) are installed away from the hazardous environment.

Cyclic pressurization and evacuation of the charge vessel is initiated by the continuous supply of air flowing from the air compressor to the valve skid. Solenoid valves on the valve skid direct the airflow to the jet tower. Depending upon the valve configuration, the air flows through one of two, or neither, of the eductors on the jet tower. Flow through one eductor evacuates the charge vessel, while flow through the other pressurizes the charge vessel. By opening and shutting solenoid valves the airflow through the valve skid, jet tower, pipe bridge, and charge vessel is modulated. Liquid is drawn into the charge vessel during the evacuation phase and expelled from the charge vessel during the drive (pressurization) phase. Air is removed from the charge vessel by routing the vent stream through the filters on the off-gas skid. Operations and monitoring of the system (both in-tank and ex-tank) are performed within the control cubicle located at or near the equipment deployment location.

Figure 1-1 Fluidics Schematic



The purpose of the jet tower is to ensure that the contaminated liquid is not siphoned from the waste tank back into the valve skid. The highest point on the jet tower is 35-feet above the liquid waste level. In the case of 241-S-102, where the waste level in the tank is well below grade, the waste cannot be siphoned from the tank because the waste liquid surface is about 30-feet below the valve skid. This will allow for the elimination of the jet tower and combination of the valve skid and jet tower. The remainder of the components included in the system perform functions consistent with their title designation.

1.4.1 Fluidic Mixers

The arrangement of components included in a standard fluidic mixing system is illustrated in Figure 1-1. The charge vessel is a generic designation, representing either a fluidic mixer or fluidic pump, as described in the following sections. The fluidic mixing system utilizes the existing recovery liquid (supernatant) to mix the waste. If an insoluble solids layer exists on the tank floor, the mixing vessel can use the overlying supernatant to mix and suspend the solids. As the solids are mobilized and eroded away, the charge vessel can be lowered until the ideal vertical placement is reached.

Liquid is drawn into the charge vessel during the evacuation cycle and expelled from the charge vessel during the pressurization cycle. The relative duration for these two cycles is generally in the range of three or four to one, respectively.

The two mixing methods (pulse-jet and pulse-tube) are largely the same with only minor differences. The pulse-jet mixing alternative is generally the preferred method due to the increased ability to control the mixing process.

The inlet nozzle on the charge vessel of a pulse jet mixing system is typically directed parallel to the tank floor. Ideally, the charge vessel is installed on a large bearing and rotated between cycles by a stepper motor to optimize the mixing area of influence. A simplified schematic of the pulse-jet mixing method is included in Figure 1-2

A pulse tube approach utilizes a charge vessel inlet that is pointed vertically and directed at the tank floor. The expulsed liquid is projected against the tank floor under pressure or allowed to self-drain under the influence of gravity. A simplified schematic of the pulse-tube mixing method is included in Figure 1-3.

Figure 1-2 Fluidic Pulse-Jet Mixer

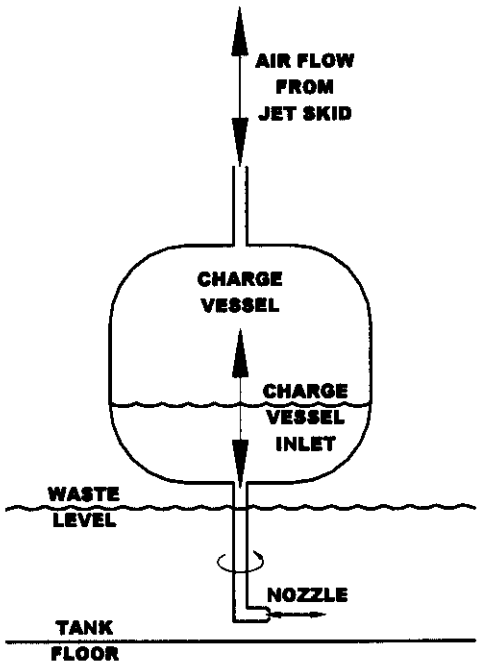
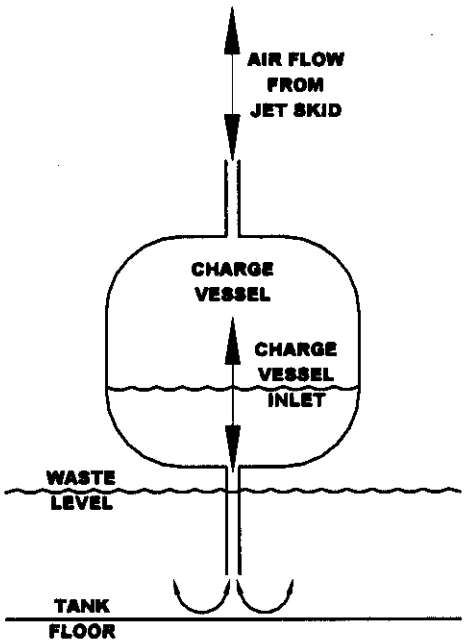


Figure 1-3 Fluidic Pulse-Tube Mixer



1.4.2 Fluidic Pumps

The arrangement of components included in a standard fluidic transfer pumping system is illustrated in Figure 1-1 with the charge vessel representing a fluidic transfer pump as described in the following section. Three different fluidic pumps have been identified. AEAT has two different pumping systems; one uses reverse flow diverters (RFD) and the other uses fluidic diodes. A third system developed and used in Russia is functionally the same as the AEAT diode pump with the diodes replaced with check valves.

Fluidic pumps produce intermittent flow as a "step" function inherent to the design. The pump produces no flow while the charge vessel is being filled during the evacuation cycle. For RFD pumps (Figure 1-4), the evacuation cycle is on the order of three to four times longer than the drive cycle when the liquid is being pumped. For higher head pressures this ratio is even higher. This results in an average flow rate from the recovery vessel one-third to one-fourth of the peak expulsion flow rate. Multiple RFD fluidic pumps could be operated out of phase (in conjunction with an accumulator or surge tank) to produce a near continuous flow. Combining flows from multiple pumps to produce continuous flow has not been demonstrated or attempted previously in field applications.

Diode pumps (Figure 1-5) operate at much lower pressures than RFD pumps. The expulsion cycle duration can be adjusted to approximately equal the fill cycle. Two separate diode pumps (a.k.a. a 4-diode pump) can then be operated out of phase to produce a continuous flow, albeit at very low head pressures.

Production of continuous flow would, in addition to producing a constant flow, allow for the installation of a conventional booster pump downstream of the fluidic pumps. Fluidic pump operation in this fashion has not, however, been previously demonstrated. It would likely require an accumulator or surge tank be used in concert with a conventional pump to produce a relatively stable and constant flow rate output.

Each of the pumping methods has unique performance characteristics suiting them for different applications. Diode pumps can generally accommodate large solid particle size and operate more efficiently, while RFD's generate greater head pressure.

Figure 1-4 Fluidic RFD Pump

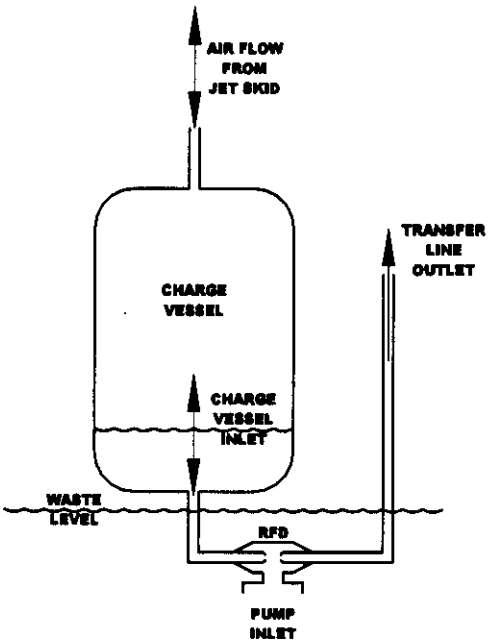
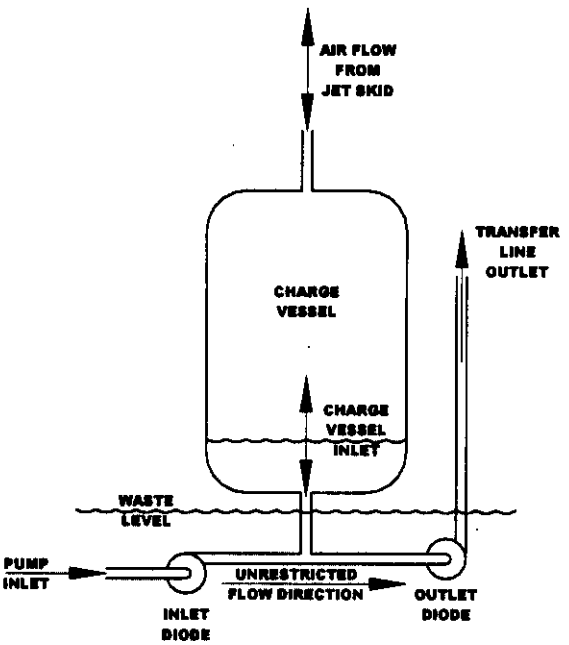


Figure 1-5 Fluidic Diode Pump



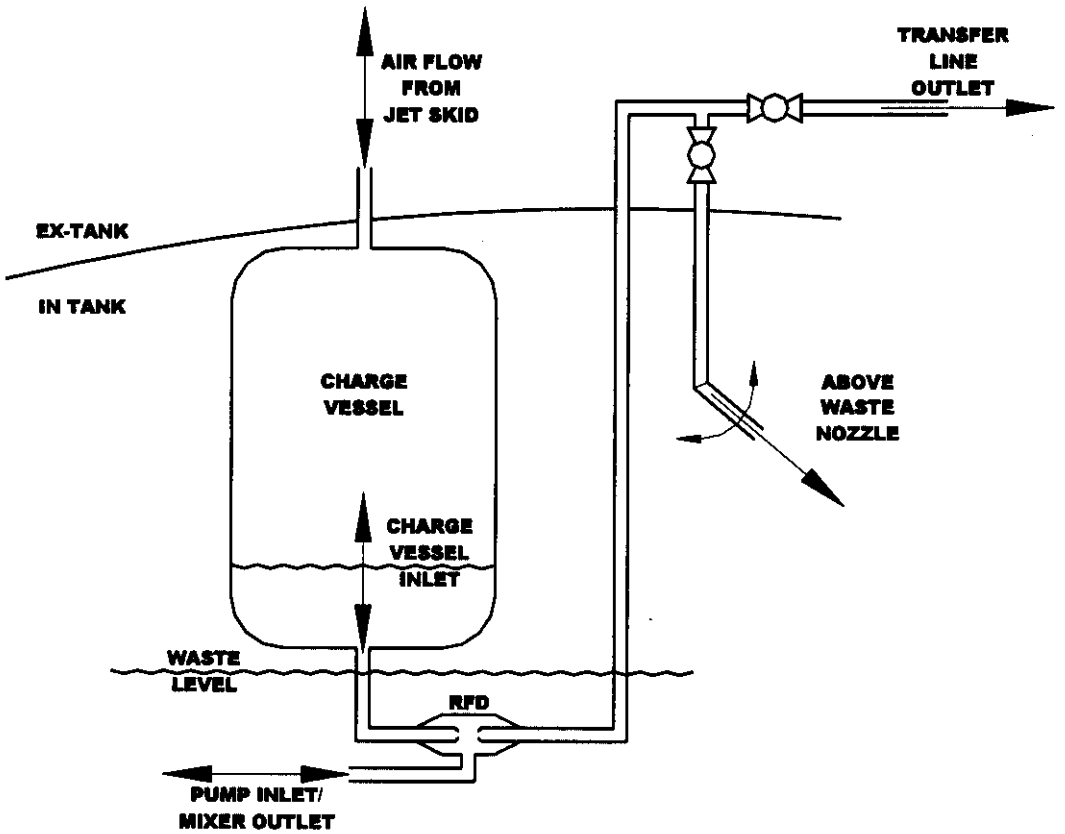
1.4.3 Fluidic Mixer and Pump Combination

The arrangement of components included in a standard combination "mix and pump" fluidic system is illustrated in Figure 1-1 with the charge vessel representing a combined unit as described in the following section.

A complete system relying solely on fluidics to perform both the mixing and pumping functions can be accomplished in one of two ways. The simplest form would be to have separate units for mixing and pumping, each with their own charge vessel. A more compact method, which may have greater utility at Hanford, would be to share a common charge vessel for both functions. The limited riser size and availability in 241-S-102 make this second option very appealing. Deploying two charge vessels into a riser of limited size reduces the volume of each of the charge vessels. This in turn reduces the performance characteristics by reducing the cycle duration. The solution to this problem is to utilize a system similar to that depicted in Figure 1-6. Depending upon the valve configuration the fluid expulsion can be directed into the transfer line, through an above waste mixing nozzle, or back into the waste via a sub-waste-surface nozzle.

The disadvantage to this system configuration, relative to a conventional pulse jet mixing system, is that the performance of the lower nozzle is degraded. Significant pressure losses are realized by forcing the expulsion stream through the RFD to the mixing nozzle. The result is a lower pressure through the nozzle and a reduced effective cleaning radius.

Figure 1-6 Combination System



1.5 Background

Engineering analysis (RPP-7819), Value Engineering (VE) workshop evaluations in fiscal year (FY) 2000 and FY 2001 (Appendix I), and preliminary engineering in FY 2000 on saltcake retrieval (RPP-6830 Rev. 0) identified fluidic mixing/pumping to be a viable technology for SST saltcake/sludge retrieval. AEA Technology's (AEAT) Fluidic pump and mixing systems have been identified as the reference technologies for use in the SST waste retrieval baseline.

Independent of the pre-conceptual engineering work for 241-S-102 retrieval, the DOE's Office of Technology Assessment (EM-50) Tank Focus Area (TFA) Group is sponsoring "proof-of-concept" testing of the Russian Fluidic and AEAT Fluidic mixing and pumping equipment to evaluate potential applications supporting SST retrieval. The results of this proof-of-concept testing will be integrated with the 241-S-102 Waste Retrieval Project activities as appropriate to ensure that a viable and cost effective retrieval system design is provided to support the M-45-05A Milestone.

This section identifies information that is pertinent to the development of the retrieval system and excludes any engineering development or analysis. Subsequent sections

describe the proposed system development and justification for the key decisions based primarily upon the background information provided in this section.

1.5.1 Tank S-102

1.5.1.1 Process History

The 241-S Farm is located in 200 West Area of the Hanford site and was constructed during the period of 1950 to 1951. Tank S-102 entered service in support of Reduction-Oxidation (REDOX) processing operations beginning in the third quarter of 1953 when the tank received REDOX high-level waste from S Plant. From the fourth quarter of 1953 to the third quarter of 1955, REDOX high-level waste was cascaded from 241-S-101 to 241-S-102. Waste additions to 241-S-102 from 241-S-101 did not occur again until the fourth quarter of 1973, and continued intermittently until the second quarter of 1979. Tank S-102 was used as the 242-S Evaporator feed tank from 1973 to 1976. Frequent transfers were made to 241-S-102 from other tanks during this period. After 1976, 241-S-102 received mostly evaporator bottoms and evaporator feed from tanks SY-102, T-101, TX-102, TX-104, and TX-105. Records show that large, intermittent transfers of water were added to the tank from 1972 through 1976. Tank S-102 was removed from service and labeled inactive in 1980 (HNF-SD-WM-ER-611).

Soil contamination around tanks S-101, S-102, and S-103 resulted from a large surface spill that occurred in 1973. The spill resulted from an overfill of 241-S-102 with waste fed from the 242-S Evaporator. The gamma-ray-emitting radionuclides cobalt-60 (Co-60) and Cs-137 were detected in the resulting plume. Co-60 concentration values were less than 10 pCi/g; Cs-137 concentration values ranged from less than 1 pCi/g to greater that 8,000 pCi/g. The surface spill appears to have migrated through the backfill material, cascaded along the tank domes, and collected at the base of the tank farm excavation. However, a small portion of the contamination does extend below the base of the tanks and into the Hanford formation sediments. The gamma-ray-emitting contamination appears to have migrated through the backfill and undisturbed Hanford formation sediments to a depth of at least 73-feet.

Tank S-102 was partially interim-isolated in 1982, and is presently awaiting the completion of final interim stabilization. Saltwell liquor waste was initially transferred cross-site during the fourth quarter of 1992 as part of the interim stabilization process. Approximately 549,000 gallons of waste was left in 241-S-102 after the initial interim stabilization transfers from the tank. Saltwell pumping of 241-S-102 was resumed during the first quarter of calendar year 1999. However, difficulties with achieving adequate process flows and numerous equipment failures have hampered the liquid recovery effort. It is currently planned to restart saltwell pumping in late 2001.

1.5.1.2 Sampling

Eleven push mode core segments were taken from the tank in March and April 1998. Three liquid grab samples were also taken from 241-S-102 in October 1998. Two prior liquid grab samples were taken in June 1995, to support the waste compatibility analysis. Additionally, four vapor samples were acquired between March 1995 and February 1997.

A summary of the recent sampling events is contained in Table 1-1. Analyses performed on these samples were used as the basis for establishing the BBI and evaluating the safety concerns associated with the tank.

Table 1-1 Tank S-102 Recent Sampling Events

Sample/Date	Phase	Location	Segmentation
Vapor sample (3/14/95 - 2/11/97)	Gas	Tank headspace, Riser 7	N/A
Push core 125 (1/9/96 - 3/8/96)	Solid/liquid	Riser 11	11 segments
Push core 130 (1/9/96 - 3/8/96)	Solid/liquid	Riser 14	11 segments
Push core 232 3/5/98 - 4/3/98)	Solid/liquid	Riser 16	11 segments
Grab (6/22/95)	Liquid	Riser 13	N/A
Grab (10/27/98)	Liquid	Riser 13	N/A

1.5.1.3 Retrieval Safety Concerns

An assessment of potential safety problems involving the saltwell pumping recovery and transfer of waste from 241-S-102 to 241-SY-102 is documented in *Tank Safety Screening Data Quality Objective* (WHC-SD-WM-SP-004, Rev. 2). Of the issues identified and evaluated, only the classification of 241-S-102 as a Flammable Gas Watch-List Tank requires further resolution. Tank S-102 remains on the flammable gas, safety issue Watch List (Public Law 101-510). Final resolution of the flammable gas safety issue is expected to be completed by September 30, 2001 (HNF-SD-WM-ER-680, Rev. 0).

1.5.1.3.1 Flammable Gas

Tank S-102 is a Facility Group 2 tank, which consists of tanks that are conservatively postulated to have the potential for small spontaneous and large induced gas release event. (HNF-SD-WM-SAR-067)

In accordance with the sampling and analysis plan (WHC-SD-WM-TSAP-074, Rev. 1) and as required by the safety screening DQO (WHC-SD-WM-SP-004, Rev. 2), the

241-S-102 headspace was sampled and analyzed before core sampling in 1996 for the presence of flammable gases, using a combustible gas meter. The analysis indicated that the flammable gas concentration in the tank headspace was 6% of the lower flammability limit (LFL), which is below the safety-screening limit of 25% of the LFL. In addition, the concentration of oxygen gas, ammonia gas, and total organic carbon (TOC) vapors were determined. The ammonia concentrations were determined to be above the "immediately dangerous to life or health" notification limit of 300 parts per million.

Retrieval of the remaining pumpable liquids by saltwell pumping will further mitigate the flammable and noxious gas safety concerns for 241-S-102.

1.5.1.3.2 Waste Compatibility

As noted previously, 241-S-102 was only partially interim stabilized in 1992. Saltwell pumping of waste from this SST (identified as waste stream SST-99-02) into DST SY-102 was reinitiated in 1998. At the onset of this second pumping campaign, approximately 480,000 gallons of waste, including dilution and flush water, were anticipated for transfer into the DST system by the saltwell pumping. Before pumping the waste liquids from 241-S-102 was re-initiated, a waste compatibility assessment was performed, as directed by the *Data Quality Objectives for Tank Farms Waste Compatibility Program* (WHC-SD-WM-DQO-001, Rev. 2, WHC-SD-WM-DQO-001, Rev. 1 and Fowler 1999), to ensure that the waste transferred from the SST was compatible with the waste contained in the receiving DST.

The waste compatibility assessment confirmed the compatibility of the 241-S-102 liquid waste with the contents of 241-SY-102, provided that seven specific requirements outlined within the assessment were addressed. These seven requirements specify that no additional waste categories, waste codes, or tank safety concerns will be created as a result of transferring the 241-S-102 wastes into 241-SY-102.

1.5.1.4 Best Basis Inventory

The BBI volume and composition estimates available for 241-S-102, as of August 1, 2000, are used as the baseline inventory values (RPP-7512). The August 1, 2000, BBI estimate for 241-S-102 was based on the following information:

- Statistical means from analysis of the 1996 and 1998 core samples as reported in Fritts (1996) and Steen (1998).
- BBI templates for the following waste types: 242-S Evaporator saltcake generated from 1977 to 1980 (S2 salt slurry) and REDOX sludge (R1 sludge).

The total volume of saltcake solids plus interstitial liquid is estimated at 472,000 gallons. Table 1-2 provides the 241-S-102 component volumes from the BBI calculation detail (effective August 1, 2000). Tank S-102 has undergone recent saltwell pumping and will continue to be pumped until the stabilization criteria are met. As a result of this pumping, the inventory of this tank will be updated quarterly until the interim stabilization criteria are

met. CHG 2000 reports that 57 kgal of the interstitial liquid have been pumped from the tank between the beginning of saltwell pumping on March 18, 1999 and August 1, 2000.

Table 1-2 Tank S-102 Best-Basis Inventory of Tank Volume[a]

Waste Phase	Waste Type	Applicable Concentration Data	Associated Density	Associated Volume
Saltcake	S2 salt slurry/S1 saltcake (solids)	1996 core samples (all segments except 11L of core 130)	1.68	1,098 kL (290 kgal)
		S2 salt slurry solids template	1.59	
	S2 salt slurry/S1 saltcake (liquids)	1996 core samples	1.39	151 kL (40 kgal)
		1998 core samples	1.40	
		S2 salt slurry liquid template	1.83	
	Retained gas	N/A	N/A	439 kL (116 kgal)
Sludge	R1 sludge (solids)	1996 core samples (segment 11L of core 130 only)	1.88	61 kL (16 kgal)
		R1 sludge solids template	1.75	
	S2 salt slurry/S1 saltcake (liquids)	1996 core samples	1.39	11 kL (3 kgal)
		1998 core samples	1.40	
		S2 salt slurry liquid template	1.83	
	Retained gas	N/A	N/A	26 kL (7gal)
Total Tank	Overall tank waste volume			1787 kL (472 kgal)

[a]This table is taken from the S-102 Tank Interpretative Report available from the TWINS database http://twins.pnl.gov/twins3/twins.html.

In addition to a volumetric retrieval goal of 99%, the 241-S-102 retrieval operation has a goal to retrieve 490 curies of mobile, long-lived radionuclides (based upon the August 2000 best basis inventory). An inventory estimate for each of the mobile, long-lived radionuclides in 241-S-102 (RPP-7087) is provided in Table 1-3. These inventories are likely to change as a result of ongoing saltwell pumping activities.

Table 1-3 Tank S-102 Inventory of Mobile Long-Lived Radionuclides

Analyte	Total Inventory (Ci)
^{14}C	6.08E+01
^{79}Se	3.74E+00
^{99}Tc	4.21E+02
^{129}I	8.15E-01
^{238}U	1.51E+00
TOTAL	**4.88E+02**

1.5.1.5 Waste Properties

Supernatant grab and core samples for 241-S-102 acquired in 1998 yielded waste salts ranging in color from white to gray. Drainable liquids were reported as clear with a yellow hue (HNF-SD-WM-ER-611, Rev. 1,). The extrusion reports from core samples taken in 1996 and 1998 indicated waste of varying consistency. Figure 1-7 graphically depicts the sample extruding technician's interpretation, and classification of the waste upon extrusion.

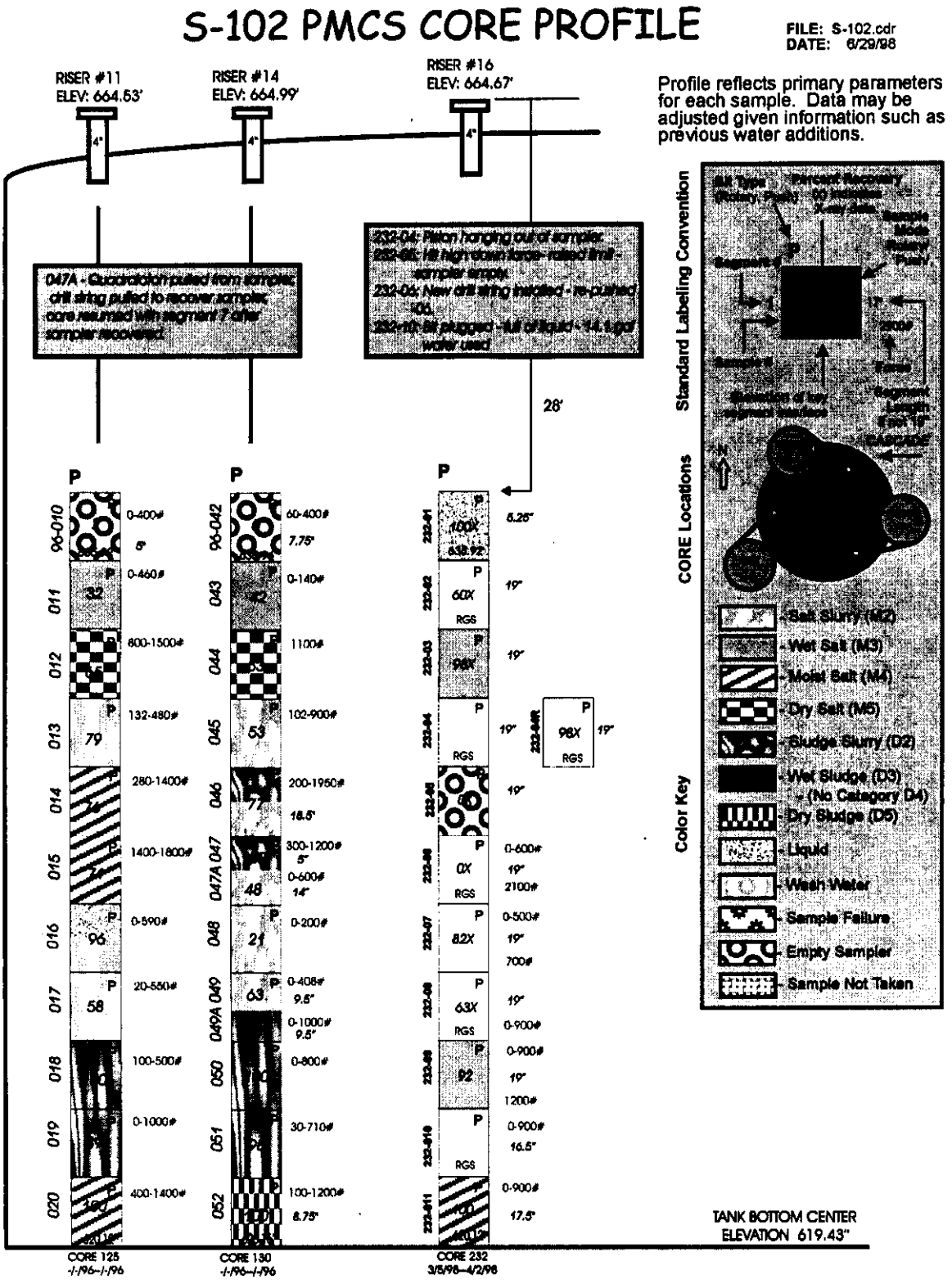


Figure 1-7 Tank S-102 Core Sampling Waste Profile

Bulk density and specific gravity measurements were performed on all subsegments of the 1996 core sampling. The subsegment-level results ranged from a high of 1.92 g/mL (from the upper half of segment 11, core 125), to a low of 1.274 g/mL (from the drainable liquid sample of segment 10, core 130), and yielded an overall mean of 1.64 g/mL. The saltcake, sludge, and saltcake/sludge composites yielded estimates of 1.69 g/mL, 1.67 g/mL, and 1.75 g/mL, respectively (HNF-SD-WM-ER-611, Rev. 1,)

Specific gravity measurements on drainable liquid samples from cores 232 and 130 ranged from 1.27 to 1.45. Shear and viscosity measurements for the saltcake acquired during the core sampling events could not be located.

Dissolution studies performed on 241-S-102 samples are applicable for use as a basis to predict the solubility of the 241-S-102 waste constituents. The results of three studies are summarized below.

Saltcake Dissolution Tests

Laboratory analysis of 241-S-102 saltcake waste samples have been performed and reported in HNF-5193 Rev. 0, *Saltcake Dissolution FY 1999 Status Report*. Tank S-102 saltcake is dominated by sodium nitrate. For 241-S-102 saltcake, most of the major salts were dissolved at 100% dilution, and over 95% of the sample dissolved at 200% dilution by weight at 50°C. This document states: "Under almost all dilution conditions, dissolution was more extensive at 50° C than at 25° C, but not dramatically so (page 2)." The 95% solubility at 200% dilution by weight (HNF-5193 Rev. 0) can be used as an upper bound for the maximum solubility.

Feed Stability Tests

Feed stability tests reported in HNF-7031, *Saltcake Dissolution FY 2000 Status Report*, provide results for 241-S-102 and other tanks to evaluate the potential for dissolved saltcake to re-precipitate in the receiver vessel. For 241-S-102, additions of sequential supernatant from washing the solids did not form a precipitate in the receiver jar.

Bulk Scale Saltcake Dissolution

Bulk scale dissolution of a non-radioactive simulated saltcake from 241-S-102 is reported in HNF-7363, Rev. 0. Tests were performed with a shallow bed (3.56 liters/bed height 5 cm) and a deep bed (12.4 liters/bed height 19 cm). The test bed diameter was 29.7 cm. Water was sprinkled uniformly over each of the beds and the disappearance of the salts was monitored. No attempt to repair channels in the bed was made in the deep bed test. Only one channel repair was made to the shallow bed. Channels were observed reforming and self-healing. Sprinkling too rapidly caused pools of liquid to form on the surface of the salts.

1.5.1.6 Tank S-102 Configuration

A summary level description and status of 241-S-102 is provided in Table 1-4. The current riser schedule is provided in Table 1-5. The tank and riser arrangement is graphically depicted in Figure 1-8. The tank has a nominal storage capacity of 758,000 gallons, and presently contains an estimated 472,000 gallons of double-shell slurry feed (CHG 2001). Interim stabilization saltwell pumping will continue in 241-S-102 until the stabilization criteria have been satisfied. The future inventory, when operations are scheduled for this effort, is expected to be somewhat less than that reported in the BBI.

Table 1-4 Tank S-102 Description and Status

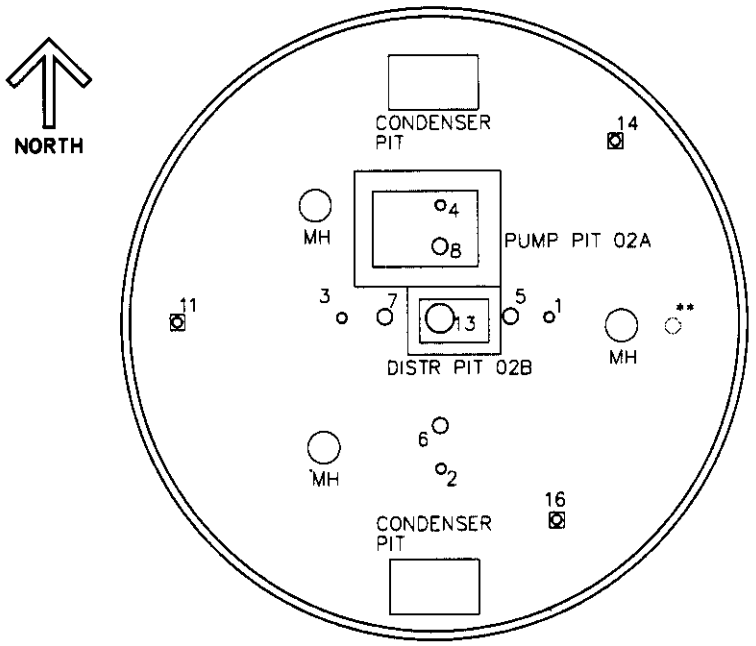
TANK DESCRIPTION	
Type	Single-Shell
Constructed	1951
In service	1953
Diameter	75 ft
Operating depth	23 ft
Capacity	758,000 gal
Bottom shape	Dish
Ventilation	Passive*
TANK STATUS	
Waste classification	Double-shell slurry feed
Total waste volume	472,000 gal
Supernatant volume	0 gal
Waste Temperature (7/27/01)	98 °F
Integrity	Sound
Watch List status	Flammable gas
Flammable gas facility group	2
SERVICE STATUS	
Declared inactive	1980
Interim isolation (partial)	1982
Interim stabilization (partial)	1992
Interim stabilization (active)	1999

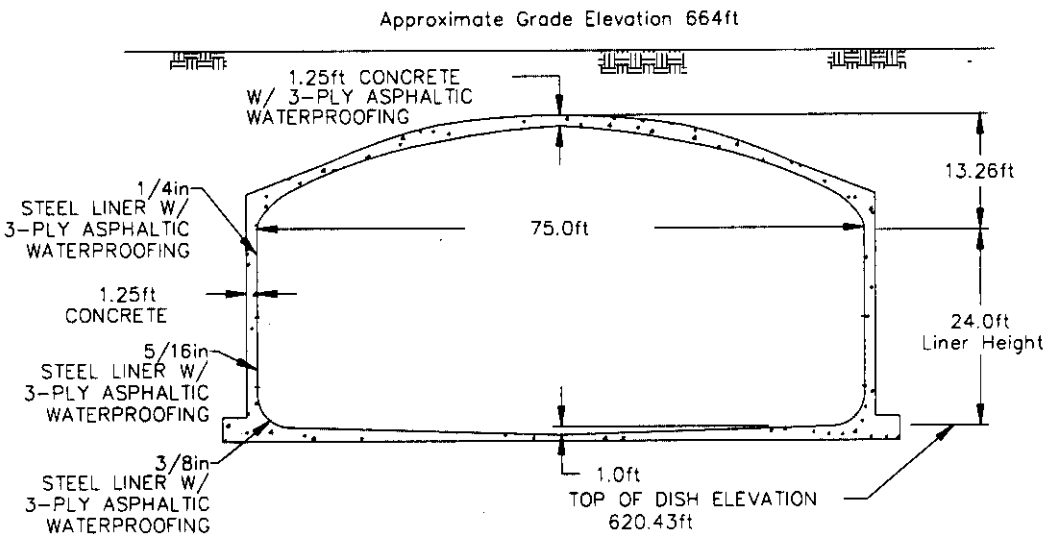
* Exhauster POR-004 is ducted to 241-S-102 and may be available for use.

Table 1-5 Tank S-102 Current Riser Utilization

RISER NUMBER	DIAMETER (Inches)	DESCRIPTION AND COMMENTS*
1	4	BREATHER FILTER
2	4	ENRAF
3	4	TEMPERATURE PROBE
4	4	SPARE
5	12	LOW [BM]
6	12	BREATHER FILTER
7	12	OBSERVATION PORT [MULTIPORT ADAPTER W/ HEATED VAPOR PROBE IN HIGHEST PORT]
8	12	SALTWELL PUMP AND SCREEN (ABANDONED)
11	4	SLUDGE MEASUREMENT PORT [EXHAUST DUCT TO PORTABLE EXHAUSTER POR-004]
13	42	SALTWELL SCREEN AND PUMP (ACTIVE, INSTALLED 1998)
14	4	SLUDGE MEASUREMENT PORT
16	4	SLUDGE MEASUREMENT PORT [BM]
MH	-	MANHOLE [BELOW GRADE]
**	12	An additional 12-inch riser was added along the north-south centerline of the tank on the east side (H-2-73182). The riser was cut off below grade with four 3-inch drop legs inside.

Figure 1-8 Tank S-102 Riser

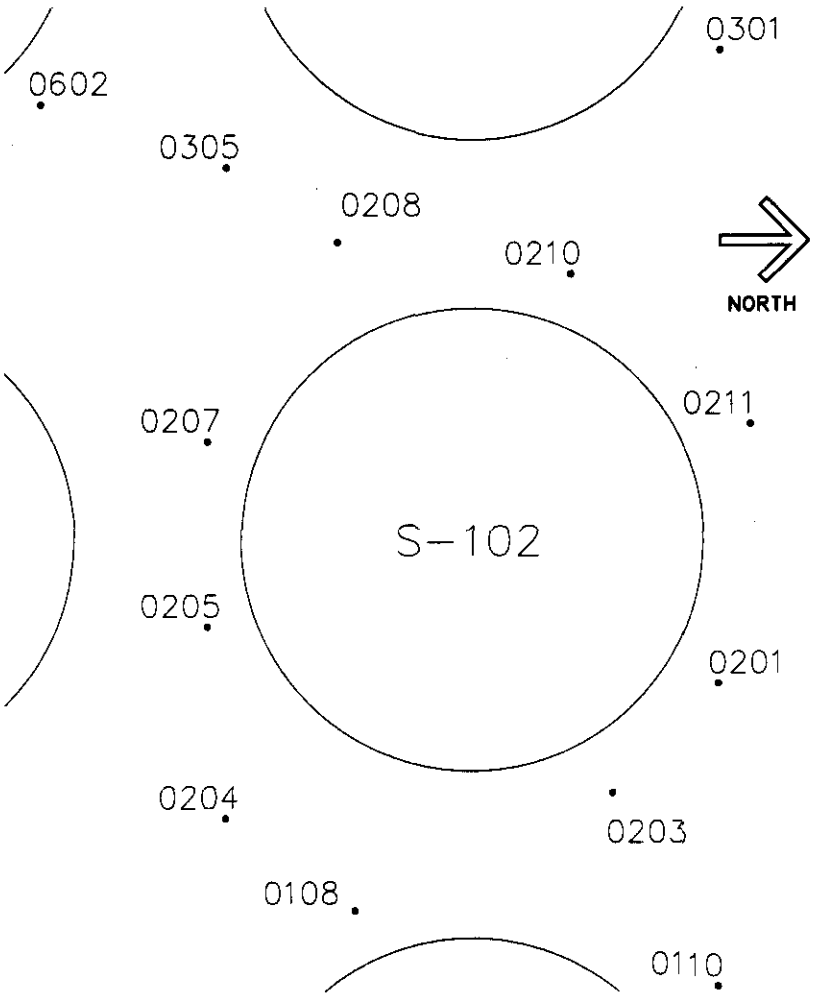




Tank S-102 is actively monitored for any changes to its integrity. Both dry wells and a liquid observation well are used to monitor tank integrity. Tank S-102 has a liquid observation well in Riser 5 to monitor interstitial liquid level (ILL) by gamma and neutron data collection and interpretation. A change (decrease) in the interstitial liquid level in an inactive tank would generally be interpreted as a leak. Tank S-102 is currently classified as sound without any significant changes in the radiological signature measured through the drywells.

Eight dry wells are associated with the tank to monitor for leakage of waste to the surrounding soil (Figure 1-9). Dry wells with higher than background radiation levels in addition to generally increasing activity can indicate a leaking tank. Dry wells 40-0203 (active prior to 1990, current readings >200 counts per second [c/s]) and 40-0208 (active prior to 1990, current readings <200 c/s), have had readings greater than the 50 c/s background reading. However, no increase in activity has been observed for these dry wells in recent history.

Figure 1-9 Drywells Adjacent to Tank S-102



1.5.2 S Farm Transfer System

The SST Interim Stabilization Project has established the general precedent of no longer utilizing any of the originally constructed, buried carbon steel piping in the 241-S and 241-SX Farms for waste transfer operations. This decision was made based on the discovery of the SN-219 transfer line failure in January 2000, when a surface pool resulting from failure of the buried transfer line was observed in the 241-S Farm (RPP-5825 Rev. 0). Based on the suspect condition of the remaining buried transfer lines in the 241-S and 241-SX Farms, the SST Interim Stabilization Project has primarily used temporary over-ground transfer (OGT) lines consisting of hose within a hose for waste transfers supporting saltwell pumping.

Although OGT lines are now generally employed for waste transfer operations in the 241-S and 241-SX Farms, two existing buried encased (pipe-in-pipe) transfer lines connect 241-S-102 with the 241-S-A Valve Pit. These two lines are the only encased transfer lines currently in use in the 241-S Farm. One of these lines, SL-140, has been pressure tested (hydraulic test to 100 psig, work package WS-98-176) and verified to be sound by hydrotesting.

Two-inch SL-140 connects the 241-S-02B Distributor Pit to the 241-S-A Valve Pit, which is currently being utilized by the Interim Stabilization Project. A hydraulic diagram depicting the existing Interim Stabilization transfer routing from 241-S-102 to 241-SY-102 is shown in Appendix D, drawing 4412.091.MDWG.001. Figure 1-10 shows the encased piping route in place that could be used to transfer waste from 241-S-102 to 241-SY-102 (based on the configuration documented in the 272WA routing board, H-2-46524). A second pipe-in-pipe encased line, three inch SN-242, connects the 241-S-02A pit to the 241-S-A pit. Pump Pit 241-S-02A and the two condenser pits on 241-S-102 have been sealed over with foam. The foam has been removed from the 241-S-02B Distributor Pit by Interim Stabilization.

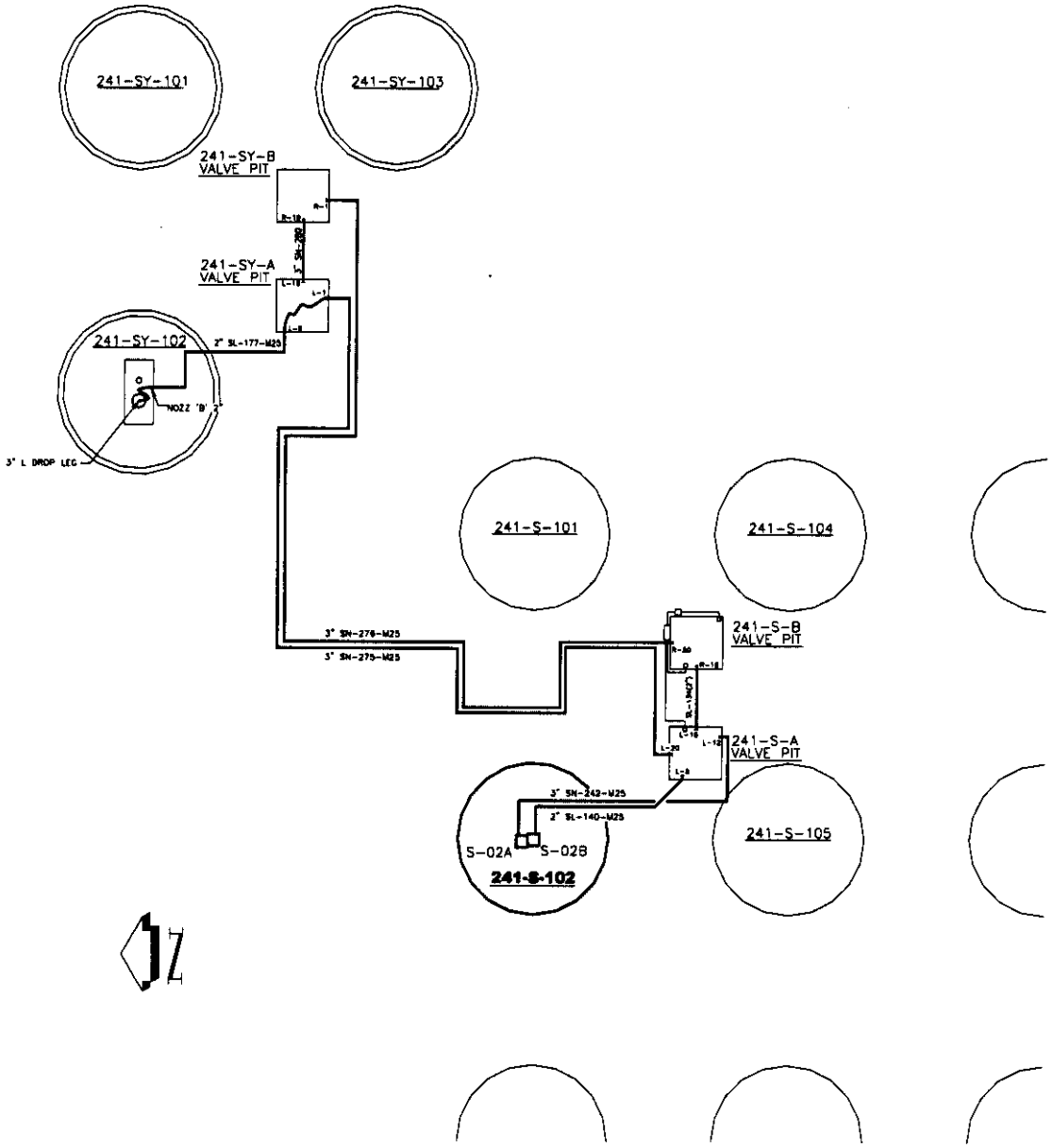
All of the tanks currently being saltwell pumped in 241-S and 241-SX Farms are routed through the 241-S-A Valve Pit. Interim Stabilization activities in these farms are scheduled for completion in FY 2003. The manifold and jumpers connecting SL-140 to SN-275 (nozzle L5 to L20 respectively) is already installed and being utilized for saltwell pumping of 241-S-102. The existing manifold and jumper (H-14-100919) in the 241-S-A Valve Pit is available for use by the 241-S-102 retrieval project. The total transfer route volume, including pit jumpers, is approximately 200 gallons, as shown in Table 1-6.

Table 1-6 Tank S-102 to Tank SY-102 Transfer Lines

Transfer Line	Size (inches)	Length (feet)	Hold-Up (gallons)	From-To	Heat Traced
SL-140	2	103	18	S-02B to S-A	Yes
SN-275	3	470	180	S-A to SY-A	Yes
SL-177	2	86	15	SY-A to SY-02A	Yes
SN-242*	3	126	48	S-02A to S-A	Yes

* The SN-242 may be available for use as an alternative route

Figure 1-10 241-S and 241-SY Farm Existing Piping Plan



1.5.3 S Farm Utilities

A temporary raw water supply line was added to 241-S and 241-SX Farms in FY 2000 to support the saltwell pumping dilution requirements (ECN 664158). The supply pressure is estimated at 70 psi with a maximum supply rate of 20 gpm, with sustained supply of approximately 15 gpm.

Electrical power is currently supplied to the saltwell pumping system located at 241-S-102 from the power distribution rack on the west side of the farm.

1.5.4 Tank SY-102

Tank SY-102 is one of three DSTs located in the 200 West Area's 241-SY Farm. It is the principal saltwell receiver tank and has a continually varying volumetric inventory as a function of saltwell/cross-site transfer activity. Tank SY-102 currently serves as the staging tank for cross-site transfers of liquid wastes from the 200 West Area to the 200 East Area. Tank SY-102 has an active ventilation system, is sound, and is not on the Watch List. The operating capacity of the tank is 1,100,000 gallons, although the current pump design limits the working volume to approximately 550,000 gallons.

Tank SY-102 was constructed with a carbon steel primary liner (heat-treated and stress-relieved), a carbon steel secondary liner (not heat-treated), and a reinforced concrete shell. The tank has a flat bottom. An insulating concrete layer separates the bottoms of the primary and secondary liners. There is a grid of drain slots in both the insulating concrete layer and the concrete foundation beneath the secondary liner.

1.5.5 SY Farm Transfer System

Two encased transfer lines connect the 241-SY and 241-S Farms. These 3-inch encased lines were installed at the time of the 241-SY Farm construction in 1977.

The construction of the transfer lines throughout 241-SY Farm is noncompliant with current regulatory requirements for waste piping, as the encasements do not penetrate the pit wall. The TPA M-43-00 milestones require upgrade of these transfer lines for compliance with the Washington Administrative Code (WAC) dangerous waste regulations by 2005. The State of Washington Department of Ecology (Ecology) (Hepper to McClusky 1996) has granted an extension for their use through June 30, 2005.

The 241-SY-A and 241-S-A Valve Pits are connected by 3-inch SN-275 and the 241-SY-B and 241-S-B Valve Pits are connected by 3-inch SN-276. The SN-275 transfer line begins at nozzle L20 in the 241-S-A Valve Pit and terminates at nozzle L-1 in the 241-SY-A Valve Pit. From the 241-SY-A Valve Pit a single 2-inch line, SL-177, runs to the 241-SY-02A Pump Pit. A hydrostatic test was performed on SN-275 and SL-177 (nozzle L-20 to B) by the Interim Stabilization Project at 100 psi (WS-98-177). The 241-SY Farm pits and transfer lines will be upgraded to extend the encasement through to the pit wall by other projects. The schedule for completion of these upgrade is not fully developed.

1.5.6 SY Farm Utilities

The 241-SY Farm flush system capacity is estimated to be approximately 140 gpm and 70 psi. The chemical addition skid was not designed to adjust the tank waste chemistry and only has sufficient capacity to inhibit the water added through the transfer lines.

Upgrades to the electrical distribution system for 241-SY-101 projects have resulted in an abundance of electrical power available in 241-SY Farm.

2.0 SYSTEM DESCRIPTION

A pre-conceptual 241-S-102 Initial WRS has been developed based on the analysis of alternative component and system configurations presented in Appendix H. A value engineering (VE) session (Appendix I) evaluated and selected the alternative system configuration from amongst those presented. The proposed system configuration, process and system design description for retrieving waste from 241-S-102 are described in this section. The level of detail developed is intended to bound the scope of the retrieval project, allow for the production of order of magnitude project cost and schedule estimates, and provide sufficient justification for proceeding with the conceptual design.

The subsystems comprising and supporting the 241-S-102 WRS are:

- Fluidic Air Handling System
- Fluidic Waste Retrieval System
- RFD Mixing System
- Waste Transfer System
- Water Introduction and Line Flush Transfer System
- Ventilation
- In Tank Surveillance System
- Instrumentation and Control System
- Leak Detection Monitoring, and Mitigation
- Utilities

Appendix D contains the Preliminary Process Flow Diagrams (PFD) (4412.091.PDWG.004 and 4412.091.PDWG.005) for the waste retrieval project and shows the major process streams and their compositions. Calculations required to support the preliminary PFD have been performed to validate the assumptions and verify requirements (4412.091.PCAL.001 in Appendix D). The 241-S-102 WRS is developed at a pre-conceptual level to satisfy the requirements for the project identified in the *Tank 241-S-102 Waste Retrieval System Level 2 Specification* (RPP-7512).

Insufficient data exists on the performance of fluidic systems to retrieve waste on this large of a scale to predict the tank end-state conditions. Tank Focus Area (TFA)-sponsored cold testing is being performed in FY 2001 to evaluate the effectiveness of systems similar to those proposed in this section. Follow-on testing is planned in FY 2002, which will be used to produce the final design configuration of the fluidic system(s) for deployment in the initial waste retrieval from 241-S-102.

The proposed system is anticipated to provide the greatest likelihood of satisfying the retrieval goals (99% volumetric and 490 curies) from all of the configurations evaluated. Additional dissolution studies and testing with fluidic systems in later project phases will help to predict the 241-S-102 residual waste volume and composition and estimate the likelihood of satisfying the goals.

2.1 Fluidic Air Handling Systems

The fluidic air handling system, as described in Section 1.4, consists of an air compressor (with or without tank), a valve skid, jet tower, piping bridge, and ventilation or off-gas skid. These general components are described in this section.

2.1.1 Air Compressor

An air compressor must be selected with sufficient flow capacity to support the pumping and/or mixing operations. Typical fluidic designs utilize air pressures on the order of 60 to 70 psig. Air consumption is based largely upon the overall size of the selected system.

The flow capacity requirements for the compressor, termed "air consumption", are considered in terms of efficiency. The Air Utilization Ratio (AUR) is defined as the average airflow rate divided by the average liquid flow rate. The AUR can be estimated based upon the performance of similar systems. The compressor can then be sized based upon the estimated AUR and desired average flow rate.

The preliminary system developed in this section will require an air compressor supplying 70 psi at approximately 1000 scfm.

2.1.2 Valve Skid

The compressed air and water supply are controlled by solenoids located on the valve skid. Airflow is directed from the compressor to either (or neither) of the two jet nozzles. Valves on the valve skid also regulate the introduction of water.

Pressure, flow, temperature, and valve position indication data are gathered from an array of instrumentation mounted in/on the valve skid piping. The signals are sent to the Operator Control Station where the retrieval process can be monitored, controlled, and optimized.

2.1.3 Jet Skid/Tower

The jet skid incorporates the jet assembly (eductors) and a typical anti-siphon feature to prevent drawing of liquid waste through the charge vessel and pipe bridge to the valve skid. The jet tower extends 35 feet vertically above the highest anticipated liquid waste level. This height exceeds the height at which water can be "lifted", or siphoned. The maximum siphon height for water is 32 feet in the theoretical event that a perfect vacuum is drawn. The tower is generally qualified seismically and is considered a fail-safe system to prevent contamination of the upstream components and systems. Due to the elevation difference between the jet skid placement and bottom elevation of 241-S-102, approximately 40 feet, the jet tower portion will not be required.

2.1.4 Piping Bridge

The pipe bridge connects the jet skid to the charge vessel. It may be as simple as rolled up ethylene propylene diene monomer (EPDM) hoses with quick-disconnects or as complex a rolling rigid structure with hard pipe, flex hoses, and swivel fittings.

2.1.5 Ventilation Skid

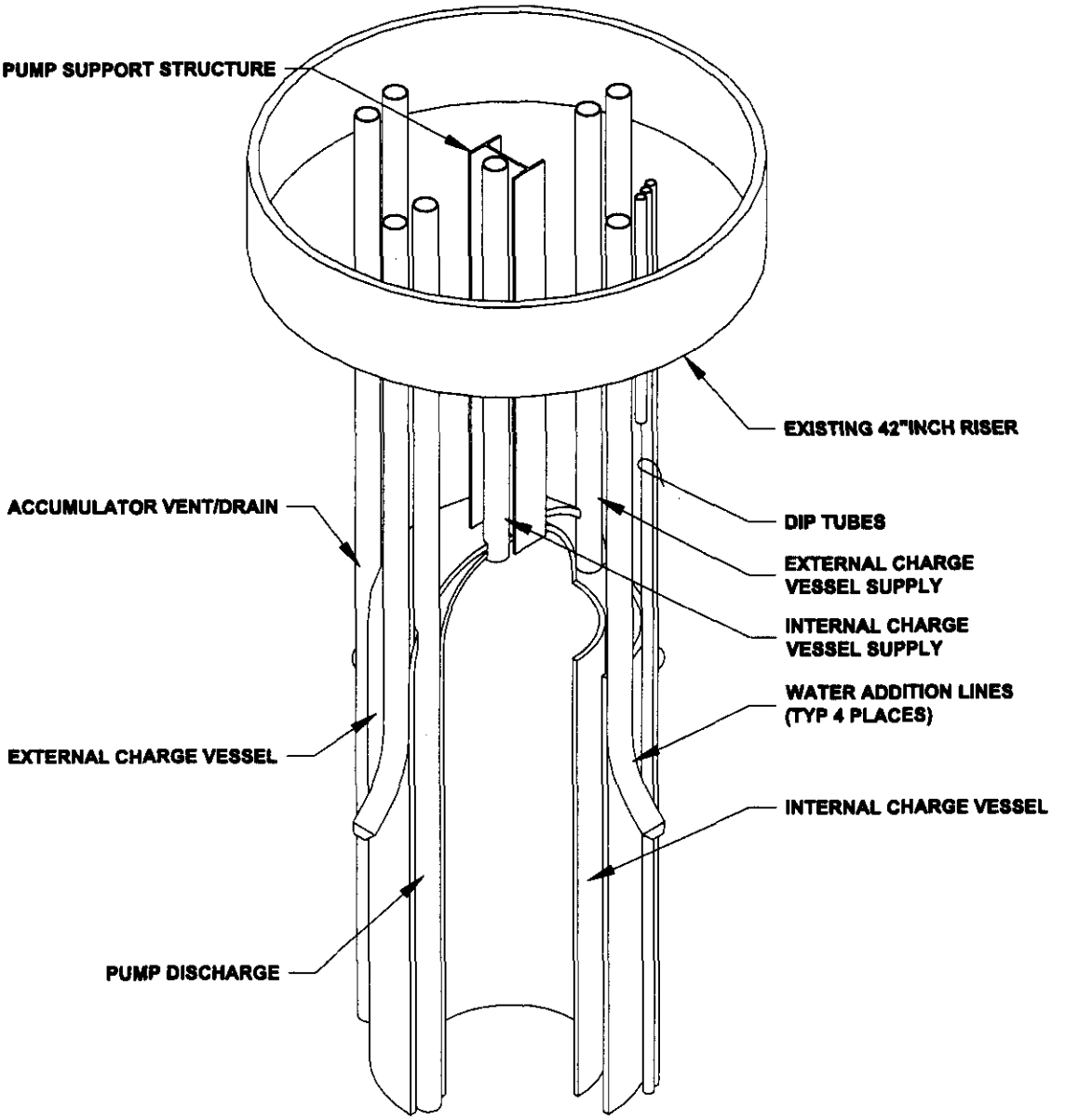
The ventilation skid is used to filter contaminants from the charge vessel exhaust stream. The vent skid is simple in form and self explanatory in function. A demister and heater are generally installed upstream of the filter housing to prevent filter saturation. The demister drain is routed back to the recovery vessel.

All of the compressed air supplied to and evacuated from the charge vessel(s) is routed back through the vent skid. Precautions are taken and engineering features incorporated into the design to prevent the expulsion of compressed air into the tank. It is likely that gases entrained within the waste will be drawn into the vessels along with the liquid waste and cycled through the ventilation skid. For this reason, an evaluation of the potential gases and contaminants should be considered during the development of a specification for this piece of equipment. Furthermore, off-gas monitoring (e.g. continuous air monitor and record sampler) will likely be required by the Washington State Department of Health to meet regulatory criteria for air discharges.

2.2 Fluidic Waste Retrieval System

The waste solution produced by dissolution during Phase I Operations retrieval and the waste slurry produced by mixing during Phase II Operations will be transferred from 241-S-102 by a 4-diode fluidic pump assembly installed in the central 42-inch riser, R-13. The inlet to the pump will be situated as near to the tank floor as possible to minimize the residual waste inventory remaining after the retrieval campaign. The assembly will consist primarily of 4-diodes mounted at the lower end of two nested charge vessels. The charge vessels will have an estimated 200 gallon capacity each and be 16-feet tall. To minimize the number of required penetrations into the tank, the assembly will also include piping for water addition, an accumulator overflow/drain line, and three dip tubes (see Figure 2-1).

Figure 2-1 4-Diode Pump Assembly



Water will be added to the tank (during both Phase I and II Operations) through a combination of four water addition lines included on the pumping assembly. Each of the addition lines will be situated 90 degrees apart and terminate at a nozzle canted away from the pumping assembly. The intent of the drop legs is to allow control over the placement of the water additions without manipulation of all or part of the pumping assembly. A manifold and valves mounted above the assembly in the 241-S-02B Distributor Pit will be controlled remotely to determine through which leg(s) the water is introduced.

The 4-diode pump assembly consists of two integrated fluidic 2-diode pump assemblies. The combined output of the two 2-diode pumps produces a near continuous flow. The proposed pump design has been modeled and will produce flows ranging from 80 to 130 gpm with an average flow rate of 100 gpm (reference simulation output, Appendix C). The pressure produced by these pumps is sufficient to recover the waste from the tank but not enough to transfer to another tank. A booster pump is required to overcome the line losses in-route to the receiver tank through the OGT (see calculation 4412-091-MCAL-001). The booster pump will provide a more stable/continuous flow of feed than is provided by the 4-diode pump. The pump system includes an accumulator or surge tank downstream of the 4-diode pump and upstream of the booster pump inlet. The accumulator tank will provide a stable feed to the booster pump and also serve as a separator or trap for any debris that is inadvertently recovered by the fluidic pump. The accumulator will have an overflow line and drain line for clearing any settled debris from the tank (4412-091-PDWG-004). The overflow will tie into the drain line downstream of the accumulator drain valve. The accumulator overflow/drain line drop leg will extend into the tank as part of the fluidic pump assembly. The outlet of the line will be covered by an open mesh basket or bag to prevent recycling of debris back through the fluidic pump.

Three ¾-inch pipes on the fluidic pump assembly will serve as dip tubes to measure the liquid waste depth and specific gravity. One pipe will terminate within the tank dome space above the waste to measure the relative tank dome pressure. The other two pipes will extend into the waste, adjacent to the pump inlet, with one terminating a fixed distance above the other (typically 10-inches for saltwell pumping). Air is blown through the legs and the differential pressure measured between the lower dip legs is used to determine the specific gravity of the waste. With the specific gravity of the liquid waste known, the differential pressure measured between the upper leg (in the dome space) and either lower leg (in the waste) is used to calculate the liquid waste depth. The specific gravity of the solution/slurry is used to determine when a waste transfer should occur. The waste depth measured by the dip tubes is used to verify that water additions have not exceeded the initial "pre-retrieval" ILL.

2.3 Reverse Flow Diverter Mixing System

Retrieval of the remaining 50% of the tank waste (saltcake and sludge) will be accomplished by deployment of three RFD mixing pumps with the capability to mix and mobilize the remaining tank waste. The RFD mixer pumps in conjunction with the central fluidic diode pump will mobilize and retrieve the maximum possible waste volume. The RFD mixer pumps are installed during Phase II Construction to support the Phase II Operations. The mixer assemblies contain an above-waste mixing nozzle and a below waste mixing nozzle. The three mixers will be operated using the lower, submerged nozzles, until the liquid specific gravity reaches the required set point, at which point waste transfer will commence using the fluidic pump assembly. The upper nozzle on the RFD mixer pumps may be utilized towards the end of the operating campaign to wash the tank walls. There are no provisions for the addition of water through the mixers in the proposed design.

The preliminary WRS design does not allow for simultaneous operation of the mixing pumps and fluidic transfer pump. The air handling and delivery systems proposed would require modification to produce and accommodate much higher air flow (approximately twice) to allow for concurrent mixing and pumping. The three mixers will be operated 120 degrees out of phase with only one mixer discharging liquid at any given time. This will minimize the total air utilization by the system and reduce the required compressor capacity. Mixer pump operation is provided by means of automated air flow through solenoid valves to select between the drive, vent, and evacuation cycles. Compressed air is supplied to the mixer at approximately 600 scfm during the drive phase and 150 scfm during the evacuation cycle.

2.4 Waste Transfer System

The waste transfers between 241-S-102 and 241-SY-102 will be made through a temporary above ground transfer line. The transfer line routing will follow existing ground contours to minimize installation time and eliminate line hold up. The transfer route following the contours (4412-091-CDWG-001) was selected over a direct route (4412-091-CDWG-002) because of the minimal line hold up volume. A temporary hose-in-hose transfer line between the 241-S-02B Distributor Pit and the 241-SY-02A Pump Pit will be installed. The design will be the same as the 2-inch in 4-inch hose assemblies utilized by Interim Stabilization. Heat trace will be provided on the primary line and insulation on the secondary encasement.

An existing transfer route between 241-S-102 and 241-SY-102 using buried pipe in pipe was reviewed and determined to be inappropriate to support waste retrieval operations. The existing transfer route contains the 3-inch diameter transfer line SN-275 between Valve Pits 241-S-A and 241-SY-A. Flow velocity calculation of the 3-inch diameter line revealed that an inadequate flow velocity would be achieved using the proposed retrieval pumping system and the existing 3-inch line (4412-091-MCAL-002). This calculation also raised concerns with the anticipated pressure losses using the existing waste transfer routing option. The waste transfer path between 241-S-102 and 241-SY-102 will travel through 2-inch SL-140 to the 241-S-A Valve Pit, 3-inch SN-275 to the 241-SY-A Valve Pit and 2-inch SL-177 to the 241-SY-02A Pump Pit (reference 4412-091-MDWG-001). The increase and reduction of the transfer line size from 2-inch to 3-inch and back to 2-inch along the route may make it impossible to achieve the critical flow velocity without exceeding the allowable transfer line pressure.

The median waste transfer flow rate for both Phase I and Phase II Operations is 100 gpm. As discussed earlier, an accumulator, or surge tank, is to be installed downstream of the fluidic pump system and will be used in conjunction with a booster pump to produce a constant steady flow rate. The accumulator tank will be installed in the 241-S-02B Distributor Pit and have a capacity of approximately 30 gallons to support steady flow waste retrieval operations. A booster pump will be installed downstream of the accumulator, also in the 241-S-02B Pit, to provide sufficient flow and pressure to deliver the waste slurry from 241-S-102 to 241-SY-102. Flow measurements will be made in both the waste transfer piping and raw water lines going into and out of 241-S-102 and 241-SY-102. These flow measurement totals will be used for material balance and leak detection.

The waste transfer system will be flushed with water following the completion of a successful batch transfer of waste from 241-S-102 to 241-SY-102. Transfer line flushing will direct flow from 241-SY-102 to 241-S-102 to help eliminate deposited solids within the transfer line. This will however, require pre-approval from the Department of Ecology to add waste back into an SST to clear the lines in a conventionally "backward" method.

2.5 Water Introduction and Transfer Line Flush System

A raw water system is required to support waste retrieval operations using the fluidics technology. The primary raw water source for 241-S-102 Initial WRS is the flush water supply available at the 241-SY-A Valve Pit. Raw water enters the 241-SY-A Valve Pit through nozzle L-14, this water is used to provide flushing of the existing cross-site waste transfer system and is capable of delivering up to 140 gpm. Water will be provided to the 241-SY-02A Pump Pit by using existing waste transfer line 2-inch SL-177 (reference to 4412.091.PDWG.006). A new manifold jumper installed in 241-SY-A Valve Pit will be required to connect nozzle L-14 to nozzle L-9. Nozzle L-9 connects to SL-177, which terminates at nozzle B at the opposite end in the 241-SY-02A Pump Pit. Automatic valve manipulation and backflushing is proposed to support this waste retrieval operating campaign. Valve manipulation would be conducted automatically by the waste retrieval Monitor and Control System (MCS). A pressure transducer tied to a system shutdown interlock would monitor for potential pressurization between the required double valve isolation between the flush water and the process piping.

The OGT line will be flushed following each waste transfer from 241-S-102 to 241-SY-102. The flush water will be supplied through a manifold installed in the 241-SY-02A Pump Pit by routing raw water from the existing supply in the 241-SY-A Valve Pit, through the 2-inch encased transfer line, SL-177. Solenoid valves on the manifold in the 241-SY-02A Pump Pit will direct flow from the 140 gpm, 70 psi raw water supply through the OGT and through a manifold installed in the 241-S-02B Distributor Pit. Valves on this manifold will direct the flush water to any combination of four water addition lines going into Riser 13, or through the accumulator. Any flush water sent to the accumulator may be used to flush the accumulator or be redirected by a separate valve back through the diode pump. To ensure that there is no path between the cross-site transfer system and tank 241-S-102, the flush water connection in the 241-SY-A Valve Pit will be disconnected and blanked before a cross-site transfer is performed.

2.6 Ventilation

Passive ventilation of 241-S-102 is planned to be performed by the existing breather filter assembly installed on Riser 1. The internal filter assembly should be replaced with a new assembly at the beginning of both Phase I and Phase II Operations. Filter replacement will allow for assessment of filter performance during waste retrieval operations.

In the event it is determined that active ventilation is required for the deployment or operation of the system, the portable exhauster POR-004 will be used. Ducting currently exists from 241-S-102 (Riser 11), which may readily be used to connect to the active

ventilation system. An assessment on the condition of the exhauster has not been performed. The design will require review to ensure appropriate interlocks and instrumentation (differential pressure and continuous air monitoring) are in place prior to any attempt to utilize this piece of equipment (see Section 11.2 for additional discussion). In addition, if active ventilation is deemed necessary, a larger breather filter than that on Riser 1 will be required to support the use of the portable exhauster.

Ventilation of 241-SY-102 will be provided by the existing active ventilation system servicing 241-SY-102.

2.7 In Tank Surveillance

In tank surveillance will be performed throughout the retrieval campaign using an assembly, which combines a topographical mapping system (TMS), closed circuit television (CCTV) camera, and light tree. The TMS portion of the assembly will send out, and measure the time for return, low energy lasers pulses to bounce off of the waste surface to produce a three dimensional map of the tank interior. The camera will be used to direct the water addition location and rotation of the mixers during the retrieval.

2.8 Instrumentation and Controls

The MCS will be used to monitor and control the 241-S-102 waste retrieval activities (reference 4412-091-IDWG-001) and automatically shut the system down in the event of an abnormal alarm condition. The major functions of the MCS are as follows:

- Monitor and control waste process parameters in 241-S-102 and 241-SY-102.
- Monitor and control waste transfer parameters, leak detectors, and equipment performance,
- Annunciate alarms,
- Automatically shut the system down in the event the approved operating envelope has been violated,
- Trend real-time process and operational data, provide remote data access, and store data for future use,
- Provide a method (CCTV) to visually monitor the in-tank retrieval operations.

The MCS will monitor the following through the system pressure controller:

- WRS Ventilation Skid,
- Air solenoid positions for fluidic pumping modes: suction, discharge, and vent.

The MCS is comprised of distributed programmable logic controllers (PLCs), Human-Machine Interface computers, a CCTV system for 241-S-102 with one in-tank camera, and field and various in-tank instrumentation and control devices to support the 241-S-102 retrieval activities. The operator control station with Human-Machine Interfaces will be located outside the 241-S Farm in the Operator Control Building. This

will allow for operator convenience and localized deployment of Operations resources. The PLC controller will be mounted near the control station while the PLC remote I/O racks will be mounted near 241-S-102 and 241-SY-102 in weatherproof enclosures to minimize field wiring.

2.9 Leak Detection Monitoring and Mitigation

Appendix J presents the "LDMM Design Concepts Evaluation Report for Fluidic Mixing and Pumping-Based Retrieval Technologies" for the retrieval of 241-S-102. The LDMM strategy is based on using risk-based performance criteria that define the level of human health and environmental risk posed by past leaks, residual waste after retrieval completion, and leakage from the tank during retrieval.

A draft Retrieval Performance Evaluation (RPE) for the 241-S farm has been prepared and defines the risk posed by the entire farm. The risk evaluation has not been completed for 241-S-102, however, the risk evaluation for tank 241-S-112 is completed. Because the wastes in tank 241-S-112 and 241-S-102 are similar in nature and contain similar levels of long-lived mobile radionuclides, the results of the 241-S-112 risk evaluation are used and are representative of the 241-S-102 anticipated risks.

The current RPE for 241-S Farm establishes leak volumes and residual waste volume requirements that exceed the capabilities of available LDMM technologies and TPA retrieval goals for 241-S-102. The LDMM approach that will be used during the retrieval of 241-S-102 will be to utilize the best available and economically achievable technology, which has yet to be fully defined.

2.10 Utilities

Existing water and electric power sources will be utilized to the maximum possible extent. Flush water available within the 241-SY-A Valve Pit will be used for automated backflush and solvent addition operations controlled by the WRS control system. The existing temporary water supply within 241-S Farm should be utilized to provide raw water to non- process applications. Existing electrical service within 241-S and 241-SY Farms will be used to provide necessary heat trace, leak detection and small equipment loads (reference 4412-091-EDWG-001). The largest single source of electrical power consumption is the air compressor skid required to drive the fluidic diode pump and RFD mixers. The air compressors will be powered by portable generators placed outside the 241-S Farm.

3.0 STAGED CONSTRUCTION AND OPERATIONS

The fluidic system performs two functions in the retrieval of waste from 241-S-102, mobilization of the waste and transfer of the waste. The proposed operational strategy is to retrieve the waste in two distinct operating phases. The Phase I Operations will rely upon dissolution to mobilize the tank waste constituents and the Phase II Operations will rely upon the impartation of mechanical energy to the waste to effect mobilization and solids suspension for pumping. This operations strategy will take advantage of the high waste solubility during the initial phase of operations to quickly and easily recover a significant portion of the waste. The majority of the dissolved waste and retrieved volume will be in the middle of the tank. It will also simplify the installation of the RFD mixers by reducing the waste volume/depth beneath the manhole locations. It has been assumed that when the mixers are installed, sufficient waste will have been recovered to allow "communication" of liquid between the mixers and the central pump assembly. The fluidic mixers working in conjunction with the fluidic pump installed in the center of the tank will mix and retrieve waste near the perimeter of the tank.

The alternative to the proposed two-phase operation and construction strategy is to install the RFD mixers into the three existing manhole locations at the onset of operations by mining holes or "wells" into the solid waste. This approach has two major disadvantages over the method proposed. The first drawback is that installation/insertion of the mixers into the salt matrix will require the introduction of significantly more water to lance the assemblies into position due to higher waste levels. This would be contrary to the LDMM strategy, which relies upon the minimization of liquid inventory in the tank as the primary means to mitigate potential leaks. The second disadvantage is that the mixers and the fluidic pump would be isolated from one another due to a physical barrier created by the saltcake waste matrix. The physical characteristics of the salt matrix will impede liquid migration from one installation well to another. Waste slurry produced in a well surrounding a mixer will not easily be conveyed to the central well occupied by the fluidic pump. The result would be a prolongation of the retrieval operation duration, increased cost associated with operations, and a higher leak potential as the result of increased liquid tank inventory. Accelerating the retrieval schedule with this configuration would require flooding of the tank to a depth exceeding the existing waste height to "connect" the liquids within the mixing wells to the pumping well. Again, this is in contradiction to the LDMM strategy and is therefore not recommended.

The recommended two-phase operational approach capitalizes on the limited 241-SY DST space by allowing for a waste transfer near the middle of the 241-S-102 waste retrieval campaign. Insufficient 241-SY space will exist to support a single, uninterrupted, retrieval of the entire tank contents to the 241-SY DST system. The design of the transfer pump in 241-SY-102 and even the proposed pump design for 241-SY-101 will only accommodate the removal of slightly more than half of the tank contents. Operations will be suspended after the Phase I Operations recovery of approximately 225,000 gallons of waste from 241-S-102 by dissolution, producing an estimated 500,000 gallons of solution transferred to 241-SY-102. During the period of suspension Phase II Construction will be initiated to install the RFD mixers into the tank

through the riser extensions installed in the three manholes. Concurrently, waste will be transferred from the 241-SY Farm cross-site to 241-AN Farm (or whichever tanks are designated to receive the waste) to free space for the second phase of 241-S-102 waste retrieval operations. The operational suspension will also allow for the performance of a static leak and tank integrity tests to be performed. With the reclaimed available space in 241-SY Farm, and the installation of the mixers into the SST, waste retrieval operations will be re-initiated.

4.0 CONSTRUCTION AND INSTALLATION

4.1 Construction Constraints and Requirements

Modifications are required to the 241-S Farm infrastructure and utilities to support the installation and operations of the 241-S-102 WRS. Construction constraints and requirements associated with the project include the following:

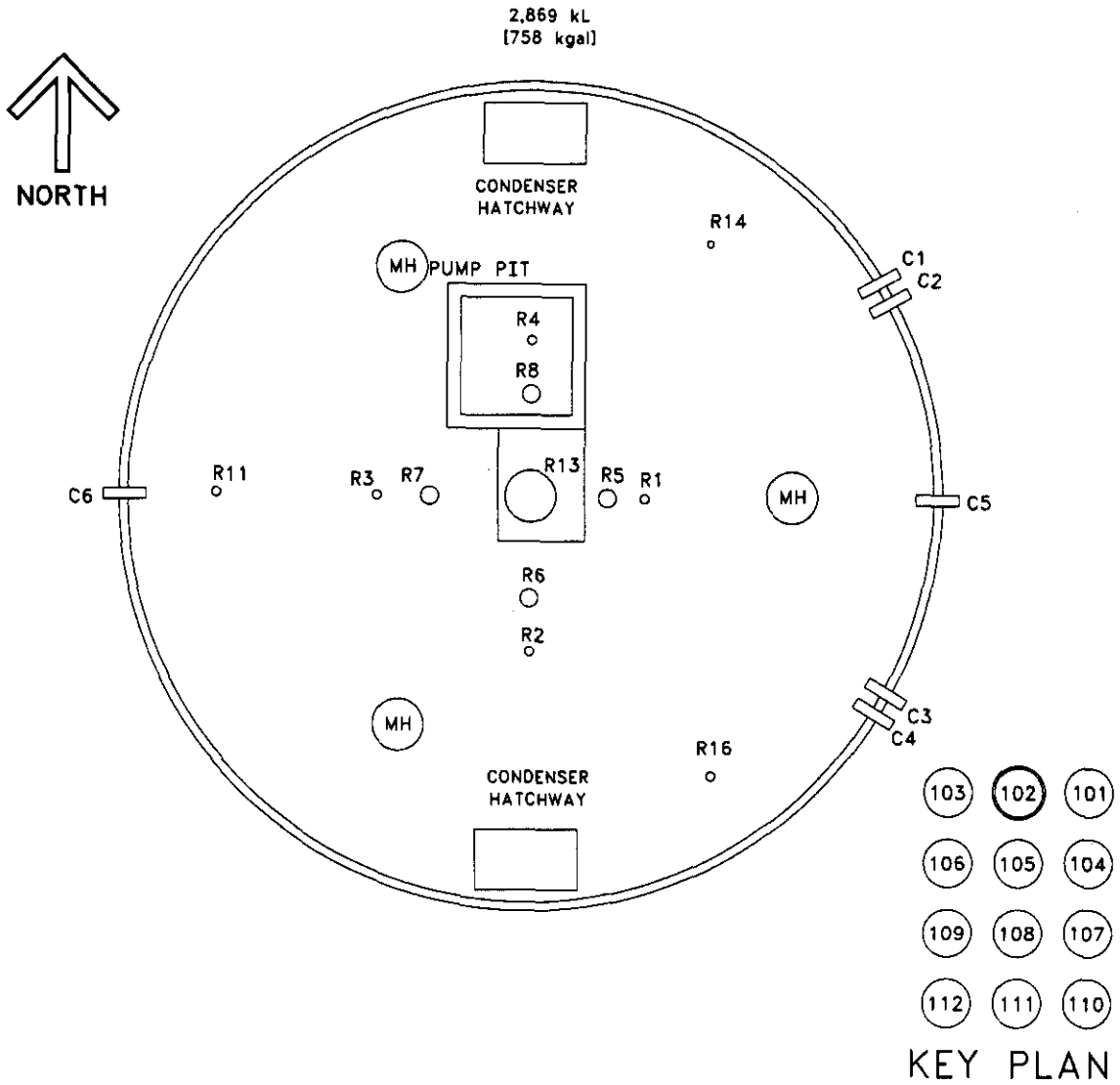
- No other project activities within 241-S and 241-SY Farms are scheduled during the planned construction phases that may adversely affect 241-S-102 retrieval system installation activities.
- Cross-site waste transfer operations will not affect planned construction work within 241-SY Farm, 241-SY-A Valve Pit and 241-SY-02A Pump Pit.
- The manifold jumper configuration required to support raw water usage from the 241-SY-A Valve Pit is acceptable within the overall context of existing tank farm operations (e.g. ensuring there is no tie-in between the raw water system and the cross-site transfer line).

Modifications and upgrades to the farm infrastructure will be completed in accordance with an approved construction specification. A draft construction specification is provided in Appendix F as an example.

4.1.1 Tank S-102 Riser Location

Figure 4-1 reflects the existing riser locations for 241-S-102 and should be used with the proposed riser utilization plan in Table 4-1 for equipment identification to support the WRS installation into 241-S-102.

Figure 4-1 Plan View of Existing Riser Locations



4.1.2 Riser Utilization Table

Table 4-1 reflects the proposed riser utilization plan to support the 241-S-102 WRS.

Table 4-1 Tank S-102 Proposed Riser Utilization

RISER NUMBER	DIAMETER (Inches)	DESCRIPTION AND COMMENTS
1	4	Breather Filter
2	4	Level Indicator (ENRAF)
3	4	Temperature Probe
4	4	Not used
5	12	LOW
6	12	Camera/TMS Assembly
7	12	Not used
8	12	Not used
11	4	Ducted to portable exhauster, if required
13	42	Fluidic 4-Diode Pump, Dip Tubes, Accumulator drain and vent, Water Introduction Lines
14	4	Not used
16	4	Not used
MH	42	Manhole – Excavated, Riser extension, and RFD Mixer
MH	42	Manhole – Excavated, Riser extension, and RFD Mixer
MH	42	Manhole – Excavated, Riser extension, and RFD Mixer

Changes in riser utilization between the current use and the proposed riser utilization table are limited to Risers 6 and 13, and utilization of the three construction manholes for installation of fluidic mixer pumps, unless active ventilation is needed.

4.1.3 Phase I Construction

Phase I Construction will be completed prior to retrieval of waste from 241-S-102. Phase I Construction includes, but is not limited to: tank farm infrastructure preparations and modifications, temporary transfer line installation between 241-S-102 and 241-SY-102, installation of fluidic pumping system support equipment, installation of the fluidic pumping system into 241-S-102 (via the 241-S-02B pit), and manhole excavation and riser extension installations.

4.1.3.1 Manhole Excavation

The three sealed manholes, installed in the 241-S-102 tank dome during initial tank construction, will be exposed to permit the installation of riser extensions that will support the installation of the fluidic mixer pumps. The manholes are 42-inch diameter passageways through the tank's concrete dome structure and are located approximately 21-feet from the tank's centerline at 120 degree spacing (reference H-2-1774, H-2-1783, H-2-1794). The manholes have been selected for installation of the mixers because of their location, size, and not affecting structural strength of the dome by their utilization. At the completion of tank fabrication, prior to installation of earthen backfill above the tank, the manholes were sealed with a small concrete cover (reference H-2-1814). Following placement of the concrete covers in the manholes, the covers' lifting bails were removed as noted on the installation drawings. The manhole covers were then layered with an asphalt waterproofing membrane and a metal mesh screen with approximately one inch thick layer of gunite. After excavation of the manholes, the covers will be freed from the gunite, metal fabric and asphalt membrane to accommodate removal of the covers and installation of the riser extensions. Temporary lifting attachments will be installed to support the hoisting of the manhole covers, because the lifting bails were cut and removed after installation of the manhole covers.

The manholes are located approximately 9-feet below the grade elevation of the overburden installed atop 241-S-102. Hand excavation of a minimum 8-foot square trench to a depth of nine feet is required to expose each individual manhole to allow for manhole cover removal and preparations and riser extension installation. Soil removed for these excavations will be disposed as contaminated material and clean soil/gravel will be used as backfill. The excavation of each manhole will generate approximately 27 cubic yards (576 cubic feet) of solid waste. High levels of soil contamination may be encountered during the excavation of one or more of the manholes due to previous Tank Farm operations involving transfer line leakage and overfill of tank 241-S-102 (see Section 1.5.1.1).

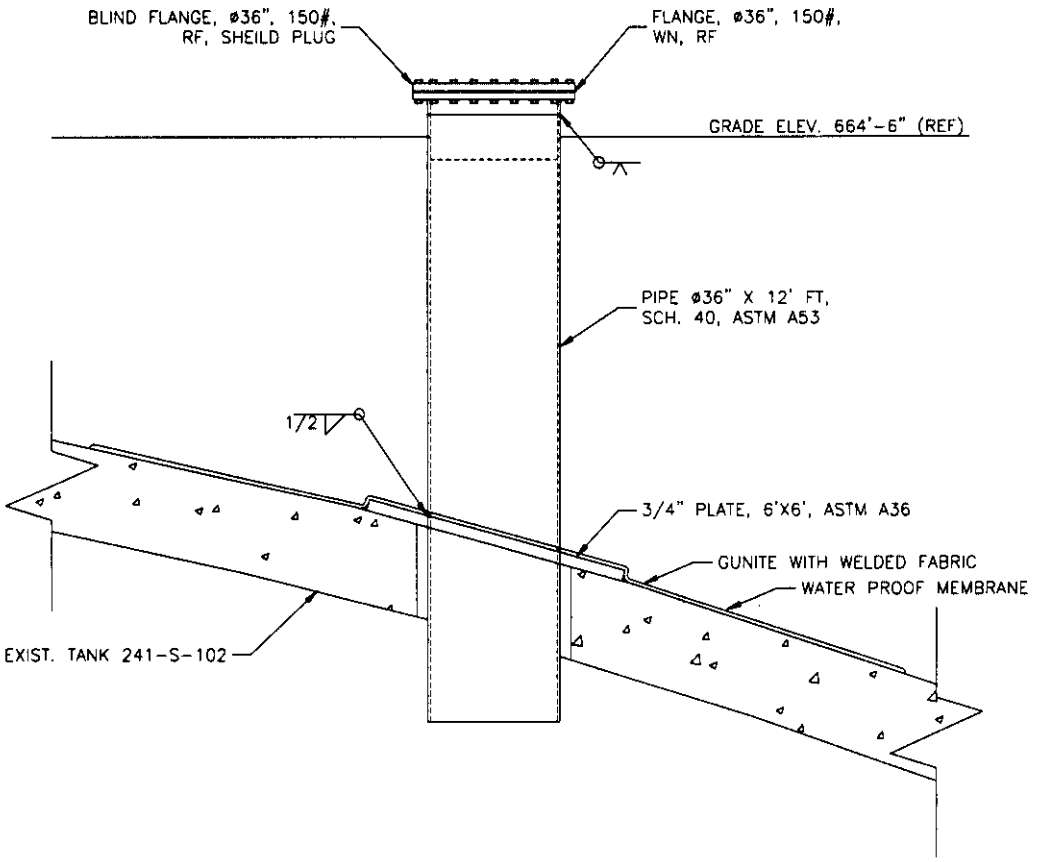
Radiological shielding calculations (reference to 4412.091.NCAL.001) were performed to determine dose levels during the excavation portion of the manhole riser extension installation. Current dose rate reading of 500 mR/hr, encountered by interim stabilization while working in 241-S-02B Distributor Pit, are present directly below the tank dome structure. Removal of existing tank overburden has little effect on the area dose rate due to the existing 12-inch think concrete tank dome and manhole cover.

4.1.3.2 Riser Extensions

Following completion of the manhole excavation work and removal of the manhole covers, tank dome preparations can be completed to accommodate the installation of the riser extensions. A 36-inch diameter flanged riser extension will be installed at each manhole location to bring riser access above grade to accommodate fluidic mixer installations (to support Phase II Operations). The flanged surface of the new riser extension will be sealed to the exterior tank dome surface in a similar fashion of the original manhole covers. An adequate waterproofing membrane and concrete overfill will be installed to complete the riser extension interface with the tank structure. It is assumed that the removed soil will be disposed. The backfill will be compacted clean

soil/gravel to return the grade level to the existing surrounding elevation. A removable shield plug will be installed into the new 36-inch diameter risers extending up from the manhole locations to provide necessary radiological shielding. Concrete pads will be placed around the riser extensions at grade level to support and distribute the load of the mixer assemblies. Figure 4-2 illustrates details of a proposed riser extension. Upon removal of the manhole covers work will be performed in a high radiation area open to the tank dome space. Adherence to current radiological and industrial safety standards will be required. Concrete support pads will be brought in and placed around each extension to disperse the load of the mixer assemblies to be installed during Phase II construction.

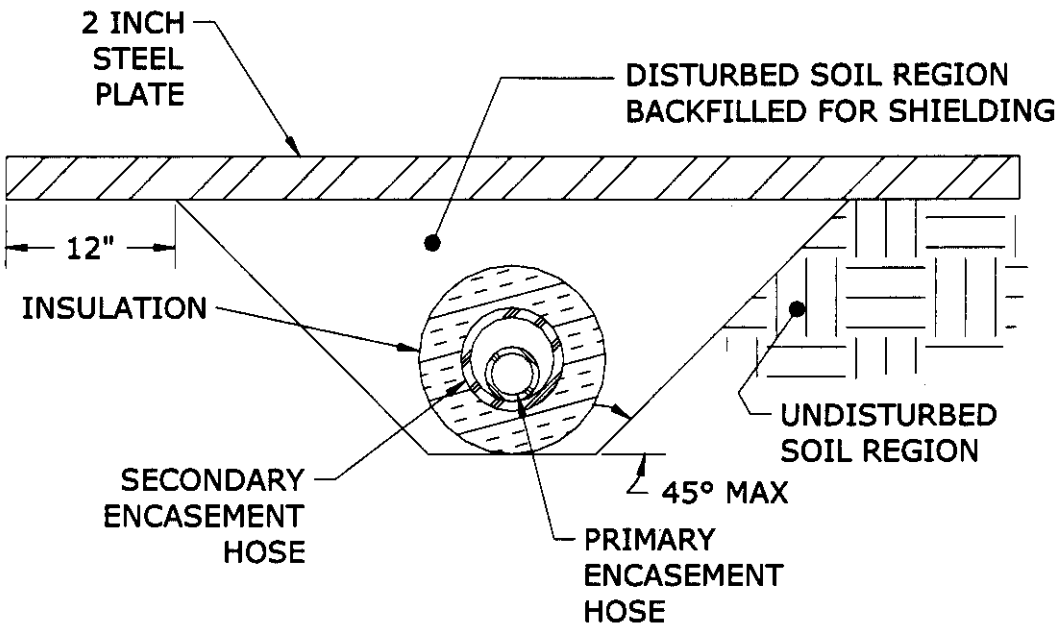
Figure 4-2 Riser Extension



4.1.3.3 Transfer Line Installation

The existing steel cover plate on the 241-S-02B Distributor Pit will be removed and disposed of as low-level solid waste. A new steel cover plate will be designed and fabricated to support necessary access for the fluidic pumping system below and to accommodate the installation of a temporary transfer line. A new hose-in-hose transfer line consisting of a 2-inch diameter (EPDM) primary hose within a 4-inch diameter (EPDM) secondary hose will be run between the 241-S-02B Distributor Pit and the 241-SY-02A Pump Pit. The OGT will be laid into a shallow trench dug by hand, loosely backfilled, and covered with 4-foot wide by 2-inch thick steel plates (See Figure 4-3).

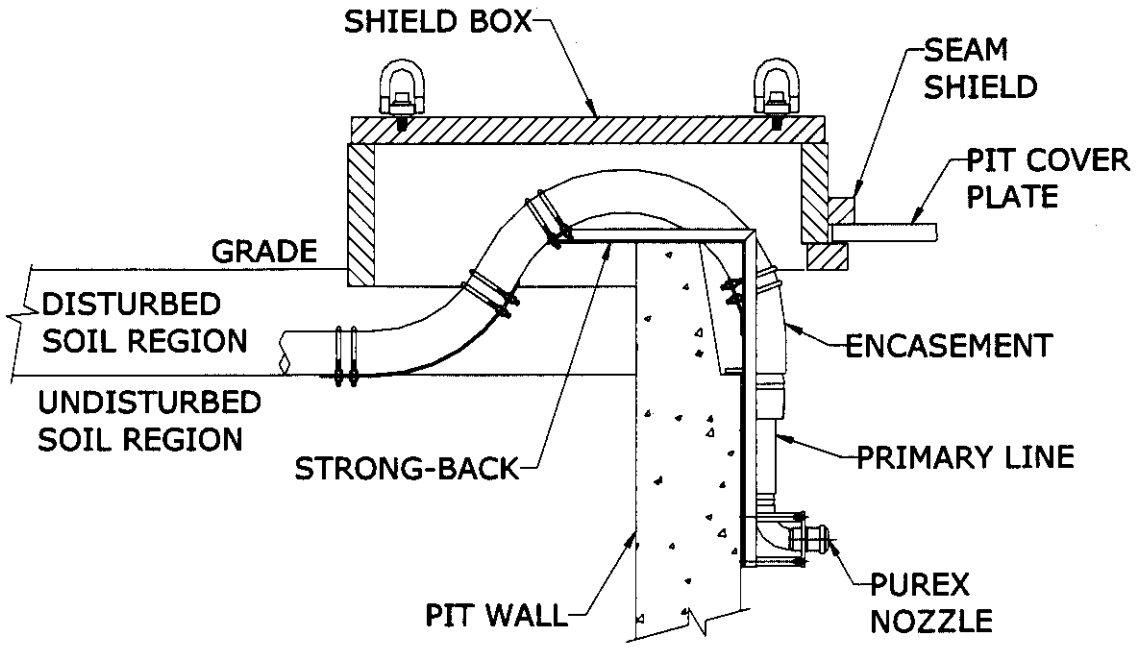
Figure 4-3 Hose-in-Hose Installation



The steel plates will serve both as radiological shielding and structural protection from vehicle traffic, (RPP-6725, *Hose-In-Hose Transfer Lines Calculation Notes for Hanford's Interim Stabilization Program).* The ends of the hose-in-hose transfer line will come above grade, go over the existing pit wall, and terminate at a 2-inch horizontal PUREX nozzle. The hose encasement will extend into the pit and terminate a short distance above the PUREX nozzle, to allow for potential drainage from the encasement in the event of a primary hose leak. The above grade portions of the transfer line transitioning into the pits will be housed within a steel box to provide radiological shielding and protection for the transfer line from potential hazards and vehicle impact. The shield box is fabricated from steel plate thick enough to reduce the radiological exposure to the worker to acceptable levels (historically 2-inches). Typical hose-in-hose transfer line installations utilize a temporary steel cover plate over the pit structures to accommodate shield box assemblies and hose entry into the associated pit. Figure 4-4 provides a typical illustration of a hose-in-hose transfer line assembly transitioning into an existing pit structure. PUREX nozzle terminations at both ends of the hose assembly

will be identical to allow for connection of associated equipment, via use of remotely installed PUREX connector heads.

Figure 4-4 Hose-in-Hose Pit Transition



4.1.3.4 241-S-02B Distributor Pit Modifications

A 4-diode or fluidic pumping system will be installed into Riser 13 in the 241-S-02B Distributor Pit. Riser 13 is a 42-inch diameter riser, centrally located in the tank dome that currently houses a saltwell screen and saltwell pumping system installed in 1999 to support Interim Stabilization pumping operations. The existing saltwell screen and pumping system must be removed to accommodate the installation of the fluidic pumping system into Riser 13. The saltwell pumping system will be removed in a similar manner as recently utilized to replace the pump legs (to facilitate foot valve changes) at 241-U-109, 241-SX-101 and 241-S-102. The saltwell system will be raised to a working level above the plane of the pit allowing, the piping section including the valves and pump to be separated and placed into a burial box. The approximately 40-foot-long pump legs and dip tubes will be removed from the screen and disposed of as either long length contaminated equipment or cut by hydraulic shears and placed into standard burial boxes.

The saltwell screen is assumed to be surrounded by a void well in the saltcake caused by localized dissolution of saltcake as the result of saltwell pumping system flushes, saltwell screen flushes and the addition of dilution water during saltwell pumping operations. This anticipated void will likely allow for the saltwell screen to be removed with limited drag imposed by sedimentation and inclusion in the saltcake and sludge waste matrix. The saltwell screen installed into Riser 13 consists of a 10-inch diameter schedule 40 pipe,

approximately 10 feet long, welded to an approximately 30 foot long section of screen material (reference H-2-69757).

In order to remove the saltwell screen a screen flush of approximately 500 to 1000 gallons of heated water will be performed to ensure the saltwell screen is free from localized reformation of saltcake following Interim Stabilization activities. Connection of flush water to the saltwell screen inlet plenum would allow for flushing of the screen as it is removed from the waste. The saltwell screen would be removed through a spray ring to remove collected waste from the outside surfaces of the screen. Additional flushing and spraying of the screen material may be required to reduce the contamination levels from the saltwell screen before it is completely removed from the distribution pit. The water usage necessary to remove the screen (internal flush and external washing) is approximated at 2000 gallons. The flush water will be provided by a water truck and pre-heated at the water loading station to approximately 160° F. The saltwell screen would either be disposed of as long length contaminated equipment or cut with hydraulic shears to reduce the length of screen sections to fit into a standard burial box.

Upon removal of the saltwell pumping system and saltwell screen from Riser 13 an additional piece of equipment is required to be removed to support installation of the fluidic pumping system. Riser 13 is a 42-inch diameter opening into the dome space of the tank. The saltwell screen was installed through existing slurry distributor adapter flange (reference H-2-46202), which reduces the effective opening of the 42-inch riser to 14 inches. The slurry distributor adapter flange assembly drawing references the installation of three bolts equally spaced around the perimeter to join the adapter flange to the face of the riser. A manned pit entry or an extension tool will be required to loosen these bolts to allow for separation of the adaptor flange from the riser. The adapter flange has been in place for approximately thirty years and substantial corrosion is assumed to have occurred between the two carbon steel pieces. This corrosion will add to the difficulty in removing the slurry distributor adapter flange. The adapter flange would be removed and disposed in a standard burial box following the removal of the spray washer and potential debris from the 241-S-02B Distributor Pit. Additional materials will require disposal including abandoned pumps from the Interim Stabilization campaign and miscellaneous equipment such as jumpers, and leak detectors, if not identified for reuse. Pit access for necessary utilities, instrumentations and controls will be designed into the new steel cover plate through the use of slot covers and access passageways.

Installation of new pit leak detection equipment, or tying into existing leak detection system is required to operate the 241-S-102 retrieval system. Installation of the hose-in-hose supporting dunnage, shield box and steel cover plate are required to facilitate application of hose-in-hose transfer line between 241-S-102 and 241-SY-102. Existing cover blocks will be removed and stored for reuse upon project completion.

4.1.3.5 Fluidic Pump System Support Equipment

The fluidic pump system requires the installation and placement of additional components to support the operation of the retrieval system. The support equipment will

be located near 241-S-102 to support the fluidic pump installed in the center of the tank and the fluidic mixer pumps installed in the three construction manholes. To minimize the tank dome load most of the equipment will be installed off the tank dome and outside of the 20-foot exclusion zone (4412.091.SCAL.001). A preliminary dome loading evaluation estimates the additional dome loading by the project 241-S-102 at 56 tons. Support equipment includes the following: valve skid, vent skid, air compressors, portable generators, control system and necessary various hoses and cables connecting the equipment to ensure proper operation and control. An operator control station is planned for installation outside the perimeter of 241-S Farm to allow remote operator control and monitoring of the Fluidic Retrieval System. Placement of the generator(s) and compressor(s) is also planned for outside of the farm boundary. This will allow for the reuse of the components, as they will not likely become contaminated.

4.1.3.6 Fluidic Pump Installation

A 4-diode fluidic pump will be installed into the 42-inch diameter Riser 13 location. The fluidic pump will be used in support of Phase I and Phase II Operations retrieval. Preliminary construction activities include the removal of the saltwell pumping system, saltwell screen, and the Riser 13 adapter flange. Following preparation of the 241-S-02B Distributor Pit the fluidic pump will be installed.

Fluidic pump installation is anticipated to install easily into the remaining tank waste following the removal of the saltwell screen. Saltcake tanks that have been saltwell pumped typically have a large cavity surrounding the screen as a result of dissolution of the salt matrix by the addition of diluent, pump priming, and system flushes. A small amount of heated water, anticipated to be less than 2000 gallons, will be introduced via a sparge ring on the lower end of the pump to clear any debris or waste that may have fallen or settled into the waste cavity directly below Riser 13. The expectation that the pump can be easily inserted is based upon review of the operational log and discussions with the personnel who installed the saltwell screen into 241-S-102 in 1998. The screen was easily inserted after lancing the waste with a high pressure water lance. There were no notable occurrences during the screen installation.

After the fluidic pump assembly is placed into Riser 13, an accumulator and piping manifold will be installed into the 241-S-02B Distributor Pit to connect the assembly to the transfer system. The accumulator used in conjunction with a booster pump will provide steady flow from 241-S-102 to the 241-SY DST during retrieval operations. Piping will be installed to connect the in-line booster pump to the valve skid and the hose-in-hose transfer line. Following equipment installation into the distribution pit, the temporary steel cover plate will be installed.

Any free liquid remaining in the tank at the conclusion of saltwell pumping activities and the water introduced during the saltwell screen removal will serve as the initial batch water addition used in support of Phase I Operations.

4.1.3.7 241-SY-A Valve Pit Modifications

The intended transfer route for pumping retrieved waste is to install a dedicated hose-in-hose transfer line between tanks 241-S-102 and 241-SY-102. The installation of the direct line between the tanks minimizes the impact on the 241-SY-A Valve Pit. Valve Pit 241-SY-A is the flush water tie-in location to support the fluidic pumping system and provide backflush to tank 241-S-102. Flush water is supplied to the 241-SY-A Valve Pit through nozzle L-14. Connection of nozzles L-14 and L-9 will be used to direct the flush water to the 241-SY-02A Pump Pit manifold. Existing encased 2-inch transfer line SL-177 connects valve Pit 241-SY-A and Pump Pit 241-SY-02A. This transfer line is connected via nozzle L-9 in 241-SY-A and wall nozzle "B" in Pump Pit 241-SY-02A. Transfer line SL-177 is currently in use by Interim Stabilization to support saltwell pumping of 241-S and 241-SX tank farms. Stabilization pumping activities in S and SX Farm are scheduled to complete two years prior to the operation of the 241-S-102 retrieval system.

Modification of the existing cross-site jumper manifold design installed in the 241-SY-A Valve Pit will be required to support the connection between nozzles L-9 and L-14. The jumper manifold configuration should attempt to incorporate existing and potential routing paths to support tank farm routing options. Any valves installed on the 241-SY-A Valve Pit jumper/manifold will be manually operated. To ensure that there is no path between the cross-site transfer system and tank 241-S-102, the flush water connection in the 241-SY-A Valve Pit will be disconnected and blanked before a cross-site transfer is performed. No modifications to the existing concrete cover blocks are anticipated. Existing valve handle extension locations should be utilized in the manifold jumper fabrication and used as required. The existing backflow preventer installed on the flush system to support cross-site transfer operations will support the project requirements. Installation of new leak detection equipment, or tying into the existing leak detection system is required to support operation of the retrieval system.

4.1.3.8 241-SY-02A Pump Pit Construction

A manifold jumper is required to support the connection of the hose-in-hose transfer line from 241-S-102 to 241-SY-102. The flush water connection from wall nozzle "B", and drop leg "L" will be used to connect the OGT to the flush system and introduce waste into 241-SY-102, respectively. A flex jumper is currently installed between wall nozzle "B" and drop leg "L" to support Interim Stabilization pumping activities in 241-S and 241-SX tank farms. This jumper will be removed and stored in the pit for potential future use. Stabilization pumping activities are scheduled to be complete prior to the operation of the 241-S-102 retrieval system. The manifold jumper will contain two flow meters: (1) to accurately monitor the transfer and addition of waste to the 241-DST system and (2) record the addition of water back to 241-S-102. The manifold will also contain remotely operated valves to control the automated process and backflush operation of the pumping system. Manipulation of the valves will be provided by the WRS control system. A pressure transducer will be installed to meet requirements for double valve isolation/interlock between the process stream and water source. Installation of new pit leak detection, or tying into existing leak detection is required, to support operation of the retrieval system operation. Installation of the hose-in-hose support dunnage, shield box,

and steel cover plate are required to facilitate application of hose-in-hose transfer line between 241-S-102 and 241-SY-102. Existing cover blocks will be removed and stored for reuse upon project completion. Removal of the installed equipment will be necessary to replace the cover blocks.

4.1.3.9 Instrumentation and Control System

Instrumentation and control systems will be installed to monitor and control the pumping operation between the 241-S-02B Distributor Pit, 241-SY-A Valve Pit, and 241-SY-02A Pump Pit. Instrumentation includes leak detection, flow measurement and process valve control. Conduit will be installed below grade, approximately 12 inches deep, between the identified pit structures to incorporate the necessary control wiring which will connect the operator control station to the pumping system within the farm. An operator control station will be installed outside the tank farm to support monitoring and control of the pumping operation. The PLC will be mounted near the control station while the PLC remote I/O racks will be mounted near 241-S-102 and 241-SY-102 in weatherproof enclosures to minimize field wiring.

4.1.3.10 Utility Upgrades and Tie-ins

Utility upgrades and tie-ins are identified in the Site Plan drawing (4412.091.CDWG.001). Leak detection is required in all associated pits that are physically connected with the pumping process. Leak detection will be required in the 241-S-02B Distributor Pit, 241-SY-A Valve Pit and the 241-SY-02A Pump Pit. Existing leak detection is currently installed in these pits and is being used by Interim Stabilization in support of saltwell pumping operations in 241-S and 241-SX Farms. The existing leak detection equipment and system may be reused in support of the 241-S-102 fluidic pumping system. The existing leak detectors and leak detection system may require replacement or upgrade, as previously discussed, to support the 241-S-102 Retrieval Project.

The existing flush water system used to support the cross-site waste transfer system and 241-SY Farm operations will be used to support the fluidic pumping system. A connection for raw water exists in the 241-SY-A Valve Pit, nozzle L-14. This water source is identified for use in support of the 241-S-102 Retrieval Project. The system will provide a maximum of 140 gallons per minute at approximately 70 psi. Utilization of this water source requires the modification and installation of a new manifold jumper in the 241-SY-A Valve Pit to support identified tank farm operations and routings, and must ensure no direct tie-in between the raw water system and the cross-site transfer line.

Electrical modifications to support the operation of the 241-S-102 retrieval system are not required at this time. The largest electrical load of the 241-S-102 fluidic pumping system is the air compressors used to drive the fluidic pump and mixers. A portable generator is planned to be used to provide the air compressors with an adequate power source. Smaller electrical loads including the hose-in-hose transfer line heat trace and booster pump power may be supplied by existing power panelboard D in Building 242-S.

However, the electrical utility access put in place for interim stabilization may be used for these loads instead of the existing electric utility access provided by panelboard D, because panelboard D may not have excess power to support the retrieval equipment.

4.1.3.11 Camera/Topographical Mapping System Installation

In-tank monitoring of waste retrieval operations in 241-S-102 will be conducted with an in-tank video camera and a topographical mapping system (TMS). An integrated camera and TMS assembly will be installed into 241-S-102 through Riser 6. Riser 6 is located near the center of 241-S-102 and will provide inspection of the entire tank from a single location. The diode pump installed in the central riser, R-13, will shield a portion of the tank from view, however, is not considered of significant concern at this stage of development. Routing of instrumentation and control wiring will connect the operator control station to the in-tank camera/TMS assembly within the tank.

4.1.3.12 Ventilation

Upgrade of the existing 241-S-102 ventilation system is not considered necessary based upon the operating parameters of the fluidic pumping system at this preliminary design stage. Ventilation modifications would be limited to the removal of the existing breather filter and replacement with a new unit at the beginning of Phase I and Phase II Operations. This would be performed to evaluate the effects upon the breather filter assembly during retrieval operations.

In the event it is determined that active ventilation is required for the deployment or operation of the system, the portable exhauster POR-004 will be used. The available ducting between 241-S-102 (Riser 11) and the exhaust skid will be re-connected. An assessment on the condition of the exhauster will be performed and required maintenance will be completed. In addition, if active ventilation is deemed necessary, a larger breather filter than that on Riser 1 will be required to support the use of the portable exhauster. Interlocks to the WRS MCS will be established and any additional instrumentation needed (differential pressure and continuous air monitoring) will be added prior to any attempt to utilize this piece of equipment (see Section 11.2 for additional discussion)

4.1.4 Phase II Construction

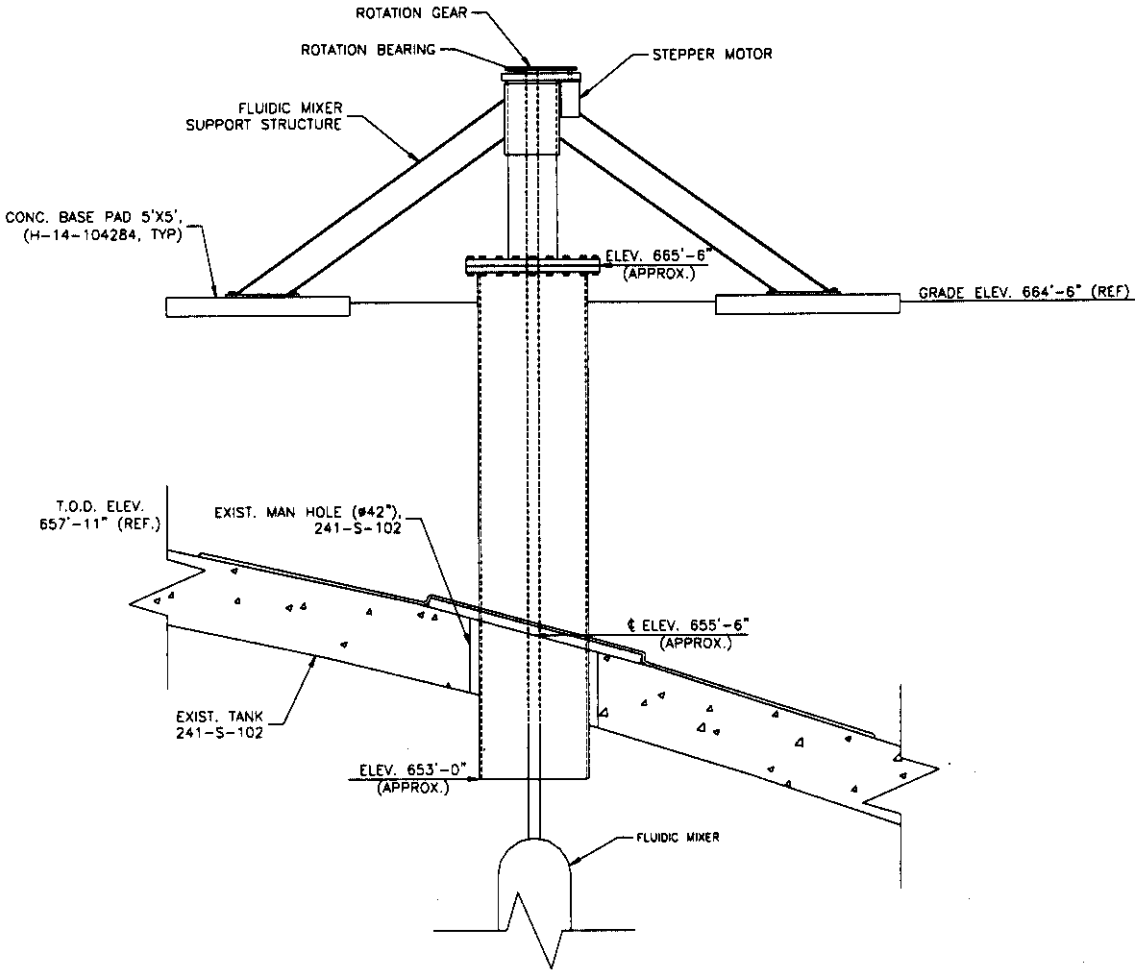
Phase II Construction will begin after the completion of Phase I Operations. Phase I Operations is expected to generate approximately 500,000 gallons of DST waste during the retrieval of 241-S-102. This volume is determined and limited by the available space in 241-SY-102 (assumed to be approximately 550,000 gallons). Following Phase I Operations a cross-site transfer of waste from 241-SY-102 to 241-AN Farm is anticipated to generate the necessary DST volume to support further retrieval of 241-S-102. During the performance of the anticipated cross-site waste transfer, Phase II Construction will commence. Phase II Construction includes the installation of the three RFD mixer pumps into the tank via the manhole extension risers installed during Phase I Construction, connection of the mixer assemblies to the air handling system, and installation of any

support utilities and instrumentation and control that could not be installed during Phase I construction.

4.1.4.1 Mixer Installation

Mixer pumps will be installed via the three manhole riser extensions that were installed during Phase I Construction activities. The riser extensions will be designed and installed to include a shield plug assembly that will be removed to facilitate mixer pump installation. The RFD mixer pumps will be installed into the tank through manhole riser extension locations. Support structures will be erected at each extension riser to provide necessary structural support of the mixer pump assemblies. This support structure will be secured to the concrete base pads installed around the riser extensions during Phase I Construction. Figure 4-5 represents a sketch of a typical mixer pump installation detail into the manhole extension risers.

Figure 4-5 Typical Mixer Pump Installation



4.1.4.2 Utility Tie-ins

Phase II Construction utility tie-ins are limited to electrical power supply for the stepper motors installed on each mixer pump assembly. Utility tie-ins are identified in the Site Plan drawing (4412.091.CDWG.001). Electrical tie-in between each mixer pump's stepper motor and the operator control station is also required.

4.1.4.3 Instrumentation and Control

Instrumentation and control systems will be installed to connect and control the mixer pump operations to the operator control station. Controls will include rotation indexing and solenoid valve operation controlling supply to the upper mixing nozzles. Conduit will be installed below grade, approximately 12-inches deep, between the mixer pump locations and the operator control station.

4.1.5 Turnover to Operations

4.1.5.1 Inspection and Testing

Equipment validation testing of the fluidic pumping system will occur prior to installation of the system within the tank farm. Acceptance inspection and testing will be performed in accordance with the equipment purchase agreement. This will include Acceptance Inspection and Factory Acceptance Tests (FAT) at the vendor facility, and an integrated cold test upon receipt of the equipment. The FAT will be developed during preliminary design and completed during final design for inclusion in the procurement specification provided to the fluidic vendor.

Upon receipt of the equipment, full-scale system integrated Operational Testing will be performed at the Cold Test Facility. This will provide the first opportunity to operate the WRS and LDMM systems in concert and identify any issues requiring resolution prior to field deployment. Operational testing of the system will include, but is not limited to the following: valve operation; interlock operation and system functional checks. Operational testing will be performed prior to the transport of waste within the pumping system. Limited operation testing will be included during initial waste retrieval operations during both Phase I and Phase II retrieval.

4.1.5.2 Acceptance for Beneficial Use

An acceptance for beneficial use checklist will be generated to support fluidic pumping system transition to Tank Farm Operations. Approval of the acceptance for beneficial use by the appropriate Engineering and Operations managers will constitute formal system turnover.

4.1.5.3 Operational Readiness Review/Assessment

The appropriate process for evaluation of readiness will be determined and conducted in accordance with applicable CHG and DOE procedures prior to authorizing operations. At this preliminary stage it is assumed that an operational readiness review will be required to complete documentation and review of all applicable processes and methodology required to authorize operations. A Readiness Evaluation is assumed to be required, to be performed prior to the Phase II Operations.

5.0 OPERATIONS

5.1 Operational Constraints and Requirements

A portion of the activities required for initiating and continuing the 241-S-102 waste retrieval operations are not within the scope of the initial Waste Retrieval Project. An assumption is made that the DST systems will be in place to receive and accommodate the waste transferred from 241-S-102 into 241-SY Farm. Insufficient space to initiate retrieval, or the inability to transfer waste within the DST system to accommodate continued retrieval, will invalidate the proposed operational approach.

The Phase I Operations retrieval requires approximately 500,000 gallons of working volume in 241-SY-102 to accommodate the planned waste transfer from 241-S-102. A sufficient volume of waste will have to be transferred from 241-SY-102, via cross-site transfer, during the Phase II Construction window to accommodate the receipt of an additional 500,000 gallons (approximate) for Phase II Operations retrieval. The infrastructure, systems, and procedures required to make any DST transfers will be provided by others and be required to be in place prior to readiness to proceed.

The two-phase approach for construction and operations is not the standard method of implementing projects at Hanford. The turnover of the system from the Project to Operations will have to be done in to separate stages. This approach will require refinement with input from the Project and Operations personnel prior to an attempted implementation.

5.2 Interim Stabilization

As discussed in Section 1.5.1.1, 241-S-102 is currently being saltwell pumped by the Interim Stabilization Project. The goals of the 241-S-102 Waste Retrieval effort are captured in the TPA milestones as 99% volumetric retrieval and the recovery of 490 curies of mobile, long-lived radionuclides based on the August 2000 BBI. Interim Stabilization and saltwell pumping of the supernatant and interstitial liquids have, and will continue to, recover a significant volume of waste from the tank. The total volume of supernatant and interstitial liquid within tank 241-S-102 prior to the initiation of recent saltwell pumping activities was approximately 120,000 gallons. Upon completion of the Interim Stabilization pumping of 241-S-102 the volume of interstitial liquid remaining will be less than 50,000 gallons. Mobile radionuclides are by definition those radioisotopes, which are highly soluble in water (listed in Table 1-3). Removal of the bulk of the liquid inventory by Interim Stabilization saltwell pumping is also assumed to remove the bulk of the mobile radionuclides.

While Interim Stabilization is helping to reach the goal of the retrieval project, it is not within the scope of this activity. The final inventory of 241-S-102 following the retrieval project will be compared to the August 2000 BBI to determine the success of the project.

Comparison will be made to the post-saltwell pumping inventory to evaluate the performance of the technology.

5.3 Pre-Retrieval Activities

Numerous prerequisites are required to establish the baseline conditions and establish a high level of confidence that waste recovery operations are ready to be initiated. Specifically, the addition of water for waste recovery and other waste disturbing activities not associated with project construction and installation will be predicated upon successful completion of the activities outlined in this section.

5.3.1 Waste Characterization

Characterization of waste constituents in the recovery and receiver tank is required prior to retrieval for numerous technical and safety related reasons. The primary purposes for characterizing the 241-S-102 waste prior to retrieval are to:

- Establish a baseline inventory (constituents and volumetric)
- Perform a waste compatibility assessment for transfer and storage
- Implement the process control strategy and the addition of corrosion inhibitors
- Perform a system technology evaluation
- Verify final recovery
- Implement environmental risk mitigation systems and actions

It is assumed that the BBI and Tank Characterization Report for 241-S-102 will be revised after the completion of saltwell pumping and prior to the initiation of retrieval operations. These waste characterization activities are beyond the scope of this project and no funds will be allocated for the completion of characterization related activities.

A waste compatibility assessment will be performed by the project prior to the transfer of waste from 241-S-102 to 241-SY Farm. Periodic samples will be acquired throughout the retrieval campaign to ensure the waste in the recovery and receiver tanks remains within the corrosion specification. Introduction of corrosion inhibitors is likely to be required to compensate for preferential dissolution of the more soluble waste constituents. Introduction of corrosion inhibitors will be performed as required in accordance with an approved process control plan. The corrosion inhibitors are tentatively planned to be added through the accumulator/surge tank.

Post retrieval sampling and analysis will be compared to the initial baseline data to determine the effectiveness of the technology for future retrievals and verify the satisfaction of the retrieval requirements (both volumetric and risk reduction by curie removal).

5.3.2 Drywell Monitoring Baseline

The existing means of leak detection in the SST storage system includes dry well monitoring with gamma and/or neutron probes and ILL measurement. An increase in the radioactivity found in a drywell is used as an indication that a leak may have occurred from an adjacent tank.

The capability and accuracy of drywell monitoring is limited. The primary weaknesses of drywell monitoring as a means of mitigating environmental risk are:

- There is a delay from when a leak occurs until the radioactive liquid "plume" migrates close enough to a well to be detected. The length of the delay is a function of the leak size, soil characteristics, and proximity of the leak to the drywell.
- The network of drywells surrounding 241-S-102 is not all encompassing and may not detect all leaks.
- An increase in measured radioactivity is not necessarily an indication of a leak. The increase may be due to the migration of existing contaminants or from other various sources. The source of increased radioactivity is difficult to verify.
- The quantity and migration of a plume are difficult to track.

Drywell monitoring is recommended regardless of the aforementioned weaknesses. The drywells and operating procedures are already in place and the cost of drywell monitoring is low relative to the increased, albeit limited, detection and monitoring capabilities. Routine drywell monitoring will be performed during the retrieval using existing operating procedures. Readings will be taken from each of the eight drywells surrounding 241-S-102 (Drywell numbers 0201, 0203, 0204, 0205, 0207, 0208, 0210, 0211) at weekly intervals while retrieval operations are ongoing. The readings will be compared to the baseline measurements and variation from the baseline greater than the uncertainty associated with the measurement will be initially assumed a leak from 241-S-102. Appropriate mitigating actions will be taken and the source of the increased radiological activity identified. Normal operations will resume only if the source of the increase radioactivity can be determined as something other than a leak from 241-S-102.

5.3.3 Liquid Observation Well Monitoring Baseline

A spectral gamma analysis will be performed in the existing 241-S-102 Liquid Observation Well (LOW) in Riser 5 prior to the start of retrieval operations. The output will be used to determine the location of the interstitial liquid, estimate the initial liquid inventory, and approximate the location and distribution of sludge within the salt matrix.

The ILL stability after saltwell pumping will be verified by acquiring numerous level indications (by LOW monitoring and interpretation) over a period of several days or weeks to ensure the Interim Stabilization pumping criteria of less than 50,000 gallons of liquid remains. The determination of the tank's initial integrity using liquid level

measurements is dependent upon the tank being in static equilibrium, minus any potential existing leak.

5.3.4 Ground Well Water Sampling

Water samples will be acquired from existing wells downstream of 241-S Farm and 241-S-102. The samples will be used for comparison to samples acquired at the conclusion of the retrieval operations to assess variations that may occur as a result of tank leakage during operations.

5.3.5 Dome Deflection Surveys

Dome surveys will be performed before retrieval is initiated and intermittently while waste is being removed. Survey will be taken at the existing benchmarks (Riser 5 and 16, see Table 1-5) at predetermined intervals consistent with the current surveys operations performed during interim stabilization pumping (OSD-TI-151-00013).

Dome deflection measurement deviations from the baseline observed during the retrieval, if any, will be used to assess the affects of waste adherence to in-tank hardware. Operations may be modified based upon the dome deflection survey results and comparison.

5.3.6 Initial Tank Integrity Assessment

An initial tank liquid integrity assessment will be performed on 241-S-102. If the tank has reached static equilibrium (following the conclusion of saltwell pumping) then a change in liquid level over time can be used as an indication of a leak. If the Interim Stabilization of 241-S-102 is completed in FY 2003 as scheduled, then the tank will be assumed in static equilibrium at the beginning of construction. Frequent LOW readings to determine the ILL shall be performed prior to the initiation of construction activities to establish soundness of tank. After Phase I construction and prior to Phase I operations, surface level measurements will be taken daily (ENRAF™ in Riser 2) over the course of 30 days to determine the statistical confidence in the level rate of change. This will be used as the baseline integrity verification and will establish the pre-retrieval ILL. This assumes that a liquid surface is present beneath Riser 2. If this assumption proves incorrect a new deployment location for the level gage will have to be determined.

It is assumed that the results of the integrity assessment will confirm (within a certain confidence interval) that the tank is sound below the current level of the interstitial liquid. Furthermore, the tank will be assumed sound for the remaining duration of the retrieval below the initial liquid level measured in Riser 2 (a.k.a. the pre-retrieval high water mark). The liquid level will not be allowed to exceed this level during waste retrieval operation as a means to mitigate the leak potential.

5.3.7 Topographical Mapping

In addition to the volumetric inventory estimates contained in the BBI, the initial total tank inventory will be measured by an in-tank topographical mapping system. This

initial volume estimate will be used for comparison to the final volume estimate to determine the end-state conditions and evaluate the effectiveness of the retrieval campaign.

Lessons learned from the deployment and operations of the TMS used in the 241-U-107 Proof-of-Concept will be incorporated. The TMS uses a laser and triangulation approach to accurately determine waste level characteristics and tank volume.

5.4 Operational Strategy

A two-phase operational approach will be used to recover the waste from 241-S-102. Waste will be recovered during Phase I Operations in a center out fashion with minimal water to reduce the tank wall exposure to free liquids. No significant energy will be imparted to the waste or tank by the introduction of solvent (water) during the first phase of retrieval operations. The second phase of waste recovery will remove the bulk of the remaining waste using the lower nozzle on the mixer units planned for installation during Phase II Construction. When mixing of tank constituents in this fashion becomes inefficient, the above waste re-circulation nozzles on the mixer pump assemblies will be used to clean the tank walls and wash the remaining waste to the centrally located pump. It is assumed that the initial tank integrity assessment will verify (within a statistical confidence interval) that the tank is sound from the current liquid level and below. The assessment will not be able to verify the integrity of the tank above the liquid waste level. For this reason, the liquid level in the tank will be maintained below the initial ILL, determined by pre-retrieval LOW monitoring, at all times during the retrieval operation.

5.4.1 Leak Detection, Monitoring and Mitigating Strategy

Although the LDMM system has not been fully developed, the following features will be incorporated into the operation of the system:

- Retrieve the waste as fast as possible – The potential leakage from the tank during retrieval is proportional to the time to retrieve the tank. Therefore, the time to retrieve the tank will be minimized within the limits of the retrieval technology and the capability of the tank farm facilities.
- The volume of liquid in the tank will be minimized – The waste will be retrieved using a "bottoms up" approach. This approach will keep the waste volume of the tank that could leak at a minimum during operation of the retrieval system. This approach also reduces the potential for a leak by reducing the tank wall area in contact with liquid with a hydraulic head that drives a leak.
- Conduct dynamic testing – The retrieval system will be supplied with instrumentation to conduct dynamic inventory measurements to monitor the retrieval operations. Instrumentation will measure the liquid added to the tank and the liquid transferred to the receiver tank, maintaining a liquid inventory balance.

- Conduct static leak testing – Static testing relies on the presence of a free liquid surface in 241-S-102. Conducting static testing increases the overall retrieval duration, and will therefore not be the primary means of leak detection. However, when opportunities for conducting static tests present themselves during the retrieval operation, such as after Phase I Operations and during the cross-site transfer of waste from 241-SY-102, static tests will be performed.
- Monitor the existing dry wells - The existing dry wells will be monitored before, during, and after retrieval operations. Before retrieval operations commence, the existing dry wells will be measured to establish a baseline. During operations, the dry wells will be monitored periodically to detect increases in radiation levels that may be indicative of a leak. The dry wells will also be monitored after completion of operations.

Various leak detection technologies, including in-tank and ex-tank methods, are being investigated. If these technologies increase the accuracy of the static and dynamic testing systems or add value by reducing the uncertainty associated with these approaches, a decision can be made to deploy them with the 241-S-102 fluidic retrieval system.

5.4.2 Phase I Operations

Phase I Operations will recover solution using a 4-diode fluidic pump installed near the bottom of the tank heel through Riser 13 during Phase I Construction. Waste will be mobilized and retrieved solely by saltcake dissolution using water added via the 241-SY Farm flush system. Retrieval by passive dissolution in this manner will decrease the likelihood of an uncontrolled gas release event and produce a more uniform release of the entrained gases. Initial retrieval by dissolution will not impart any mechanical energy to the tank waste or structure. This will further mitigate the potential of creating a leak site or aggravating/exposing any potential existing leak sites.

Removal of the saltwell screen and installation of the pump in Riser 13 is anticipated to introduce no more than 2000 gallons of water to the tank. This volume, in conjunction with the free liquid remaining in the well around the saltwell screen after pumping, will be initially removed by fluidic pumping. This initial liquid removal batch is estimated to be approximately 5000 gallons.

A backflush of the waste transfer line and system will be completed following each batch waste transfer operation. The raw water backflush supplied from the 241-SY-A Valve Pit, will remove solids from within the transfer line and pumping system to reduce the likelihood of system plugging. Introduction of raw water at 55-60°F will also reduce the likelihood of system plugging by eliminating any potential supersaturation conditions in the retrieval solution. The backflush would continue until the specified amount of water is introduced into 241-S-102 to support the next batch of saltcake dissolution and waste transfer. Water additions, up to 20,000 gallons, are planned to support the retrieval of individual batch waste transfers. Water volume additions may be altered to reflect retrieval operations and efficiencies realized during the waste retrieval operating campaign.

The four-drop legs on the pump assembly in 241-S-102 will be oriented 90 degrees apart and be used to direct the addition of raw water away from the center well. The intent is to maximize exposure of the unsaturated water to the waste salt for accelerating dissolution. Introduction of the water straight into the well may slow the dissolution process by not providing sufficient circulation of the solvent.

The 241-SY cross-site flush system (nozzle L-14 in the 241-SY-A Valve Pit) will also serve to add the batch dissolution water to 241-S-102. The temporary water supply in 241-S Farm, installed to support Interim Stabilization activities in 241-S and 241-SX tank farms, has insufficient capacity (20 gpm maximum) to support the required rate for water addition. At 20 gpm, a 20,000 gallon water addition would take approximately 17 hours. To accelerate the additions, water will be supplied from the flush system, which has the capability of providing approximately 140 gpm. The water will be added into the tank until the liquid level reaches a level approximately 6-inches below the initial liquid level as discussed in Section 5.3.3, or the maximum working volume is obtained. The liquid volume within tank 241-S-102 will be measured by using the dip tubes installed in Riser 13 during this process. The maximum working volume is determined by compromising between minimizing leak potential and providing sufficient volume to allow for a pumping cycle of meaningful duration. The maximum volume of allowed water addition assumed in the retrieval calculations is 20,000 gallons. This value will likely be revised during subsequent design phases. At 140 gpm, a 20,000 gallon batch of dissolution water will be added in less than 2 ½ hours.

Sufficient time will be provided for the liquid within the well to become saturated prior to pumping for all batches subsequent to the first batch removed. The initial waste transfer will be the removal of solution already present within the tank. Bubblers, or dip tubes, will be installed adjacent to the pump in Riser 13 to measure the liquid waste level and specific gravity. The specific gravity will be used to determine the solution saturation and provide an indication of when solution removal should be performed. The anticipated specific gravity for the solution ranges from 1.37 to 1.39. The maximum solution specific gravity should not be allowed to exceed 1.41. Saturation beyond this level will require the solution be diluted to satisfy the DST specification for the receipt of waste. Once the solution reaches saturation, continued waiting will only serve to increase the operating duration and associated costs, as well as increase the potential for leakage.

The fluidic pump will be operated in a modified fashion during the dissolution period to accelerate saturation of the water. The two pumping charge vessels will be simultaneously evacuated and then vented in a repeating process to provide for circulation of the solution within the well. The waste circulation within the central well containing the diode pump will promote localized mixing of varying liquid saturation points within the well.

Once the solution reaches a high enough saturation (i.e. reaches a predetermined specific gravity) a waste transfer will be initiated. Waste will be removed via the 4-diode pump at a cyclical rate (on an approximate 26 second period) varying from 80 to 130 gallons per

minute. The output of the pump will be routed through an accumulator or surge tank installed above the diode pump in the 241-S-02B Distributor Pit. The surge tank provides a constant feed to the booster pump and also serves as a separator to exclude debris from the waste transfer system. A centrifugal booster pump will draw liquid from the accumulator via a stand pipe in the vessel and increase the pressure to approximately 65 psi for transfer to 241-SY-102. Removal of the largest anticipated solution batch of 27,000 gallons will take approximately 4 ½ hours at an average pumping rate of 100 gpm. Waste removal will continue until insufficient feed can be supplied from the diode pumps to the booster pump. A low level switch in the surge tank in the 241-S-02B Pit will inform the control system to halt pumping and initiate backflushing and water addition.

The waste transfer will be completed when insufficient liquid can be pumped from the tank to provide a constant feed to the booster pump. Immediately following the waste transfer, a backflush and water addition cycle will be initiated. The cycle of water addition, dissolution, and transfer will continue until the space available in the receiver tank (assumed at this time to be 241-SY-102) is consumed. Based on the design of the current 241-SY-102 transfer pump, it is assumed that Phase I Operations retrieval will transfer approximately 500,000 gallons of solution representing approximately 225,000 gallons of 241-S-102 waste salt recovery.

It has been assumed that dissolution during Phase I Operations retrieval will require 24-hours to produce a saturated solution (4412.091.PCAL.001 in Appendix C). The two pump charge vessels will be continually filled and evacuated back into the tank during this period to assist the liquid circulation and accelerate dissolution. The duration estimated to produce a saturated solution (24-hours) is believed to be conservative, lacking any dissolution rate data for the 241-S-102 waste. Similarly, mixing during Phase II Operations retrieval is conservatively estimated as one volume turn over. That is, for a 1,000 gallon mixing batch, 1,000 gallons must be drawn into and expelled from the mixing charge vessels to create an adequately saturated solution before a transfer can occur.

Additional dissolution tests on actual 241-S-102 waste samples would be warranted to refine the retrieval duration estimates and waste transfer performance expectations (e.g. to ensure that the line fouling observed during Interim Stabilization of this tank was prevented) during Phase I Operations retrieval. Cold testing of the Russian and AEAT systems, sponsored by TFA, will also eliminate uncertainty associated with the estimated Phase II Operations mixing retrieval duration and the overall effectiveness of the technology.

Regardless of the anticipated retrieval durations, batch waste transfers during the actual operations will occur once the waste solution/slurry reaches a predetermined specific gravity as measured by the dip tubes (not to exceed the DST transfer limit of 1.41). Additional waiting (Phase I) or mixing (Phase II) will not recover significantly more waste and is contrary to the LDMM strategy of leak mitigation by retrieval acceleration.

It is assumed that sufficient solution will exist in the tank to initiate the Phase I Operations retrieval without any additional solvent additions beyond those added during the removal of the saltwell screen and installation of the diode pump. After the initial waste transfer, the OGT will be flushed and water added to 241-S-102 through the 241-SY Farm flush system. The batch size will be determined by the size of the previous batch and liquid level after introduction compared to the initial ILL. The initial Interstitial Liquid Level (ILL) will never be exceeded during retrieval as the tank integrity above this height cannot be verified. The batch water additions will increase until the maximum addition threshold is reached. This volume has been assumed to be 20,000 gallons for purposes of estimating the retrieval duration. The maximum batch volume will be refined as additional data is obtained. The initial volume estimate is based upon the volume required to fill the tank heel (12,500 gallons) plus three or four inches to cover the mixer nozzle (at approximately 2,700 gallons per inch).

The maximum water addition batch will be determined as a compromise between maximizing the retrieval efficiency and minimizing the leak potential. The LDMM strategy is to maintain a minimum inventory of liquid in the tank for the least amount of time. The effects of larger liquid batches and the retrieval acceleration will have to be weighed against the risk of the greater volume. Water additions are continued batchwise until an estimated 50% of the tank contents by volume (approximately 223,000 gallons), have been transferred to 241-SY-102. The maximum batch transfer of waste slurry (Phase I Operations) is estimated to be 27,000 gallons. Retrieval of 223,000 gallons is calculated to take approximately 27 days (4412.091.PCAL.001).

5.4.3 Phase II Operations

Phase II Operations will commence after the completion of Phase II Construction and the cross-site transfer of sufficient waste volume from 241-SY Farm to accommodate the continued retrieval.

Batch water additions of approximately 20,000 gallons will be added to 241-S-102, through the return drop legs or 4-diode pump, as is done during the Phase I Operations (described in Section 5.4.2). The three RFD mixers installed in the manholes will be operated using the lower, submerged nozzles, until the liquid's specific gravity reaches the predetermined set point. The mixers will be operated 120° out of phase to minimize air consumption. Only one mixer will be expulsing liquid at any given time. Air consumption of a mixer during the drive phase is approximated at 600 scfm verses 150 scfm during the evacuation cycle. Each of the mixers will be mounted on bearings and rotated up to 360 degrees to maximize the mixing area. A stepper motor mounted on each of the mixer assemblies will index the assembly to re-orient the nozzle to a new direction. The stepper motor will be tied to the master Instrument and Control system to record the mixer(s) orientation. Visual observation through the in-tank Closed Circuit Television camera will be used to manually position the mixers, as required, to target areas of immobilized waste. Once adequate saturation and solid suspension is obtained by the mixers the mixing operations will be suspended. Pumping will then commence in the same manner as described during Phase I Operations.

It is anticipated that mixing with the submerged nozzles will dissolve and mobilize the waste sufficiently to recover all but the remaining 10% of the initial tank waste volume. At that time the valves to the upper mixer nozzles will be opened and "tank washing" will begin. Orientation of the mixers by the stepper motors will be directed manually at areas of immobilized waste. The stream projected from the upper mixer nozzles will be directed at waste beyond the range or capabilities of the lower nozzle.

Mixing using the upper nozzles will only be performed once the bulk of the waste has been recovered and after the lower nozzles become ineffective at waste mobilization. This approach will minimize the exposure of the tank walls to "energized" fluid impaction.

The mixing batch water additions are estimated to be 20,000 gallons whether mixing with the upper or lower nozzles. Phase II Operations are anticipated to consume approximately 500,000 gallons of DST space, representing the recovery of approximately 223,000 gallons of waste from 241-S-102.

5.5 Post-Retrieval Activities and Project Closeout

5.5.1 Waste Characterization

Several inches of waste are anticipated to remain in the tank heel at the conclusion of the 241-S-102 retrieval campaign. This waste will be sampled for analysis to determine the remaining constituents. An estimate of the inventory of COC will be established and compared to the initial estimates as a technology performance measure. The analysis will also determine whether the TPA goal of recovering 490 curies of mobile, long-lived radioisotopes has been satisfied and estimate the residual inventory of COCs.

Pre-deployment characterization activities include the generation of a Tank Sampling Analysis Plan and DQO, sampling, analysis, and BBI revision. These activities are not within the scope of the activity (RPP-8108), but will be funded and executed by the Characterization Program. It is assumed that the Characterization Program will assume ownership and ensure completion of these activities.

5.5.2 Drywell Monitoring

Neutron and gamma measurements will be acquired from the eight drywells surrounding 241-S-102 at the conclusion of the retrieval. These values will be compared to the initial and routine drywell measurements and used as an indication of tank leakage that may have occurred during the retrieval.

5.5.3 Liquid Observation Well Monitoring

A spectral gamma analysis will be performed in the existing LOW in Riser 5 at the conclusion of the retrieval. The output will be used to estimate the final waste inventory,

estimate of the inventory of COC (in conjunction with characterization), and as a technology performance measure for total recovery. The analysis will also be used (secondary to topographical mapping) to determine whether the TPA goal of recovering 99% of the tank volume has been satisfied.

5.5.4 Ground Well Water Sampling

Water samples will be acquired from existing wells downstream of 241-S Tank Farm and 241-S-102. The samples will be used for comparison to samples acquired prior to and during waste retrieval operations to assess variations that may have occurred as a result of tank leakage during operations.

5.5.5 Final Tank Integrity Assessment

A final tank integrity assessment will be performed following the completion of the waste retrieval operations by evaluating the data collected during operations including LOW and ENRAF readings. A visual observation of the tank contents can be collected by internal tank camera. Graphical representation of tank contents can be collected by use of the TMS. Continued ENRAF readings to determine the liquid level shall be performed following the completion of waste retrieval activities to establish a confidence level of tank volume and stability.

5.5.6 Topographical Mapping

ENRAF, LOW interpretation and visual observation will be used to produce post-retrieval volumetric inventory estimates. Because the LOW and ENRAF readings provide only a single datum point, a level surface is required to produce an accurate volume estimate. It is unlikely, however, that the waste will be recovered to a flat uniform surface within the tank. For this reason, a TMS will be deployed as the primary means of determining the final waste inventory. The volume determined by the TMS will be compared to those generated using the aforementioned means for secondary verification. The final volume estimate will be used to revise the BBI and evaluate the effectiveness of the retrieval technology.

Lessons learned from the deployment and operations of the TMS used in the 241-U-107 Proof-of-Concept will be incorporated. The evaluation will also determine whether the TPA goal of recovering 99% of the tank volume has been satisfied.

5.5.7 Equipment Removal

All of the in-tank equipment is currently planned to be abandoned in place, similar to what occurs in the interim stabilization project. The ex-tank portions of the fluidic system will be removed and placed into storage for use in future retrieval efforts. The temporary piping systems, including the OGT, will be removed and disposed.

5.5.8 Tank Isolation

Upon completion of the waste retrieval operations and acquisition of required waste sampling for characterization of remaining tank constituents tank isolation will be performed. However, tank isolation could be affected by the decisions regarding final tank closure. Isolation of exposed risers and pit structures should prevent the potential transfer or addition of waste or drainage into 241-S-102. Existing transfer line nozzle connections should have process blanks installed to isolate lines. Pit structures should be foamed to prevent water intrusion as the result of accumulated rain. Additional riser modification may be required to account for drainage from other sources including Valve Pits 241-S-A and 241-S-B.

5.5.9 Lessons Learned Report

A lessons learned report will be generated upon the completion of the 241-S-102 waste retrieval operations. The lessons learned will document process operations and potential improvements identified for future retrieval operations.

5.5.10 Technology Evaluation Report

A technology evaluation report will be generated upon the completion of the 241-S-102 waste retrieval operations. The report will evaluate the operational successes and success or failures of the fluidic pumping system. System operation will be evaluated versus waste volume removed and equipment operation during the retrieval campaign. The evaluation will specifically focus on the potential application and improvements that can be realized applying fluidics for future SST waste retrievals.

6.0 SYSTEM INTERFACES

Project interfaces have been defined at a preliminary level for WRS system process inputs and outputs, electrical feed, and primary waste tank interfaces. The interfaces are identified and described in Table 6-1. Interface numbers are referenced to drawings, which identify their schematic location. An "E" preceding the interface number refers to an interface external to the project and an "I" to an internal interface. A general description of interface characteristics, responsible organization for each side of the interface, and key issues are described in the table.

Table 6-1 System Interfaces

System	Location	Description	Project Interface	Mating Interface	Issues Comments	Interface #	Controlling Documents	Agreement Status
OGT Line	241S-102 241-S-02B Pit	Typical Hanford Hose in Hose assembly with Purex Connectors, 1.01 Mgal waste	241-S-102 Project	241-S-102 Operations		IC-E01	4412.091.PDWG.006-1	Open
WRS Ventilation	241-S Farm	Fluidic WRS Offgas skid exhaust stack vent to ATM 1000 SCFM	241-S-102 Project	WA State Dept. Of Ecology	Permit Required	IC-E02	4412.091.PDWG.006-2	Open
241- S-102 Ventilation	241-S-102 Riser 1	Existing Passive Ventilation System vent to ATM	241-S-102 Operations	WA State Dept. Of Ecology	Assume Existing Permit Ok	IC-E03	4412.091.PDWG.006-1	Closed
241-SY Farm Flush Water Supply	241-SY-A Valve Pit	Tie in to Flush System at nozzle L-14 in 241-SY-A valve pit. 140 gpm supply raw or inhibited	241-S-102 Project	241-SY-102 Operations	Flush water will be required by others	IC-E04	4412.091.PDWG.004-2	Open
MH Riser Extensions	Tank S-102 Construction MH (3 Places)	Excavation, MH Cover Removal, and Extension install required	241-S-102 Project	241-S-102 Operations	Need soil samples for contamination/dose	IC-E05	4412.091.PDWG.006-1	Open
RFD Mixer Pumps	Riser Extensions on Manholes on 241-S-102	Excavation and installation of riser extension required	241-S-102 Project	241-S-102 Operations and Fluidics vendor	Seal of rotating equipment in riser	IC-E06	4412.091.PDWG.006-1	Open
Fluidic Retrieval Pump	241-S-02B Distributor Pit Riser 13	Installation of pump assembly into 241-S-102, riser 13. 100 gpm waste	241-S-102 Project	241-S-102 Operations and Fluidics vendor	Saltwell screen removal	IC-E07	4412.091.PDWG.006-1	Open
Electrical Power	WRS System	Tie in to power panel D through breaker D5, D9, and D10	241-S-102 Project	241-S Farm Operations		IC-E08	4412.091.EDWG.001	Open
Transfer Line SL-177	241-SY Farm	Convey flush water to OGT line, 140 gpm raw or inhibited water.	241-S-102 Project	241-SY Farm Operations		IC-E09	4412.091.PDWG.006-1	Open
OGT Line	241-SY-102 241-SY-02A Pit	Typical Hanford hose–in-hose assembly	241-S-102 Project	241-SY-102 Operations	Cross site transfer waste compatibility assessment	IC-E10	4412-091.PDWG.006-2	Open
241-S Farm Raw Water Supply	241-S Farm	Tie in to temporary water supply system. 20 gpm raw water	241-S-102 Project	241-S-102 Operations	Temporary supply may not be available	IC-E11	4412.091.PDWG.004-1	Open
Camera	Riser 6 241-S-102 tank	Camera installation	241-S-102 Project	241-S Farm Operations		IC-E12	4412.091.IDWG.001	Open
Datalink	241-S-102	Communication from TMACS to PIC	241-S Farm Operations	241-S-102 Project		IC-E13	4412.091.IDWG.001	Open
Datalink	241-SY-102	Communication from TMACS to PIC	241-S Farm Operations	241-S-102 Project		IC-E14	4412.091.IDWG.001	Open
Site wiring	Operator control room	Installation of all wiring into the Ethernet hub and to TFMCS	241-S-102 Project	Site Telecom contractor		IC-E15	4412.091.IDWG.001	Open
Compressed Air For WRS	Air Compressor Skid Generator	Air Supply to Fluidic mixer and pumps. 1000 SCFM air	241-S-102 Project Engineering	241-S-102 Fluidics Vendor		IC-I01	4412.091.PDWG.004-1	Open
Datalink	Operator control room	Communication from vendor controller to PIC	241-S-102 Project	241-S-102 Fluidics Vendor		IC-I02	4412.091.IDWG.001	Open

7.0 AUTHORIZATION BASIS

The pre-conceptual cost estimate and schedule for the 241-S-102 Waste Retrieval Project are based on the preliminary engineering information presented in this report. This engineering basis includes utilization of equipment currently covered by an existing Authorization Basis (AB) to support SST saltwell pumping activities, as well as new SSCs that are not covered within the current AB (e.g., Fluidic mixing and pumping system). During the conceptual design phase, an AB assessment (following the type of evaluation used in the Unreviewed Safety Question process) will be performed to determine the extent to which the project might require an AB amendment. Using the hazard and accident analysis/control allocation process defined in HNF-IP-0482, Volume IV, Sections 6.9 through 6.12, the potential hazards and accident scenarios associated with the project SSCs will be identified, risk consequences and frequencies will be quantified, specific safety classifications will be determined, and appropriate controls (possibly including changes to design requirements) will be developed to ensure that environmental, worker, and public safety are appropriately addressed in the project activities. A preliminary hazard evaluation has already been completed (Shultz 2001). Based on the results of these activities, the draft AB amendment documentation necessary to support 241-S-102 waste retrieval operations will be prepared and submitted for DOE-ORP approval.

Assumptions made during the project's pre-conceptual development phase will be reassessed and validated during the conceptual design phase. Any changes to the current list of assumptions, such as a change in safety classification of a significant component or system utilized to support waste retrieval, could impact the ROM cost estimate and schedule for this project. Any such changes affecting the project cost or schedule will be documented as part of the conceptual-level estimate and schedule development activities.

8.0 ACQUISITION STRATEGY

This section provides a preliminary acquisition strategy for the 241-S-102 Waste Retrieval Project. The main focus of this preliminary strategy is to outline the recommended approach for obtaining the necessary development and test data, design documentation, hardware and equipment, and other technical support needed to deploy and operate a fluidic mixing and pumping system in one of Hanford's SSTs. This preliminary strategy is consistent with the Site's current understanding of the suitability of Fluidics in support of SST waste retrieval, and with current planning relative to deployment of a fluidics-based retrieval system. Lessons learned from previous DOE acquisitions of similar equipment, including the use of Fluidic mixing systems to recover high-level radioactive tank waste at the DOE's Oak Ridge Site, have been considered in developing this preliminary strategy.

The recommended contracting strategy for acquisition of the fluidic retrieval system includes the use of multi-phase contracts and parallel project development activities for the initial technology assessment, design, fabrication, testing, and deployment and operations support. This approach will offer the most flexibility to allow for programmatic and/or technical changes.

8.1 Technology Assessment

The DOE – Headquarters TFA Group, EM-50, is currently entered into a contractual agreement with AEAT and the Russian Government to perform a series of high-level proof-of-concept tests in FY 2001 to assess the suitability of fluidic technology for SST waste retrieval. This testing is being planned and executed in parallel with the 241-S-102 Waste Retrieval Project pre-conceptual engineering activities managed by CHG. The results of this technology assessment testing activity will support decisions by DOE-ORP and CHG on whether to proceed with deployment of a fluidics-based waste retrieval system for 241-S-102.

8.2 Design Development

Assuming that the TFA-sponsored proof-of-concept testing for fluidic mixing/pumping system is deemed successful in demonstrating the feasibility of this type of technology in supporting the SST Retrieval Project goals, additional system testing should be conducted in support of the 241-S-102 Waste Retrieval Project's conceptual design development (FY 2002). The aim of this testing should be to demonstrate the feasibility of specific Fluidic system design concepts that will support the preferred waste retrieval system configuration described in the 241-S-102 Waste Retrieval Project's Conceptual Design documentation. Adequate confirmation of the Fluidic system's performance will be essential to validating the project's design concept, and in obtaining DOE authorization to proceed with additional design development work.

A detailed retrieval system performance specification should be approved following completion of conceptual design. This specification will be used as the technical basis for a design and build contract to be bid and awarded. A preliminary performance specification is provided in Appendix K. The Design Agent will integrate the design with the Tank Farm infrastructure upgrades design developed. Upon approval of the integrated design package, and DOE authorization to proceed, the design will be released for fabrication.

8.3 Fabrication

The selected vendor will fabricate the fluidic retrieval system for 241-S-102, including all of the necessary ancillary systems and equipment required to operating the fluidic mixing/pumping hardware and to interface properly with the Tank Farm infrastructure. Following completion of the fabrication/assembly work at the vendor facilities, the completed hardware and operating software systems will be subjected to a series of FATs in the shop environment. These FATs will be witnessed and approved by appropriate project personnel. Upon completion of the FATs, and resolution of any open test items, the equipment will be appropriately packaged and shipped to the Hanford Site. A detailed receipt inspection of the shipment should be performed before the procured system is formally accepted to ensure that all components and required documentation are received and are undamaged.

8.4 On-Site Acceptance Testing

Prior to deploying the fluidic equipment into the SST Farm, the Fluidic retrieval system functionality will be further assessed during a series of pre-installation tests. These tests may be conducted in a new Cold Test Facility to provide a simulated tank environment in which to demonstrate and practice installation and mock operations of the new equipment. The tests will demonstrate operation of the fully integrated system.

8.5 Installation and Operation

Factory technical and operations support should be utilized during field installation activities for the fluidics equipment and subsequent construction acceptance test procedures. Participation by vendor specialists during the system's startup, turnover, and hot operations activities is also recommended.

9.0 PERMITTING

An environmental permitting plan, RPP-8196, "241-S-102 Tank Waste Retrieval System Environmental Permits and Approvals Plan", presents a sound strategy and plan for meeting environmental requirements during construction and installation of SSCs for a typical SST retrieval project. This Environmental Plan includes a summary of required permits and approvals, planning assumptions, cost estimates, and schedule information for implementing selected environmental permitting strategies to support SST waste retrieval activities. The information provided in the RPP-8196 document provides the basis for ROM cost and schedule information presented in this report.

The addition of water to any of the SSTs to support retrieval must be carefully planned and minimized as a best management practice. The State of Washington *Dangerous Waste Regulations* (WAC 173-303) do not preclude the addition of water for the purpose of retrieving tank waste in support of tank cleanout and closure; however, prudent use of water will minimize the potential for contaminants to be carried into the environment in the event tank integrity is not maintained. Ecology should be appraised at an early stage of project development of any plans to use water for the 241-S-102 Waste Retrieval effort, along with the intended steps to minimize the liquid volume and optimize waste removal. The Environmental Plan used as the planning and estimate basis for this project outlines the anticipated regulatory steps and approvals necessary to obtain the required regulatory approvals to complete the initial SST waste retrieval effort.

10.0 TEST AND EVALUATION

There are a number of technical, programmatic and operational objectives associated with the initial WRS deployment in 241-S-102. These include the specific performance goals identified in TPA Milestone M-45-05A, i.e., retrieve to safe storage approximately 490 curies of mobile, long-lived radioisotopes and 99% of tank contents by volume, as well as various objectives supporting the resolution or mitigation of open technical issues, uncertainties, and risks associated with saltcake/sludge retrieval. The data collected in the pursuit of the defined project objectives will allow for potential advantages in terms of environmental risk reduction and technical advancement of waste retrieval technologies in support of eventual SST closure.

The 241-S-102 Waste Retrieval Project will develop and execute a Test and Evaluation Plan (TEP) establishing the need/timing for any required vendor testing, component tests, on-site verification tests, functional test, required/recommended cold tests, and training to support the 241-S-102 waste retrieval effort. DQOs associated with the initial SST waste retrieval project will also be addressed in the TEP. The TEP will be developed in concert with the project's conceptual design activities, according to the guidelines and process defined in HNF-2029, *River Protection Project Test and Evaluation Management Plan*, and will be updated as required throughout the project's life cycle.

11.0 UNCERTAINTIES

11.1 DST waste volume

The volume of waste generated during the 241-S-102 retrieval campaign is dependent upon several factors that are currently not well defined. Uncertainties in the current estimates for 241-S-102 waste solubility and insoluble solids inventory could dramatically impact the anticipated waste volume projections. Although the dissolution studies performed to-date (RPP-6915 Rev. 0 and HNF-7363 Rev. 0) increase the accuracy of the waste volume projections, the results are only as accurate as the inputs (waste simulant and/or samples) representing the composite waste chemistry and rheological properties.

While dissolution testing has been performed to determine the solubility of the waste at various temperatures, rates of dissolution were not captured. Typical dissolution testing was performed at 25° C and 50° C (77° F and 122° F). The 241-S-102 tank waste temperature is around 98° F (37° C), while the raw water supply (if unheated) will be approximately 55° F (13° C). Additional testing and analysis should be conducted to determine the effects of temperature on the dissolution and dissolution rate.

In retrieving the 241-S-102 wastes, approximately 1.01 Mgals of generated waste (Garfield et al. 2000, 4412.091.PCAL.001)) will be introduced into the DST system via 241-SY-102. This is in addition to the estimated 1.34 Mgal of waste that will be introduced from the dissolution retrieval demonstration performed on 241-S-112. These two SST retrieval activities will introduce a combined 2.35 Mgal of waste into the DST system via 241-SY-102, reducing the available storage volume considerably, and constraining further SST retrieval and waste management operations in the tank farms. Utilizing 241-SY-101 in lieu of, or in addition to, 241-SY-102 would be a potential means of mitigating the DST space availability concern. Planning for the receipt of the SST waste into the DST system will have to be completed based on Hanford Tank Waste Operations Simulation modeling during the project's conceptual design phase.

To deal with the DST space availability issue, the ROM cost and schedule that was developed for the project includes cost/time factors to account for one waste transfer out of 241-SY-102, midway through the retrieval campaign. Before 241-S-102 retrieval begins, additional DST transfers may be required if the tank has a substantial initial waste volume inventory (as a function of saltwell pumping receipts), or if the current 241-SY-102 transfer pump is not replaced with a different pump design.

An evaluation of the activities and SSCs outside of the Project boundaries required to support the complete recovery of 241-S-102 waste into the DST system should be performed. While the Project boundaries are clearly defined at 241-SY-102, successful project completion is dependent upon the availability of DST architectures, the cross-site transfer system, and available East Area storage capacity. Critical activities within the DST system should be tracked on the project schedule to avoid potential conflicts.

11.2 Safety and Regulatory Issues

Safety and regulatory considerations needing to be taken into account before initiating waste retrieval operations include potential toxic gas releases, SST dome loading, and possible waste leakage, as discussed below.

It is estimated that there is between 430 and 901 cubic meters of retained gas present in 241-S-102 (Mahoney et al. 1999, Hodgson 1996). Retrieval activities have the potential to release these retained gases from the waste. Concentrations of ammonia at the immediately dangerous to life or health levels are present in 241-S-102. At the start of retrieval activities, appropriate surveillance and respiratory protection will be required for workers in the immediate vicinity of the 241-S-102 breather filter.

A specific concern with respect to 241-S-102 that will need to be addressed during design and construction activities is that dome loading may need particular attention, depending on the configuration of the fluidics equipment.

The addition of water to any of the SSTs should be carefully planned and minimized as a best management practice due to liquid integrity concerns associated with these older tanks. The State of Washington Dangerous Waste Regulations (WAC 173-303) do not preclude the addition of water for the purpose of retrieving waste in support of tank cleanout and closure. However, in the event that tank integrity is not maintained, prudent use of water will minimize the potential for contaminants to be passed into the environment. Generation and submittal of a Process Control Plan to the appropriate stakeholders (e.g., Ecology) is recommended to gain concurrence and approval prior to the initiation of any tank intrusive or waste disturbing operations. Ecology is not anticipated to object to the addition of limited quantities of dissolution water in support of the 241-S-102 retrieval, based on the agency's desire to effect expeditious cleanup and tank closure. Furthermore, the fluidics technology will minimize the amount of water added to effect retrieval. In comparison to the "past-practice sluicing" retrieval method, the fluidics process will introduce substantially less water to the tank, and the residence time of the dissolution liquid will be assumed much lower, thus reducing the risk of any potential waste leakage to the environment.

11.3 Receiver Tank Conditions (241-SY-102)

Numerous potential issues arise with utilizing 241-SY-102 as the receiving tank. An estimated 1.34 million gallons of solution will be transferred to 241-SY-102 from the 241-S-112 dissolution retrieval demonstration in FY 2005 (TPA Milestone M-45-03C). This waste will require transfer to another DST prior to completing the 241-S-102 initial waste retrieval.

The existing transfer pump in 241-SY-102 will not support removal of the 241-SY-102 contents to a level that is sufficient to allow complete recovery of the 241-S-102 contents without interrupting the retrieval operations numerous times to made cross-site waste transfers. The existing transfer pump is beyond its intended design life (in terms of gallons transferred) and there will likely be other pumping activities prior to the FY 2006 operations start for 241-S-102 retrieval. It is assumed the pump in 241-SY-102 will be operable and support the project needs. This issue will be carried forward into the project's conceptual design phase pending resolution.

11.4 Recovery Tank Conditions (241-S-102)

The waste volume estimates in the BBI used to support this pre-conceptual engineering document do not reflect the actual current waste inventory. Tank S-102 is in the process of being interim stabilized by saltwell pumping. The inventory of liquids and solids that will remain at the end of this pumping campaign have not been estimated. The values used to estimate the 241-S-102 retrieval duration (168 days start to finish) and retrieval volume (1.01 Mgal) are based on the current waste volumes reported in the BBI (CHG 2001) and the retrieval assumptions contained in (Garfield et al. 2000). These values should be conservative considering that the Interim Stabilization Project will have removed considerable quantities of liquid from 241-S-102 prior to the initial retrieval operations, and the dissolution behavior of the saltcake is expected to be within the current dilution ratio assumption.

The entrained gas volume and composition that will remain at the completion of saltwell pumping will require evaluation. It has been assumed that the inventory relative to the rate of release will not be sufficient to warrant use of active ventilation. This assumption will require further validation in subsequent project phases.

Numerous and repeated mechanical failures of the 241-S-102 saltwell pumping system(s) have delayed the initial completion schedule. The saltwell pump and pump legs have been removed from the tank several times. The saltwell pumping equipment that will remain in the SST upon completion of the interim stabilization effort is undefined. It is likely that multiple pump leg and/or dip tube combinations will be present in the saltwell screen. Significant amounts of debris are also likely to remain in the 241-S-02B Distributor Pit that will require removal and disposal. Based on these uncertainties, an allocation has been provided in the ROM cost estimate and project schedule for the removal and disposal of undefined waste (debris and hardware) in the 241-S-102 pits and equipment from the tank dome.

11.5 Waste Bridging, Settling

The preliminary retrieval strategy established for 241-S-102 recovers waste in a bottoms-up fashion. This is desirable from a leak mitigation perspective to allow for waste recovery with a minimum tank liquid inventory. The waste recovered near the tank floor will be replaced by waste from above settling to fill the void generated by dissolution and pump out. The mining of waste near the tank floor may or may not produce caverns in the saltcake of sufficient size that a "bridge" collapse will pose a risk of damaging the

tank or the mixing/pumping equipment. In addition to the risks associated with a catastrophic collapse of a saltcake bridge, the mixing system efficiency may be reduced if the waste has sufficient strength to bridge relatively large spans. Additional dome loading caused by waste stalactite formations adhering to existing tank equipment may need to be analyzed during waste removal. Dome deflection surveys will be required at specified intervals throughout the retrieval campaign.

11.6 Project Interfaces

Multiple projects have been identified which may have ongoing work in 241-S and/or 241-SY Farms during the 241-S-102 Waste Retrieval project construction and retrieval operations activities. Some of these projects are currently scheduled for completion prior to the initiation of the 241-S-102 retrieval and are not anticipated to have any impact on the project. These projects have nonetheless been identified as potential interfaces that could occur as a result of unforeseen project delays. The potential projects with interfaces to the 241-S-102 retrieval activities are:

- DST Operations
- Project W-314, Tank Farm Restoration and Safe Operations
- Project W-525, Double Shell Tank Compliance Upgrades
- SST Interim Stabilization Project (saltwell pumping)
- 241-S-112 Saltcake Dissolution Retrieval Demonstration

Construction and operations schedules will require integration to minimize the potential for impacts and adverse programmatic consequences. Resources and utilities availability will also have to be considered. For example, electric power and raw water availability will have to be considered based on concurrent utilization by overlapping projects, if required.

11.7 Limits of Technology Definition

The Fluidic WRS will be operated with a goal of meeting or exceeding the 241-S-102 waste retrieval goal of 99% by volume and 490 curies of long-lived radionuclides. These goals may or may not be satisfied by the project. The retrieval rate and efficiency are likely to decrease exponentially as the waste volume is reduced. A determination on when to terminate retrieval operations will likely be made based on the volume of waste being generated as a function of waste retrieved and the cost of continued operations. As yet undefined tank closure criteria may also play a role in determining the retrieval end point. A definition or procedure should be established at an early stage of project development, based upon the critical factors that must be considered, to define the planned end point for the initial SST retrieval project.

11.8 Retrieval System Performance Characteristics

The pre-conceptual system configuration described in this Preliminary Engineering Report was developed based on a variety of considerations. One of the primary design considerations is the performance expectation associated with the proposed Fluidic WRS. The mixing and pumping capabilities achieved in the tank by this system will determine the actual retrieval schedule and retrieval volume. The predicted values provided within this report are ROM estimates, based on preliminary calculations and the performance of similar systems in similar applications. In addition to the ongoing TFA-sponsored proof-of-concept testing of fluidic mixing and pumping equipment, additional "cold testing" of the proposed design configuration should be performed to refine and/or verify the performance expectations and to identify possible areas for design optimization.

The temperature of the working fluid used for dissolution and mixing should be evaluated to determine any benefits that may be achieved by heating the water. While the dissolution studies conducted to date have focused on total dissolution independent of time, it is likely that pre-heating of the water will accelerate initial dissolution. The cost associated with addition of a water heater should be compared with any potential/anticipated efficiencies gained in the operations schedule to make the final determination of the inclusion or exclusion of a water heater. No heater has been included in the preliminary development based upon the limited data available.

11.9 Leak Detection Performance Capabilities

Predecessor SST retrieval testing and demonstration activities, including work performed for 241-S-112, will be used to confirm the performance expectations for the proposed 241-S-102 LDMM system and to support the design of this system. Information and lessons learned from these predecessor retrieval activities, and other related LDMM work conducted in the out-years, will be directly applied to the development of the final 241-S-102 LDMM strategy and system design. The results of these activities, however, will not be available to the project until later stages of design. The preliminary LDMM strategy and design concept(s) proposed in this document will be updated and refined as necessary throughout the project's life cycle based on the data and lessons learned from other relevant SST retrieval activities.

The LDMM system performance requirements for this project are derived from the RPE. Based on the preliminary draft RPE output, it is anticipated that the performance capabilities of existing leak detection technologies will not meet the minimum performance requirements established for the 241-S-102 retrieval activities. This causes a greater emphasis to be placed on mitigative steps during the retrieval campaign to avoid or minimize a tank leak. Ways to mitigate potential waste leaks include shortening the overall waste retrieval campaign and minimizing the tank liquid inventory during retrieval. Testing activities and design analyses during later design development stages of the project should be performed to further develop a leak mitigation strategy.

11.10 Retrieval Performance Evaluation output

The RPE output for 241-S-102 is not available to support the pre-conceptual design development work. The output of the RPE process will affect the LDMM system development and retrieval strategy.

11.11 Closure

The criteria and procedures for achieving SST closure have not been defined or approved by the stakeholders. It has been assumed for the purposes of this report that closure of 241-S-102 in the regulatory sense is out of scope for the 241-S-102 Waste Retrieval Project. Therefore, the estimated project cost and schedule included in this report do not include any specific resources or activities associated with achieving tank closure. When the regulatory criteria and procedure(s) required for tank closure are eventually defined, an assessment should be performed to determine any impacts to the project's retrieval operation activities, post-retrieval activities, and SSCs included in the design of the waste retrieval system.

11.12 Operations Integration

Integration of 241-S-102 retrieval operations and 241-SY-102 cross-site transfer operations is essential if the 168 day requirement (RPP-7512) for completion of retrieval is to be met. Preparations for the cross-site transfer must be made well in advance including any infrastructure or facility upgrades needed to support this activity. It is assumed that the DST system is responsible for the transfer and associated activities, modifications, and upgrades.

Consideration of using 241-SY-101 in addition to 241-SY-102 should be given to increase the available storage space.

11.13 Manhole Riser Installation

Soil contamination around 241-S-102 resulted from a large surface spill that occurred in 1973 during waste transfer operations. Soil contamination below grade level is indeterminate until actual excavation activities commence. High levels of soil contamination may be encountered during manhole excavations. Other significant sources of uncertainty include the potential presence of undocumented subsurface equipment, the degree of additional risk introduced as a result of doing possible confined space work, determining proper shoring requirements for excavation in this novel situation, and the potential for airborne contamination while excavation and mixer deployment is in process (e.g. the dust kicked up from the contaminated soil).

11.14 Saltwell Screen Removal

The difficulty or effort required to remove the saltwell screen from Riser 13 cannot be ascertained. Saltwell screen removal or disposal has not been attempted in recent history.

It is likely that solids have formed around the screen effectively cementing it into place. The water addition required to dissolve the screen free from the waste cannot be estimated. Typical saltcake tanks do result in a well created around the screen resulting from dissolution by the dilution water addition, pump priming, and back flushing. It is assumed at this preliminary stage that the well in the salt will free the screen and allow for easy removal. This may or may not be the case and the assumption will be difficult to validate short or removing the screen.

12.0 COST ESTIMATE

12.1 Work Breakdown Structure

A preliminary Work Breakdown Structure (WBS) for 241-S-102 Waste Retrieval Project is provided in Appendix A. The WBS provides a deliverable-oriented grouping that organizes and defines the total scope of the initial SST retrieval effort. The WBS identifies the project elements that require resources, thus the WBS is the primary input to the cost estimate. Work not identified in this WBS is considered outside the scope of the project.

12.2 Pre-Conceptual Cost Estimate

A rough order of magnitude (ROM), pre-conceptual cost estimate for the 241-S-102 Waste Retrieval Project has been developed based on the scope of work defined in this report. This cost estimate is organized in accordance with the 241-S-102 Waste Retrieval Project WBS. The estimate is intended to identify the cost of resources required to complete the project activities and establish the planning basis for the out-year costs associated with the project. The discussion below presents the approach used to develop the pre-conceptual cost estimate.

The pre-conceptual ROM cost estimate for the 241-S-102 retrieval effort is presented in Appendix B of this report. Cost estimate detail and supporting information is maintained in the project file. The Total Project Cost for this project is estimated to be $50.3 million.

12.3 Cost Estimating Basis

A pre-conceptual description of the technical scope (i.e., proposed system configuration) and recommended operating strategy for the 241-S-102 Waste Retrieval activities are provided in Section 2.0 of this report. The pre-conceptual cost estimate has been prepared primarily using:

- Similar work from SST Interim Stabilization Project (i.e., saltwell pumping),
- Vendor estimates, and
- Historical factors and percentages from previous projects performed at Hanford.

The approach to estimating costs for the retrieval alternatives is as follows:

- The construction and procurement costs for the retrieval activities are developed from material takeoff from the sketches developed for this report. Vendor quotes, data from similar projects, and Hanford cost database information is used to develop the procurement and construction base costs.

- DOE accepted costs factors are used to develop fully burdened construction and procurement costs.
- Costs for design are developed from factors applied to the construction and procurement costs.
- Operations and startup/turnover costs are taken from previous Hanford experience for developmental systems.

12.4 Escalation

Information regarding escalation was obtained from the following sources:

- U.S. Department of Energy Office of Environmental Management, "Accelerating Cleanup: Paths to Closure," Attachment D. Project Baseline Summary Format and Instructions, dated April 1998.

- U.S. Department of Commerce, "Energy Price Indices and Discount Factors for Life-Cycle Cost Analysis," NISTIR 85-3273-14r, dated April 1999.

- Fluor Hanford Fiscal Year 2001 Multi-Year Work Plan Guidance

An escalation rate as high as 3.0 percent per year is recommended by DOE and Department of Commerce sources. Based on approved Hanford Site Multi-Year Work Planning Guidance for operating and maintenance projects, an annual escalation rate of two percent per year was used.

12.5 Contingency

The definition provided by the DOE *Program and Project Management Manual, Section 3, Practices, Chapter 3.10 TPCE/Contingency/Reserves, July 28, 2000* states that contingency "covers costs that may result from incomplete design, unforeseen and unpredictable conditions, or uncertainties within the defined project scope. The amount of contingency will depend on the status of design, procurement, construction, and the complexity and uncertainties of the component parts of the project. Contingency is not to be used to avoid making an accurate assessment of expected cost."

Many of the factors normally included within the contingency portion of a pre-conceptual estimate have been assigned allowances based on Hanford actual cost accrued on similar projects. These items include allocations for weather delays, equipment failures, spares and inefficiencies associated with the hazardous work environment. With the major contributing sources of contingency dollars accounted for within the estimate, a flat ten percent contingency was applied to all WBS work elements for all alternatives excluding Project Definition. The contingency value(s) and application are as directed by CHG.

12.6 Rounding

The project cost summary report is summarized and adjusted/rounded as follows. The escalated total costs, contingency total costs, and the total dollar costs are adjusted/rounded to the nearest $10,000.

13.0 SCHEDULE

A preliminary life-cycle project schedule has been developed for the 241-S-102 Initial Waste Retrieval Project (Appendix A). The 241-S-102 Waste Retrieval Project schedule requirements, consistent with the TPA M-45 Milestone series, are specified in the Multi-Year Work Plan (MYWP) and summarized in the mission summary diagram. Pre-conceptual planning efforts completed for each of the project activities indicates that the project's TPA schedule requirements, listed in Table 13-1 below, are achievable. As design activities progress, schedule difficulties may arise, but none have been identified at this time that would pose a high risk to achieve the project milestones.

Table 13-1 TPA Milestones

TPA Milestone	Activity	Completion Date
M-45-05-T16	Submit S-102 initial waste retrieval function and requirements document	10/30/2002
M-45-05B	Complete S-102 initial retrieval project design	3/31/2004
M-45-05C	Complete S-102 initial waste retrieval project construction	11/30/2005
M-45-05A	Complete initial waste retrieval from 241-S-102	9/30/2006

13.1 Project Schedule

The project schedule is organized in accordance with the WBS developed for the 241-S-102 Waste Retrieval Project. The project schedule provided in Appendix A of this report identifies the summary-level activities and estimated schedule durations required to develop, construct, and turn the 241-S-102 WRS over to Operations and to produce the deliverables identified within this PER. All Critical Decisions are also identified on the schedule. Normal work weeks are assumed except for retrieval operations which were assumed to be an around the clock schedule.

13.2 Operation Schedule

An estimated retrieval operations schedule for 241-S-102 is included in the project schedule provided in Appendix A. This schedule is based on the preferred retrieval system configuration and operating strategy as discussed in this report. The operations schedule duration identified in the schedule includes consideration of the following:

- Baseline measurements including integrity verification,
- Initial waste volume estimate,
- Final waste volume estimate,
- Installation of mixing pumps in preparation for Phase II Operations

- Readiness Evaluation for Phase II Operations
- Post-retrieval sampling and analysis,
- Tank isolation, and
- Retrieval activities including:
  - Mixing cycle durations (as a function of waste volume),
  - Pumping cycle durations (as function of waste volume),
  - Line flushing and water introductions,
  - Preventative maintenance activities, and
  - Suspension for the performance of material balance measurements.
  - Transfer of waste from the receiving tank, 241-SY-102, to provide space for the secondary waste generation.

13.3 Constraints / Uncertainties

The greatest uncertainty in the 241-S-102 waste retrieval schedule is in the retrieval operations. Integration of retrieval operations, Phase II equipment installation and cross-site transfer operations is the primary vulnerability. Pre-planning for immediate initiation of cross-site transfer of waste from 241-SY-102 following Phase I Operations is crucial to successfully execute this portion of the schedule. The other major uncertainty is the level of effort that will be required during Phase I construction to excavate the manholes and pull the saltwell screen.

14.0 REFERENCES

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H-2-73182
H-2-46524
H-2-1774
H-2-1783
H-2-1794
H-2-1814
H-2-69757
H-2-46202
H-14-100919

TANK S-102 WASTE RETRIEVAL

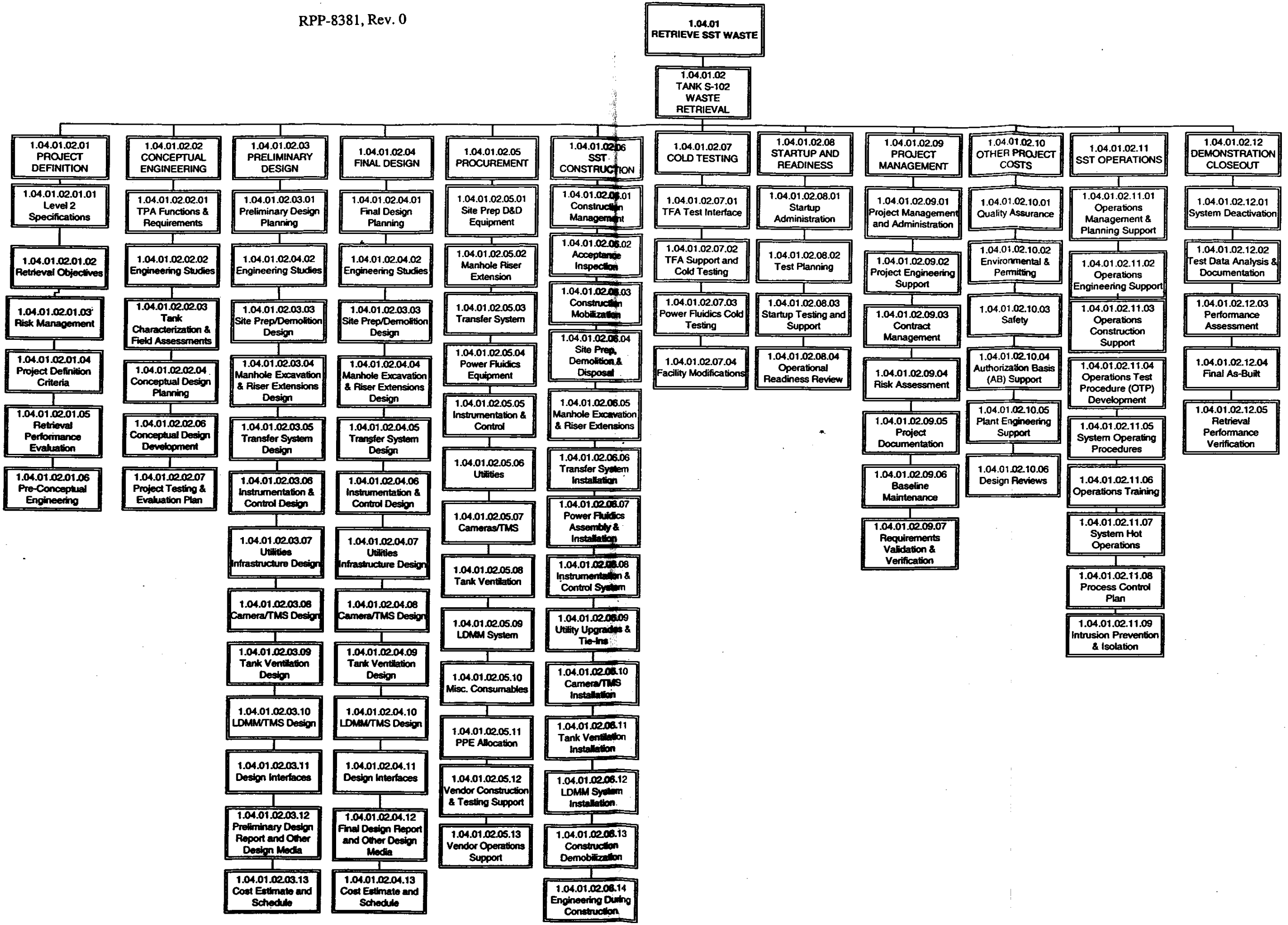
WBS	TITLE
1.04.01	**RETRIEVE SST WASTE**
1.04.01.02	**TANK S-102 WASTE RETRIEVAL**
1.04.01.02.01	**PROJECT DEFINITION**
1.04.01.02.01.01	Level 2 Specifications
1.04.01.02.01.02	Retrieval Objectives
1.04.01.02.01.03	Risk Management
1.04.01.02.01.04	Project Definition Criteria
1.04.01.02.01.05	Retrieval Performance Evaluation
1.04.01.02.01.06	Pre-Conceptual Engineering
1.04.01.02.02	**CONCEPTUAL ENGINEERING**
1.04.01.02.02.01	TPA Functions & Requirements
1.04.01.02.02.02	Engineering Studies
1.04.01.02.02.03	Tank Characterization & Field Assessments
1.04.01.02.02.04	Conceptual Design Planning
1.04.01.02.02.05	Conceptual Design Development
1.04.01.02.02.06	Project Testing & Evaluation Plan
1.04.01.02.03	**PRELIMINARY DESIGN**
1.04.01.02.03.01	Preliminary Design Planning
1.04.01.02.03.02	Engineering Studies
1.04.01.02.03.03	Site Prep/Demolition Design
1.04.01.02.03.04	Manhole Excavation & Riser Extensions Design
1.04.01.02.03.05	Transfer System Design
1.04.01.02.03.06	Instrumentation & Control Design
1.04.01.02.03.07	Utilities Infrastructure Design
1.04.01.02.03.08	Camera/TMS Design
1.04.01.02.03.09	Tank Ventilation Design
1.04.01.02.03.10	LDMM/TMS Design
1.04.01.02.03.11	Design Interfaces
1.04.01.02.03.12	Preliminary Design Report and Other Design Media
1.04.01.02.03.13	Cost Estimate and Schedule
1.04.01.02.04	**FINAL DESIGN**
1.04.01.02.04.01	Final Design Planning
1.04.01.02.04.02	Engineering Studies
1.04.01.02.04.03	Site Prep/Demolition Design
1.04.01.02.04.04	Manhole Excavation & Riser Extensions Design
1.04.01.02.04.05	Transfer System Design
1.04.01.02.04.06	Instrumentation & Control Design
1.04.01.02.04.07	Utilities Infrastructure Design
1.04.01.02.04.08	Camera/TMS Design
1.04.01.02.04.09	Tank Ventilation Design
1.04.01.02.04.10	LDMM/TMS Design
1.04.01.02.04.11	Design Interfaces
1.04.01.02.04.12	Final Design Report and Other Design Media
1.04.01.02.04.13	Cost Estimate and Schedule

TANK S-102 WASTE RETRIEVAL

WBS	TITLE
1.04.01.02.05	**PROCUREMENT**
1.04.01.02.05.01	Site Prep, Demolition & Disposal
1.04.01.02.05.02	Manhole Riser Extension
1.04.01.02.05.03	Transfer System
1.04.01.02.05.04	Power Fluidics Equipment
1.04.01.02.05.05	Instrumentation & Control
1.04.01.02.05.06	Utilities
1.04.01.02.05.07	Cameras/TMS
1.04.01.02.05.08	Tank Ventilation
1.04.01.02.05.09	LDMM System
1.04.01.02.05.10	Misc. Consumables
1.04.01.02.05.11	PPE
1.04.01.02.05.12	Vendor Construction & Testing Support
1.04.01.02.05.13	Vendor Operations Support
1.04.01.02.06	**SST CONSTRUCTION**
1.04.01.02.06.01	Construction Management
1.04.01.02.06.02	Acceptance Inspection
1.04.01.02.06.03	Construction Mobilization
1.04.01.02.06.04	Site Prep, Demolition & Disposal
1.04.01.02.06.05	Manhole Excavation & Riser Extensions
1.04.01.02.06.06	Transfer System Installation
1.04.01.02.06.07	Power Fluidics Assembly & Installation
1.04.01.02.06.08	Instrumentation & Control System
1.04.01.02.06.09	Utility Upgrades & Tie-Ins
1.04.01.02.06.10	Camera/TMS Installation
1.04.01.02.06.11	Tank Ventilation Installation
1.04.01.02.06.12	LDMM System Installation
1.04.01.02.06.13	Construction Demobilization
1.04.01.02.06.14	Engineering During Construction
1.04.01.02.07	**COLD TESTING**
1.04.01.02.07.01	TFA Test Interface
1.04.01.02.07.02	TFA Support and Cold Testing
1.04.01.02.07.03	Power Fluidics Cold Testing
1.04.01.02.07.04	Facility Modifications
1.04.01.02.08	**STARTUP AND READINESS**
1.04.01.02.08.01	Startup Administration
1.04.01.02.08.02	Test Planning
1.04.01.02.08.03	Startup Testing and Support
1.04.01.02.08.04	Operational Readiness Review

TANK S-102 WASTE RETRIEVAL

WBS	TITLE
1.04.01.02.09	**PROJECT MANAGEMENT**
1.04.01.02.09.01	Project Management and Administration
1.04.01.02.09.02	Project Engineering Support
1.04.01.02.09.03	Contract management
1.04.01.02.09.04	Risk Assessment
1.04.01.02.09.05	Project Documentation
1.04.01.02.09.06	Baseline Maintenance
1.04.01.02.09.07	Requirements Validation and Verification
1.04.01.02.10	**OTHER PROJECT COSTS**
1.04.01.02.10.01	Quality Assurance
1.04.01.02.10.02	Environmental and Permitting
1.04.01.02.10.03	Safety
1.04.01.02.10.04	Authorization Basis (AB) Support
1.04.01.02.10.05	Plant Engineering Support
1.04.01.02.10.06	Design Reviews
1.04.01.02.11	**SST OPERATIONS**
1.04.01.02.11.01	Operations Management and Planning Support
1.04.01.02.11.02	Operations Engineering Support
1.04.01.02.11.03	Operations Construction Support
1.04.01.02.11.04	Operations Test Procedure (OTP) Development
1.04.01.02.11.05	System Operating Procedures
1.04.01.02.11.06	Operations Training
1.04.01.02.11.07	System Hot Operations
1.04.01.02.11.08	Process Control Plan
1.04.01.02.11.09	Intrusion Prevention & Isolation
1.04.01.02.12	**DEMONSTRATION CLOSEOUT**
1.04.01.02.12.01	System Deactivation
1.04.01.02.12.02	Test Data Analysis and Documentation
1.04.01.02.12.03	Performance Assessment
1.04.01.02.12.04	Final As-Built
1.04.01.02.12.05	Retrieval Performance Verification


1.04.01 RETRIEVE SST WASTE
1.04.01.02 TANK S-102 WASTE RETRIEVAL
1.04.01.02.01 PROJECT DEFINITION
1.04.01.02.01.01 Level 2 Specifications
1.04.01.02.01.02 Retrieval Objectives
1.04.01.02.01.03 Risk Management
1.04.01.02.01.04 Project Definition Criteria
1.04.01.02.01.05 Retrieval Performance Evaluation
1.04.01.02.01.06 Pre-Conceptual Engineering
1.04.01.02.02 CONCEPTUAL ENGINEERING
1.04.01.02.02.01 TPA Functions & Requirements
1.04.01.02.02.02 Engineering Studies
1.04.01.02.02.03 Tank Characterization & Field Assessments
1.04.01.02.02.04 Conceptual Design Planning
1.04.01.02.02.06 Conceptual Design Development
1.04.01.02.02.07 Project Testing & Evaluation Plan
1.04.01.02.03 PRELIMINARY DESIGN
1.04.01.02.03.01 Preliminary Design Planning
1.04.01.02.04.02 Engineering Studies
1.04.01.02.03.03 Site Prep/Demolition Design
1.04.01.02.03.04 Manhole Excavation & Riser Extensions Design
1.04.01.02.03.05 Transfer System Design
1.04.01.02.03.06 Instrumentation & Control Design
1.04.01.02.03.07 Utilities Infrastructure Design
1.04.01.02.03.08 Camera/TMS Design
1.04.01.02.03.09 Tank Ventilation Design
1.04.01.02.03.10 LDMM/TMS Design
1.04.01.02.03.11 Design Interfaces
1.04.01.02.03.12 Preliminary Design Report and Other Design Media
1.04.01.02.03.13 Cost Estimate and Schedule
1.04.01.02.04 FINAL DESIGN
1.04.01.02.04.01 Final Design Planning
1.04.01.02.04.02 Engineering Studies
1.04.01.02.03.03 Site Prep/Demolition Design
1.04.01.02.04.04 Manhole Excavation & Riser Extensions Design
1.04.01.02.04.05 Transfer System Design
1.04.01.02.04.06 Instrumentation & Control Design
1.04.01.02.04.07 Utilities Infrastructure Design
1.04.01.02.04.08 Camera/TMS Design
1.04.01.02.04.09 Tank Ventilation Design
1.04.01.02.04.10 LDMM/TMS Design
1.04.01.02.04.11 Design Interfaces
1.04.01.02.04.12 Final Design Report and Other Design Media
1.04.01.02.04.13 Cost Estimate and Schedule
1.04.01.02.05 PROCUREMENT
1.04.01.02.05.01 Site Prep D&D Equipment
1.04.01.02.05.02 Manhole Riser Extension
1.04.01.02.05.03 Transfer System
1.04.01.02.05.04 Power Fluidics Equipment
1.04.01.02.05.05 Instrumentation & Control
1.04.01.02.05.06 Utilities
1.04.01.02.05.07 Cameras/TMS
1.04.01.02.05.08 Tank Ventilation
1.04.01.02.05.09 LDMM System
1.04.01.02.05.10 Misc. Consumables
1.04.01.02.05.11 PPE Allocation
1.04.01.02.05.12 Vendor Construction & Testing Support
1.04.01.02.05.13 Vendor Operations Support
1.04.01.02.06 SST CONSTRUCTION
1.04.01.02.06.01 Construction Management
1.04.01.02.06.02 Acceptance Inspection
1.04.01.02.06.03 Construction Mobilization
1.04.01.02.06.04 Site Prep, Demolition & Disposal
1.04.01.02.06.05 Manhole Excavation & Riser Extensions
1.04.01.02.06.06 Transfer System Installation
1.04.01.02.06.07 Power Fluidics Assembly & Installation
1.04.01.02.06.08 Instrumentation & Control System
1.04.01.02.06.09 Utility Upgrades & Tie-Ins
1.04.01.02.06.10 Camera/TMS Installation
1.04.01.02.06.11 Tank Ventilation Installation
1.04.01.02.06.12 LDMM System Installation
1.04.01.02.06.13 Construction Demobilization
1.04.01.02.06.14 Engineering During Construction
1.04.01.02.07 COLD TESTING
1.04.01.02.07.01 TFA Test Interface
1.04.01.02.07.02 TFA Support and Cold Testing
1.04.01.02.07.03 Power Fluidics Cold Testing
1.04.01.02.07.04 Facility Modifications
1.04.01.02.08 STARTUP AND READINESS
1.04.01.02.08.01 Startup Administration
1.04.01.02.08.02 Test Planning
1.04.01.02.08.03 Startup Testing and Support
1.04.01.02.08.04 Operational Readiness Review
1.04.01.02.09 PROJECT MANAGEMENT
1.04.01.02.09.01 Project Management and Administration
1.04.01.02.09.02 Project Engineering Support
1.04.01.02.09.03 Contract Management
1.04.01.02.09.04 Risk Assessment
1.04.01.02.09.05 Project Documentation
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1.04.01.02.11.04 Operations Test Procedure (OTP) Development
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1.04.01.02.11.07 System Hot Operations
1.04.01.02.11.08 Process Control Plan
1.04.01.02.11.09 Intrusion Prevention & Isolation
1.04.01.02.12 DEMONSTRATION CLOSEOUT
1.04.01.02.12.01 System Deactivation
1.04.01.02.12.02 Test Data Analysis & Documentation
1.04.01.02.12.03 Performance Assessment
1.04.01.02.12.04 Final As-Built
1.04.01.02.12.05 Retrieval Performance Verification

Appendix B

Cost Estimate

S-102 POWER FLUIDIC MIXING STUDY COST SUMMARY REPORT
BY WBS

WBS	WBS DESCRIPTION	ESCALATED TOTAL COST	CONTINGENCY %	CONTINGENCY TOTAL	GRAND TOTAL
.01.02.01	PROJECT DEFINITION	1,760,000	0%	-	1,760,000
.01.02.02	CONCEPTUAL ENGINEERING	1,720,000	10%	172,200	1,890,000
.01.02.03	PRELIMINARY DESIGN	2,150,000	10%	215,200	2,370,000
.01.02.04	FINAL DESIGN	3,110,000	10%	311,100	3,420,000
.01.02.05	PROCUREMENT	11,620,000	10%	1,162,400	12,780,000
.01.02.06	SST CONSTRUCTION	12,540,000	10%	1,253,600	13,790,000
.01.02.07	COLD TESTING	1,120,000	10%	112,400	1,230,000
.01.02.08	STARTUP AND READINESS	1,370,000	10%	137,000	1,510,000
.01.02.09	PROJECT MANAGEMENT	2,410,000	10%	241,300	2,650,000
.01.02.10	OTHER PROJECT COSTS	2,060,000	10%	206,400	2,270,000
.01.02.11	SST OPERATIONS	4,290,000	10%	428,900	4,720,000
.01.02.12	DEMONSTRATION CLOSEOUT	1,660,000	10%	166,300	1,830,000
	TOTAL PROJECT COST (TPC)	45,810,000	10%	4,406,800	50,220,000

REMARKS:

The escalated total costs, and the total project costs are adjusted/rounded to the nearest $10,000.

Hanford site allocations are included in the escalated total cost column.

TYPE OF ESTIMATE: Study

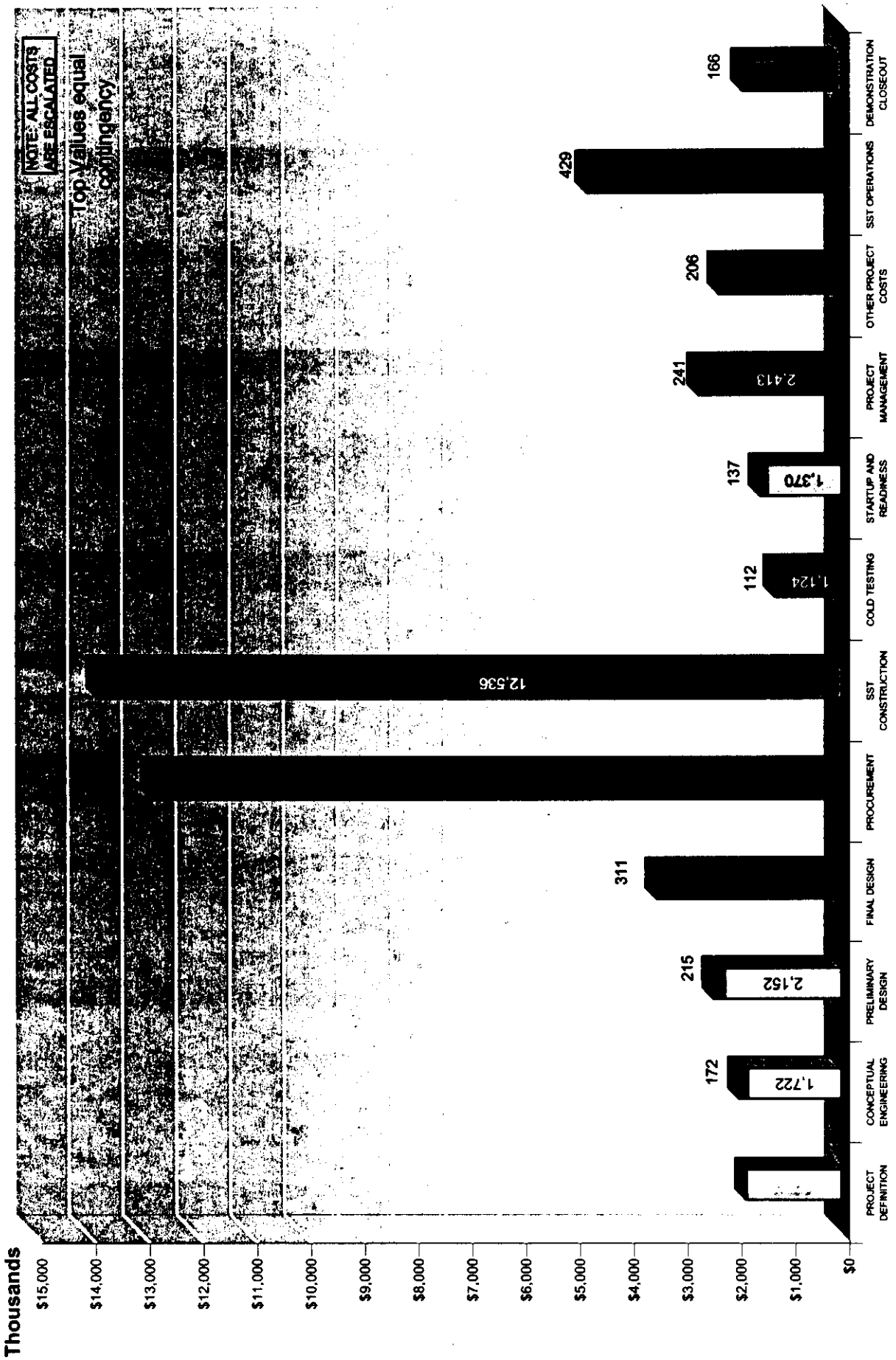
JULY 30, 2001

HND TEAM LEAD ESTIMATOR:

HND TEAM PROJECT MANAGER:

CHG:

S-102 POWER FLUIDIC MIXING STUDY ESTIMATE SUMMARY



Appendix C

Calculations

HNDTEAM

CALCULATION COVER SHEET

Date: 6/28/01

Calculation No: 4412.091.ECAL.001
Calculation Title: Electrical Power Calculations for 241-S-102 Salt Cake Dissolution
Project No. & Title: 4412-091, S-102 Preliminary Engineering Report

ORIGINAL AND REVISED CALCULATION/ANALYSIS APPROVAL

	Rev. A Name/Signature/Date	Rev. _____ Name/Signature/Date	Rev. _____ Name/Signature/Date
Originator:	B. Hickman 6/28/01 D. Rahming Dim Rahmg 6/28/01		
Checked By:	Steve Romero SG Romero 6/28/01		
Approved By:			
Other:			

AFFECTED DOCUMENTS

Document Number	Document Title	Rev. Number

RECORD OF REVISION

Rev.	*Reason for Revision*
A	Preliminary Issue

Attachment A (1 Sheet)

DESIGN CALCULATION SHEET

Calculation No. 4412.091.ECAL.001 Rev. No. 0A 8/2-2-01	Performed By: B. Hickman\D. Rahming Date: 6/28/2001 BH/ DR
Calculation Title: Electrical Power Calculations for 241-S-102 Salt Cake Dissolution	Checked By: Steve Romero Date: 6/28/2001 SM

INTRODUCTION

Purpose The purpose of this calculation is to verify that there is adequate existing capacity to supply power for all loads needed for the waste retrieval of 241-S-102

Scope The scope of this calculation is to estimate the 480 VAC and 120 VAC power requirements for the 241-S-102 Salt Cake Dissolution system based on current project drawings.

DESIGN BASIS

Design Inputs The design inputs for this calculations are:

1. Project 4412.091 P&ID, Dwg. 002.
2. 241-S Electrical One-Line Diagram, H-14-030033 Sheets 1-23.
3. Conversations with Eric Clements, AEA Technology.
4. Email from AEA Technology – 4412.91-CS-005

Criteria The design must meet the National Electrical Code (NEC) and accepted Hanford practices.

Assumptions

1. Due to the short duration of the retrieval, the two 200 HP air compressors will receive power from a portable electrical generator. Note that only one air compressor will be operated at a time while the other acts as a spare.
2. According to the vendor of the retrieval equipment (AEA Technology), the total estimated electrical power requirement for the vendor-supplied equipment (other than the air compressors) is 39kW at 480 VAC. This currently includes the valve skid (120 VAC) and the off-gas skid (480 VAC). For purposes of planning, it will be assumed that power for the Salt Cake Dissolution retrieval system will come from a single 480 VAC circuit from an existing source.
3. The estimated size of the booster pump is 20 HP at 480 VAC.
4. A 400-foot hose-in-hose transfer line from 241-S-102 will require heat tracing at 10 W per foot at 120 VAC.
5. Since the majority of the expected load is inductive in nature, a conservative power factor of 0.80 will be assumed.

REFERENCES

1. National Electrical Code, NFPA 70. 1999.

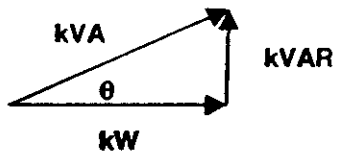
DESIGN CALCULATION SHEET

Calculation No. 4412.091.ECAL.001 Rev. No. 0A AJ 7-2-01	Performed By: B. Hickman\D. Rahming Date: 6/28/2001 BH DR
Calculation Title: Electrical Power Calculations for 241-S-102 Salt Cake Dissolution	Checked By: Steve Romero Date: 6/28/2001 SJR

METHODS

Total Power, Real Power, and Power Factor:

The method of finding total power (kVA) from "real" power (kW) is accomplished by using vector addition as shown in the following diagram:



kVA = kW ÷ Cos(θ)
where: Cos(θ) = power factor

RESULTS AND CONCLUSIONS

The 241-S-102 loads are comprised of a vendor-supplied skid and the 241-S-102 Salt Cake Dissolution System tank loads, which includes a booster pump and a new 10 kVA Mini Power Zone for the new 120V loads. The feeder breakers and main breakers found on Panelboard D in building 242-S is sufficiently size to handle the equipment and loads. Redundant 200 hp air compressors for this system will receive power from a 150 KW portable generator.

CALCULATION ANALYSIS

Loads Estimate: (see Methods section)

New Vendor Skid:

The vendor supply skid package is comprised of an Off-gas system and valve skid. This combination is estimated to draw 39kW at 480 VAC. Assuming a conservative power factor of 0.80:

$$kVA = \frac{39\ kW}{0.80} = 48.75\ kVA$$

Feeder Breaker Sizing for Vendor Skid:

To determine if the breaker size for the new valve skid and off-gas skid is adequate, the following calculation is done:

$$(48.75kVA \times 1000VA/kVA) \div (480V \times \sqrt{3}) = 58.6\ A$$

There is an existing 70-amp breaker on Power Panelboard D that will be the feeder breaker for the vendor skid (see Attachment A). Since this project is in the preliminary phase and the tendency for electrical growth and expansion during definitive design is common, good engineering indicates contingency planning at this stage. If a contingency factor of 15% - 20% is used, it can be seen that the amperage requirement very nearly approaches 70A. The 70 A, 480V feeder will therefore be left in place.

COMMENTS ON DESIGN CALCULATION SHEET FOR PROJECT 4412.091. CALCULATION NO.3312.091.ECAL.001.

PAGE 3 OF 5:
It is an NEC violation to apply a 58.6 amp load to a 70 amp breaker (See NEC Art. 210-20). The NEC only allows you to load the breaker to 80% (unless 100% rated and these are not) of it's trip rating.

70 x .80 = 56 amp < 58.6 amp shown

PAGE 5 OF 5:

Added Load:	Skid	58.6 a
	Pump	27 a
	MPZ	20.8 a
	Total	106.4 a

This load is unacceptable on the 252-S Substation which feeds Panelboard D. At present Bus #2 of 252-S is overloaded and can't accept this increase. In order to add new load to 252-S new transformers must be installed (the 500 KVA's must be upgraded to 1500 KVA's).

NOTE: It has been recommended that this project obtain it's electrical power from a service located on the west side of the 241-S tank farm.

J Roberts
review

DESIGN CALCULATION SHEET

Calculation No. 4412.091.ECAL.001 Rev. No. 0A	Performed By: B. Hickman\D. Rahming Date: 6/28/2001
Calculation Title: Electrical Power Calculations for 241-S-102 Salt Cake Dissolution	Checked By: Steve Romero Date: 6/28/2001

Booster Pump

The booster pump is estimated to be 20 HP at 480 VAC. Assuming a conservative power factor of 0.80, and using NEC Table 430-150 for the estimated current:

$$kVA = \frac{480V \times 27A \times \sqrt{3}}{0.80 \times 1000W/kW} = 28.06\ kVA$$

Feeder Breaker Sizing for Booster Pump:

A 20 hp motor from the NEC handbook will run full load at approximately 27 amps.
There is an existing 70-amp breaker on Power Panelboard D circuit number D9 that will be the feeder breaker for the booster pump (see attachment A).

New 120 VAC Load Estimate:

Heat tracing for the hose-in-hose transfer line will be approximately 400 feet long at 10 W per foot. Assuming unity power factor:

$$kVA = \frac{10W/ft \times 400\ ft}{1 \times 1000W/kW} = 4.00\ kVA$$

In the absence of more definite information, the 120VAC loads (solenoid valves, heat tracing, etc.) can be estimated from the P&ID:

Assume that all transfer valves and heat tracing are operating:

$$[(5\ valves \times 2\ A \times 120\ V) + 4000VA\ (heat\ tracing)] \times 1kVA/1000VA = 5.2\ kVA$$

Thus, a 10 kVA Mini Power-Zone will be adequate to supply the required 120 VAC power, including miscellaneous instrumentation for this project.

New Feeder Breaker Sizing for 10 kVA Mini Power Zone:

To determine if the breaker size for the new 1ϕ Mini Power Zone is adequate, the following calculation is done:

$$(10\ kVA \times 1000VA/kVA) \div (480V) = 20.83A$$

Therefore the existing 50A breaker located on circuit D10 is sufficient for the 10 kVA Mini Power Zone.

DESIGN CALCULATION SHEET

Calculation No. 4412.091.ECAL.001 Rev. No. 0A BJ 7-2-01	Performed By: B. Hickman\D. Rahming Date: 6/28/2001 BJH DR
Calculation Title: Electrical Power Calculations for 241-S-102 Salt Cake Dissolution	Checked By: Steve Romero SJR Date: 6/28/2001

Total Connected loads on Power Panelboard D, including existing loads marked with an asterisk.

EQUIPMENT	kVA/hp	Ampere
*Exhauster	1.5 hp	3.00A
*Mini Power Zone	--	15.00A
New Vendor Skid	48.75 kVA	58.60 A
*Vacuum Pump	3/4 hp	1.6 A
*Vacuum Pump	5 hp	7.6 A
*Seal water pump	.5 hp	1.1A
*Mini Power Zone (Panel Board C)	7.5 kVA	15 A
New Booster Pump	20 hp	27 A
New Mini Power Zone	10 kVA	20.83 A
Total Demand Load		**149.73A**

Therefore the main protection feeder breaker of 400A is more than adequate to handle the loads for this project.

Generator sizing:

The generator will be used solely to provide power to the air compressors needed for this project.

For a 200 hp motor (from the NEC handbook) the full load amps are given as 240A.

[480 V x 240A x .8 x 1.73] / 1000 = 159 KW

Therefore a 160 KW generator will be adequate for supplying power to the compressors.

HNDTEAM

CALCULATION COVER SHEET

Date: 4/10/01

Calculation No: 4412.091.MCAL.001
Calculation Title: Line Pressure Drop, SST – AEAT Fluidic Pumping
Project No. & Title: 4412-091, S-102 Preliminary Engineering Report

ORIGINAL AND REVISED CALCULATION/ANALYSIS APPROVAL

	Rev. A Name/Signature/Date	Rev. B Name/Signature/Date	Rev. _____ Name/Signature/Date
Originator:	Shawn Hailey	Shawn L. Hailey 8/1/01 Shawn Hailey	
Checked By:	Brian Sullivan	John Elsen 8/1/01 John Elsen	
Approved By:			
Other:			

AFFECTED DOCUMENTS

Document Number	Document Title	Rev. Number

RECORD OF REVISION

Rev.	*Reason for Revision*
A	Preliminary issue.
B	Additional clarification added.

HNDTeam

DESIGN CALCULATION SHEET

Design Calculation Title:
Line Pressure Drop,
SST-AEAT Fluidic Pumping
Project No. & Title:
4412-091, S-102 Preliminary
Engineering Report

Orig: S. Hailey SLH 8/1/01
Date: 8/1/2001 (Rev. B)
Date: 4/10/2001 (Rev. A)
Checker: J. Elsen JE 8/1/01
Date: 8/1/2001 (Rev. B)
Checker: B. Sullivan
Date: 6/28/2001 (Rev. A)

INTRODUCTION

Purpose — The purpose of this calculation is determining the pressure drop at a given flow, and a flow based on a pre-determined pressure.

Scope — The scope of this calculation consists of an evaluation to determine the line pressure drop or flow rate, considering the following conditions: 1) 140gpm flow, which provides a minimum velocity of 6 fps in the line, and 2) flow for a 200 psi maximum pressure drop.

DESIGN BASIS

Design Inputs — Design input information provided by the References listed below.

Criteria — Criteria as noted in calculation.

Assumptions — Assumptions as follows:

1. Slurry specific gravity, SG = 1.4
2. Desired minimum flow velocity = 6ft/s
3. Slurry viscosity = 30 centipoise
4. Maximum desired pipe pressure, 200 psi

REFERENCES

1. Flow of Fluids, Technical Paper 410, Crane
2. MICROFLEX, Inc. - Proprietory data for flow pressure drop in hoses manufactured by Microflex.
3. Hanfod Site Documents:
   a. Drawing H-2-73182
   b. Drawing H-2-37381
   c. Drawing H-2-37525
   d. Drawing H-2-37778
   e. Drawing H-2-37782
   f. Drawing H-2-37783
   g. S_SXFARM.DWG
   h. Drawing H-14-104150
   i. ECN 663013
   j. Drawing H-2-822293
   k. Drawing H-14-104028
   l. Drawing H-2-46523
   m. Drawing H-2-46524
   n. Drawing H-2-92059
   o. Drawing H-2-37805
   p. Drawing H-2-37771
   q. Drawing H-2-92089
   r. Drawing H-2-37785
4. Engineering Fluid Mechanics, Roberson/Crowe, Fifth Edition

METHODS — Hand Calculation

RESULTS AND CONCLUSION — The pressure drop from top of tank to top of tank, considering a flow of 140 gpm is 204 psi, not including pressure losses occurring inside the tank.

Based on a pressure of 200 psi, the resulting flow will be 139 gpm at a minimum line velocity of 6.0 fps (reference points top of tank to top of tank).

HNDTeam

DESIGN CALCULATION SHEET

Design Calculation Title:
Line Pressure Drop,
SST-AEAT Fluidic Pumping
Project No. & Title:
4412-091, S-102 Preliminary
Engineering Report

Calc #: 4412.091.MCAL.001
Rev.: B
Page: 3 of 9

Orig: S. Hailey SH 8/1/01
Date: 8/1/2001 (Rev. B)
Date: 4/10/2001 (Rev. A)
Checker: J. Elsen JE 8/1/01
Date: 8/1/2001 (Rev. B)
Checker: B. Sullivan
Date: 6/28/2001 (Rev. A)

DESIGN/ANALYSIS:

Find the equivalent length of 2" diameter schedule 40 pipe:

$E_{Length1}$ = 2" diameter, 3' sweep, 90 degree radius (Equivalent length, feet of Schedule 40 pipe)
$E_{Length2}$ = 2" diameter, 3' sweep, 45 degree radius (Equivalent length, feet of Schedule 40 pipe)
$E_{Length3}$ = 2" diameter long radius elbow (Equivalent length, feet of Schedule 40 pipe)
$E_{Length4}$ = 2" PUREX connector (Equivalent length, feet of Schedule 40 pipe)
$E_{Length5}$ = 2" diameter flex hose (Equivalent length, feet of Schedule 40 pipe)
$E_{Length6}$ = 2" pipe (Equivalent length, feet of Schedule 40 pipe)
N_1 = Number of 2" diameter, 3' sweep, 90 degree radius
N_2 = Number 2" diameter, 3' sweep, 45 degree radius
N_3 = Number 2" diameter long radius elbow
N_4 = Number 2" PUREX connector
N_5 = Number of increments of 1 foot length of 2" diameter flex hose
N_6 = Number of increments of 1 foot length of 2" diameter pipe

$E_{Length1} := 8ft$ Reference 1 (A-30)

$E_{Length2} := 4ft$ Reference 1 (A-30)

$E_{Length3} := 2.4ft$ Reference 1 (A-30)

$E_{Length4} := 11ft$ Reference 1 (A-30), 4 (Table 10.2)

$E_{Length5} := 4.90ft$ See equivalent length of 2" schedule 40 pipe for 2" flex pipe

$E_{Length6} := 1ft$

$N_1 := 4$ Reference 3

$N_2 := 2$ Reference 3

$N_3 := 4$ Reference 3

$N_4 := 8$ Reference 3

$N_5 := 44$ Reference 3

$N_6 := 195$ Reference 3

Total equivalent length of 2" diameter pipe = E_{Length}*N

$$E_{Total2InchPipe} := E_{Length1} \cdot N_1 + E_{Length2} \cdot N_2 + E_{Length3} \cdot N_3 + E_{Length4} \cdot N_4 + E_{Length5} \cdot N_5 + E_{Length6} \cdot N_6$$

$$E_{Total2InchPipe} = 548.2\,ft$$

Find the equivalent length of 3" diameter schedule 40 pipe:

$E_{Length7}$ = 3" diameter, 3' sweep, 90 degree radius (Equivalent length, feet of Schedule 40 pipe)
$E_{Length8}$ = 3" PUREX connector (Equivalent length, feet of Schedule 40 pipe)
$E_{Length9}$ = 3" pipe (Equivalent length, feet of Schedule 40 pipe)
N_7 = Number of 3" diameter, 3' sweep, 90 degree radius
N_8 = Number 3" PUREX connector
N_9 = Number of increments of 1 foot length of 3" diameter pipe

$E_{Length7} := 9.2ft$ Reference 1 (A-30)

$E_{Length8} := 17ft$ Reference 1 (A-30), 4 (Table 10.2)

$E_{Length9} := 1ft$

$N_7 := 10$ Reference 3

$N_8 := 2$ Reference 3

$N_9 := 470$ Reference 3

Total equivalent length of 3" diameter pipe = E_{Length}*N

$E_{Total3InchPipe} := E_{Length7} \cdot N_7 + E_{Length8} \cdot N_8 + E_{Length9} \cdot N_9$

$E_{Total3InchPipe} = 596\,ft$

$L_{2Inch} := E_{Total2InchPipe}$

$L_{2Inch} = 548.2\,ft$

$d_{2Inch} := 2.067in$ Inside diamter of pipe (2" schedule 40)

$A_{2Inch} := \pi \cdot \frac{d_{2Inch}^2}{4}$ $g = 32.174 \frac{ft}{sec^2}$

$A_{2Inch} = 3.356\,in^2$ $cP \equiv 6.7197 \cdot 10^{-4} \cdot \frac{lb}{ft \cdot sec}$

Mass density of water

$\rho_{Water} := 62.4 \frac{lb}{ft^3}$ $SpG := 1.41$ Specific gravity of waste

Weight density of water

$\gamma_{Water} := \rho_{Water} \cdot g$ $\gamma_{Water} = 62.4 \frac{lbf}{ft^3}$ $\mu := 30cP$

Flow rate

$Q := 140 \frac{gal}{min}$

Velocity of fluid in 2" diameter pipe

$V_{2InchPipe} := \frac{Q}{A_{2Inch}}$

$V_{2InchPipe} = 13.386 \frac{ft}{s}$

Reynold's number

$$Re_{2InchPipe} := d_{2Inch} \cdot V_{2InchPipe} \cdot \frac{\rho_{Water} \cdot SpG}{\mu}$$

Roughness of pipe

$$\varepsilon_{2Inch} := .0005 \cdot d_{2Inch}$$ Reference 1

$Re_{2InchPipe} = 1.006 \times 10^4$ Strictly valid for: $3 \cdot 10^3 \le Re \le 10^8$

Friction factor

$$f_{2Inch} := \left[-2 \cdot \log\left[\left[\frac{\left(\frac{\varepsilon_{2Inch}}{d_{2Inch}}\right)}{3.7} \right] - \left(\frac{5.02}{Re_{2InchPipe}} \right) \cdot \log\left[\left[\frac{\left(\frac{\varepsilon_{2Inch}}{d_{2Inch}}\right)}{3.7} \right] + \left(\frac{14.5}{Re_{2InchPipe}} \right) \right] \right] \right]^{-2}$$

$f_{2Inch} = 0.032$

Head loss

$$\Delta h_{L2InchPipe} := \frac{L_{2Inch}}{d_{2Inch}} \cdot f_{2Inch} \cdot \frac{V_{2InchPipe}^2}{2 \cdot g}$$

$\Delta h_{L2InchPipe} = 279.692$ ft

Pressure Loss

$$\Delta p_{2InchPipe} := \Delta h_{L2InchPipe} \cdot \gamma_{Water} \cdot SpG$$

[redacted]

$$L_{3Inch} := E_{Total3InchPipe}$$

$L_{3Inch} = 596$ ft

HNDTeam

DESIGN CALCULATION SHEET

Design Calculation Title:
Line Pressure Drop,
SST-AEAT Fluidic Pumping
Project No. & Title:
4412-091, S-102 Preliminary
Engineering Report

Calc #: 4412.091.MCAL.001
Rev.: B
Page: 7 of 9

Orig: S. Hailey SLH 8/1/01
Date: 8/1/2001 (Rev. B)
Date: 4/10/2001 (Rev. A)
Checker: J. Elsen JE 8/1/01
Date: 8/1/2001 (Rev. B)
Checker: B. Sullivan
Date: 6/28/2001 (Rev. A)

$d_{3Inch} := 3.068in$ Inside diamter of pipe (3" schedule 40)

$A_{3Inch} := \pi \cdot \frac{d_{3Inch}^2}{4}$ $g = 32.174 \frac{ft}{sec^2}$

$A_{3Inch} = 7.393 in^2$ $cP \equiv 6.7197 \cdot 10^{-4} \cdot \frac{lb}{ft \cdot sec}$

Flow rate

$Q = 140 \frac{gal}{min}$

Velocity of fluid in 3" diameter pipe

$V_{3InchPipe} := \frac{Q}{A_{3Inch}}$

$V_{3InchPipe} = 6.076 \frac{ft}{s}$

Reynold's number

$Re_{3InchPipe} := d_{3Inch} \cdot V_{3InchPipe} \cdot \frac{\rho_{Water} \cdot SpG}{\mu}$

Roughness of pipe

$\varepsilon_{3Inch} := .0005 \cdot d_{3Inch}$ Reference 1

$Re_{3InchPipe} = 6.78 \times 10^3$ Strictly valid for: $3 \cdot 10^3 \le Re \le 10^8$

Friction factor

$$f_{3Inch} := \left[-2 \cdot \log\left[\left[\frac{\left(\frac{\varepsilon_{3Inch}}{d_{3Inch}}\right)}{3.7}\right] - \left(\frac{5.02}{Re_{3InchPipe}}\right) \cdot \log\left[\left[\frac{\left(\frac{\varepsilon_{3Inch}}{d_{3Inch}}\right)}{3.7}\right] + \left(\frac{14.5}{Re_{3InchPipe}}\right)\right]\right]\right]^{-2}$$

$f_{3Inch} = 0.035$

Head loss

$$\Delta h_{L3InchPipe} := \frac{L_{3Inch}}{d_{3Inch}} \cdot f_{3Inch} \cdot \frac{V_{3InchPipe}^{2}}{2 \cdot g}$$

$$\Delta h_{L3InchPipe} = 46.572\,ft$$

Pressure Loss

$$\Delta p_{3InchPipe} := \Delta h_{L3InchPipe} \cdot \gamma_{Water} \cdot SpG$$

[redacted]

Net lift from 241-S-102 to 241-SY-102

$$\Delta Y := 8ft$$

$$\Delta p_{NetLift} := \frac{\Delta Y}{2.31 \frac{ft}{psi}} \cdot 1.4$$

$$\Delta p_{NetLift} = 4.848\,psi$$

$$\Delta p_{Total} := \Delta p_{2InchPipe} + \Delta p_{3InchPipe} + \Delta p_{NetLift}$$

[redacted]

Equivalent length of 1 foot 2" flex pipe, in feet of schedule 40 pipe

$\Delta p_{2InchFlex} := 1.2psi$

$$\Delta h_{L2InchFlex} := \Delta p_{2InchFlex} \cdot \frac{2.31 \cdot \frac{ft}{psi}}{SpG}$$

$\Delta h_{L2InchFlex} = 1.966\,ft$

$d_{2Inch} = 0.172\,ft$

$$L_{2InchPipe} := \Delta h_{L2InchFlex} \cdot \frac{d_{2Inch}}{f_{2Inch}} \cdot \frac{2g}{V_{2InchPipe}^{2}}$$

$V_{2InchPipe} = 13.386\,\frac{ft}{s}$

$L_{2InchPipe} = 3.853\,ft$ 4.903 ft per foot of 2" flex pipe, equivalent length 2" schedule 40 pipe

Determine total line flow and minimum flow velocity at 200psi:

$\Delta p_{Max} := 200psi$

$$Q_{Max} := \left(\frac{\Delta p_{Max}}{\Delta p_{Total}}\right)^{\frac{1}{2}} \cdot Q$$

[redacted]

$$v_{Min} := \frac{Q_{Max}}{A_{3Inch}}$$

[redacted]

HNDTEAM

CALCULATION COVER SHEET

Date: 4/20/01

Calculation No: 4412.091.MCAL.002
Calculation Title: Line Pressure Drop, SST – AEAT Fluidic Pumping
Project No. & Title: 4412-091, S-102 Preliminary Engineering Report

ORIGINAL AND REVISED CALCULATION/ANALYSIS APPROVAL

	Rev. A Name/Signature/Date	Rev. _____ Name/Signature/Date	Rev. _____ Name/Signature/Date
Originator:	Shawn L. Hailey 4/24/01 Shawn Hailey		
Checked By:	Brian Sullivan 4/24/01 Brian Sullivan		
Approved By:			
Other:			

AFFECTED DOCUMENTS

Document Number	Document Title	Rev. Number

RECORD OF REVISION

Rev.	*Reason for Revision*
A	Preliminary Issue

HNDTEAM DESIGN CALCULATION SHEET	Project No. 4412-091 Sheet 2 of 4
Calculation No. 4412.091.MCAL.002	PERFORMED BY S. Hailey DATE 6/20/01 Print & Sign Name
Rev. No. A	CHECKED BY Brian Sullivan DATE ____ Print & Sign Name
Calculation Title Line Pressure Drop, SST - AEAT Fluidic Pumping	B. Sullivan 6/28/01

INTRODUCTION

Purpose

The purpose of this calculation is to determine the required transfer line size and estimate the pressure drop in a direct route line from the Distributor Pit (S-02B) on 241-S-102 to the Pump Pit (SY-02A) on 241-SY-102.

Scope

The scope of this calculation consists of:

1. A determination of the hose size required to maintain the critical flow velocity to prevent solids settling, and
2. An estimate of the line pressure drop from 241-S-102 to 241-SY-102, using a hose of the required diameter to maintain the critical flow velocity.

DESIGN BASIS

Design Inputs
Criteria
Assumptions

Design input information provided by the References.
Criteria as noted in calculation.
Assumptions as follows:

1. Waste transfer rate = 100 gallons per minute
2. Slurry specific gravity, S.G = 1.4 grams per cubic centimeter
3. Critical flow velocity ≈ 6 feet per second
4. Length of transfer line = 400 feet
5. Elevation difference between S-02B and SY-02A ≈ 7 feet

REFERENCES

1. Cameron hydraulic data, Ingersol-Rand Co. 14th Edition
2. Hydraulic Handbook, 16th Edition, Fairbanks Morse Co.
3. "Evaluation of Power Fluidics™ for application in the Single Shell Tank Retrieval Program, by Greg Bogen/ HND TEAM
4. Le Manufacturier Granford Inc., St-Alphonse de Granby, Quebec Canada
5. Hanford Site Documents:
   a. Drawing H-2-73182, Revision
   b. Drawing H-2-37525, Revision
   c. Drawing H-2-37381, Revision
   d. Drawing H-2-37778, Revision
   e. Drawing H-2-37782, Revision
   f. Drawing H-2-37783, Revision
   g. Drawing H-14-104150, Sht 1, Revision
   h. Drawing H-14-104150, Sht 2, Revision
   i. Drawing H-2-822293, Revision
   j. Drawing H-14-104028, Revision
   k. ECN 663013

METHOD

Hand Calculation

RESULTS AND CONCLUSIONS

A two-inch hose connecting the 241-S-02A Distributor Pit and the 241-SY-02A Pump Pit, which flows the contours will maintain the critical flow velocity and result in a pressure drop of approximately 52 psi. The pump should be sized to over come this head as well as losses incurred in the yet to be defined tie-in fittings, assumed to be total loss of approximately 65 psi.

HNDTEAM	DESIGN CALCULATION SHEET	Calc.#: 4412.091.MCAL.002 Rev: A Page 3 of 4

Design Calculation Title: Line Pressure Drop, SST – AEAT Fluidic Pumping	Orig: S. Hailey	Date: 4/10/01
Project No. & Title: 4412-091, S-102 Preliminary Engineering Report	Checker: B. Sullivan	Date: 4/28/01

DESIGN/ ANALYSIS:

Determine the maximum hose size that can be used to maintain the minimum critical flow velocity at a 100 gpm transfer rate

Hose Cross-sectional Area = Flow Rate / Critical Flow Velocity

= (100 gallon/minute) * (1/7.48 foot^3/gallon) * (12 inch/foot)^3 * (1/60 minute/second) / [(6 foot/second) * (12 inch/foot)]

= 5.35 inch^2 = (π * diameter^2) / 4

Diameter = (4 * 5.35 inch^2 / π)$^{1/2}$

Diameter = 2.6 inches

Although 2 ½ - inch diameter hose would provide the desired transfer velocity, the closest standard hose size available is 2 – inch.

Therefore, 2 - inch hose will be used for primary transfer line.

HNDTEAM	DESIGN CALCULATION SHEET	Calc.#: 4412.091.MCAL.002 Rev: A Page 4 of 4
Design Calculation Title: Line Pressure Drop, SST – AEAT Fluidic Pumping	Orig: S. Hailey	Date: 4/10/01
Project No. & Title: 4412-091, S-102 Preliminary Engineering Report	Checker: B. Sullivan	Date: 6/28/01

Calculate the pressure loss that results from transferring the 241-S-102 recovered solution at a rate of 100 gpm through a 2 – inch transfer line.

The total pressure drop is defined as the sum of the sources for pressure loss, as follows:

$H = \sum hd + hp + hl$, where

H	= total pressure drop
hd	= static head
hp	= pressure head loss due to friction in the pipe
hl	= pressure head loss due to exit (assumed to be 1.0)

The sources of pressure loss can further be defined as:

hd = Lift
hp = Pressure loss per foot * Specific Gravity * Length

Furthermore,

hd = (7 foot*water) * (12 inch/foot) * (1/27.703 (pounds/inch^2)/(inch*water) * (1.4 specific gravity)

hd = 4.25 pounds/ inch^2

hp = (8.28 (pounds/ inch^2)/(100 foot)[reference 4, table 11-3, page 85]) * (1.4 specific gravity) • (400 foot)

hp = 46.4 pounds/ inch^2

Therefore,

H = 4.25 pounds/ inch^2 + 46.4 pounds/ inch^2 + 1 pounds/ inch^2

H = 52 psi

The calculated value doe not include losses through fittings that will be required on either end of the transfer line for tie in. The loss through these yet to be defined fittings will be assumed to be on the order of 10 pounds / inch^2. Therefore, the booster pump at 241-S-102 should be preliminarily sized for approximately 65 pounds / inch^2.

Holmes & Narver | D M J M

CALCULATION COVER SHEET

Date: 6/21/01

Calculation No: 4412.091.NCAL.001
Calculation Title: Radiation Shielding Analysis for S-102 System Components.
Project No. & Title: 4412-091 241-S-102 Rad Waste Transfer

ORIGINAL AND REVISED CALCULATION/ANALYSIS APPROVAL

	Rev. 0 Name/Signature/Date	Rev. Name/Signature/Date	Rev. Name/Signature/Date
Originator:	[illegible] 6/22/01		
Checked By:	[illegible] 6/22/01		
Approved By:			
Other:			

AFFECTED DOCUMENTS

Document Number	Document Title	Rev. Number

RECORD OF REVISION

Rev.	*Reason for Revision*
0	Initial Preliminary Issue

DESIGN CALCULATION SHEET

Calculation No.	PERFORMED BY: R. Spencer DATE 06/27/01 Print & Sign
4412.091.NCAL.001	
Rev. No. 0	CHECKED BY: C. Kidd DATE 06/27/01 Print & Sign
Calculation Title: Radiation Shielding Analysis for S-102 System Components.	

INTRODUCTION

Purpose Determine the shielding requirements for selected S-102 related system components.

Scope Shielding and radiation dose rate analyses were requested for the following S-102 system components:

1. Over Grade Transfer (OGT) 2-inch diameter lines in a 12-inch deep filled trench carrying liquid waste from tank 241-S-102.
2. The excavation of a manhole to a 1-ft thick concrete plug buried about 8-ft deep in soil using a measured radiation dose rate of 500 mRem/h just under the tank dome.
3. A pit steel cover plate with a 30-gallon accumulator full of tank waste as the source.

DESIGN BASIS

Design Inputs The radiation sources for the system components 1 and 3 are to be based on an estimated ^{137}Cs radioisotope containing waste with a concentration of 344 µCi/ml. Of course the short-lived radioactive decay daughter ^{137m}Ba will also be present in the ratio of 49/51 with the ^{137}Cs.

Criteria Since this is a temporary waste transfer campaign, the dose rates can be somewhat higher than for a permanent facility. The goal is to determine the shielding to bring the 1-ft distance dose point to around the 10 mRem/h level.

Assumptions Calculation #1. –

- The liquid waste has a specific gravity of 1.4.
- The ^{137}Cs and ^{137m}Ba radioisotopes are in the waste with concentrations of 344 µCi/ml and 330.51 µCi/ml, respectively.
- The 2-in. diameter source hose is surrounded by a 4-in. diameter hose and then a 1-in. thick layer of insulation, all in the bottom of a 12-in. deep trench.
- The trench is backfilled with soil to grade level and then steel plates are used for additional shielding.

Calculation #2. –

- The radiation source producing the 500 mRem/h inside the tank dome is a 14-ft thick, 75-ft dia. Tank volume of assumed ^{137}Cs

and ^{137m}Ba salt cake and liquid waste at a density of 1.4 g/cc.
- The inside tank dimensions are 75-ft dia. x 49-ft to dome (35-ft above the top of the waste).
- There are 8-ft of soil above a 1-ft thick concrete dome cover.

Calculation #3. –
- The top of the accumulator is 4-ft below the bottom of the pit cover plate.
- The accumulator is a right circular cylinder, sitting on end and with an L/D of 1.0.
- There is a 0.5-in. thick steel top on the accumulator.

REFERENCES

1. "MicroShield, Version 5 User's Manual," dated October 1996, Grove Engineering, Rockville, Maryland.

2. WHC-SD-HWV-TI-020, Rev. 0 "Soil Density and Mass Attenuation Coefficients For Use In Shielding Calculations At Hanford Waste Vitrification Plant," dated 1/2/92.

METHOD

All Three Calculations:
The model for each calculation is input to the MicroShield code, (See Ref. 1). The dose point is located at a distance of 1-ft above the top shield. MicroShield then computes a gamma spectrum based on the energies of the disintegrating radioisotopes. The source gamma radiation is then attenuated from the source locations to the point source using the point-kernel method (dividing the source up into a number of equal point sources). The individual resulting dose rates are then summed (point-kernel integration) to obtain the final result.

The shielding curves are obtained by placing various thickness shields between the source and the dose point. The resulting dose rates are then plotted against the shield thicknesses.

RESULTS AND CONCLUSIONS

Calculation #1 –
The 2-in. diameter hose was modeled as a 20-ft segment. Experience has shown that sources greater than about 10-ft away contribute little to the overall dose rate. The shielding results of the buried hose analysis are shown in Figure 1. These curves show that for the 1-ft dose point about 3 inches of steel plate would reduce the dose rate to less than 10 mRem/h.

Calculation #2 –
The 75-ft dia. tank is filled to a depth of 14-ft with salt cake and liquid

waste resulting in a measured dose rate of 500 mRem/h just inside the top of the dome (measured through an open tank riser). The source strength was back-calculated to be 3.6927 μCi/ml of ^{137}Cs and 3.5479 μCi/ml of ^{137m}Ba to result in the 500 mRem/h at the underside of the tank dome (35-ft above the waste). The results of the shielding analyses are shown in Figure 2. These curves show the dose rates as a function of the soil depth above the 1-ft thick concrete tank top. These curves can be used to estimate the total dose received by the crew during the excavation work.

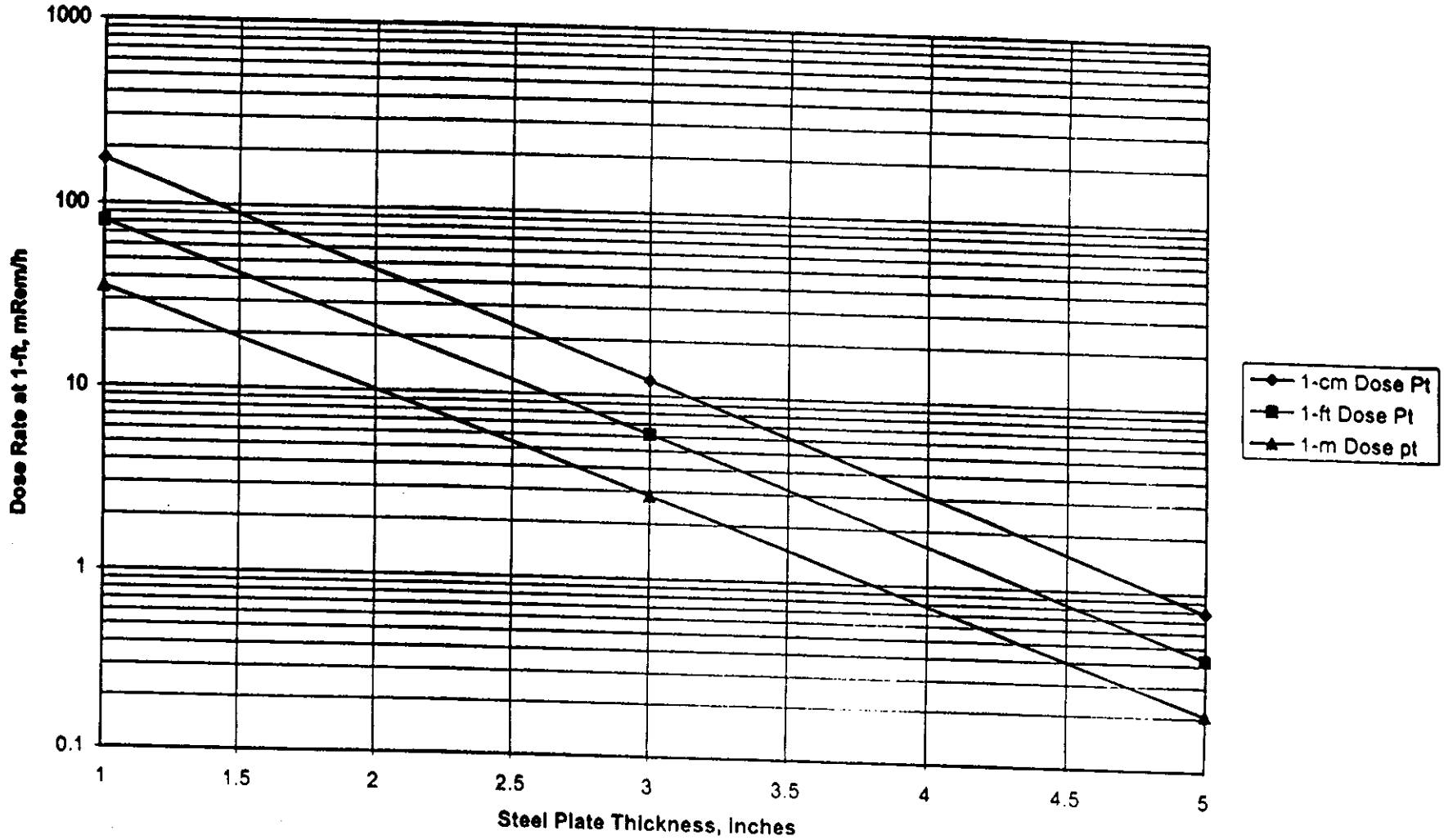
Calculation #3 –
The 30-gal liquid waste accumulator source represents a total source of about 39 Ci of ^{137}Cs and 37.533 Ci of ^{137m}Ba. The results of the shielding analyses are shown in Figure 3. These curves show that for the 1-ft dose point a cover plate of about 4 inches of steel would reduce the dose rate to about 10 mRem/h.

ANALYSIS

The details of the MicroShield analysis are summarized in the output sheets attached to this analysis (Attachment A). These printed output sheets provide all of the input data representing the analysis model and the source along with energy spectrum and resulting dose rates for each of the shield configurations.

FIGURE 1: 241 S-102 OGT Line Steel Plate Shielding
(2-in. Dia Hose 344uCi/ml Source in 1-ft Filled Trench)

RB Sjenny 6/27/01
6/27/01



RB Jameson 6/27/01
Chuck 6/29/01

FIGURE 2: 241 S-102 Pit Manhole Excavation
(500 mRem/h in 6'x6'x6' Pit, + 1 ft of Concrete = 0 Soil)

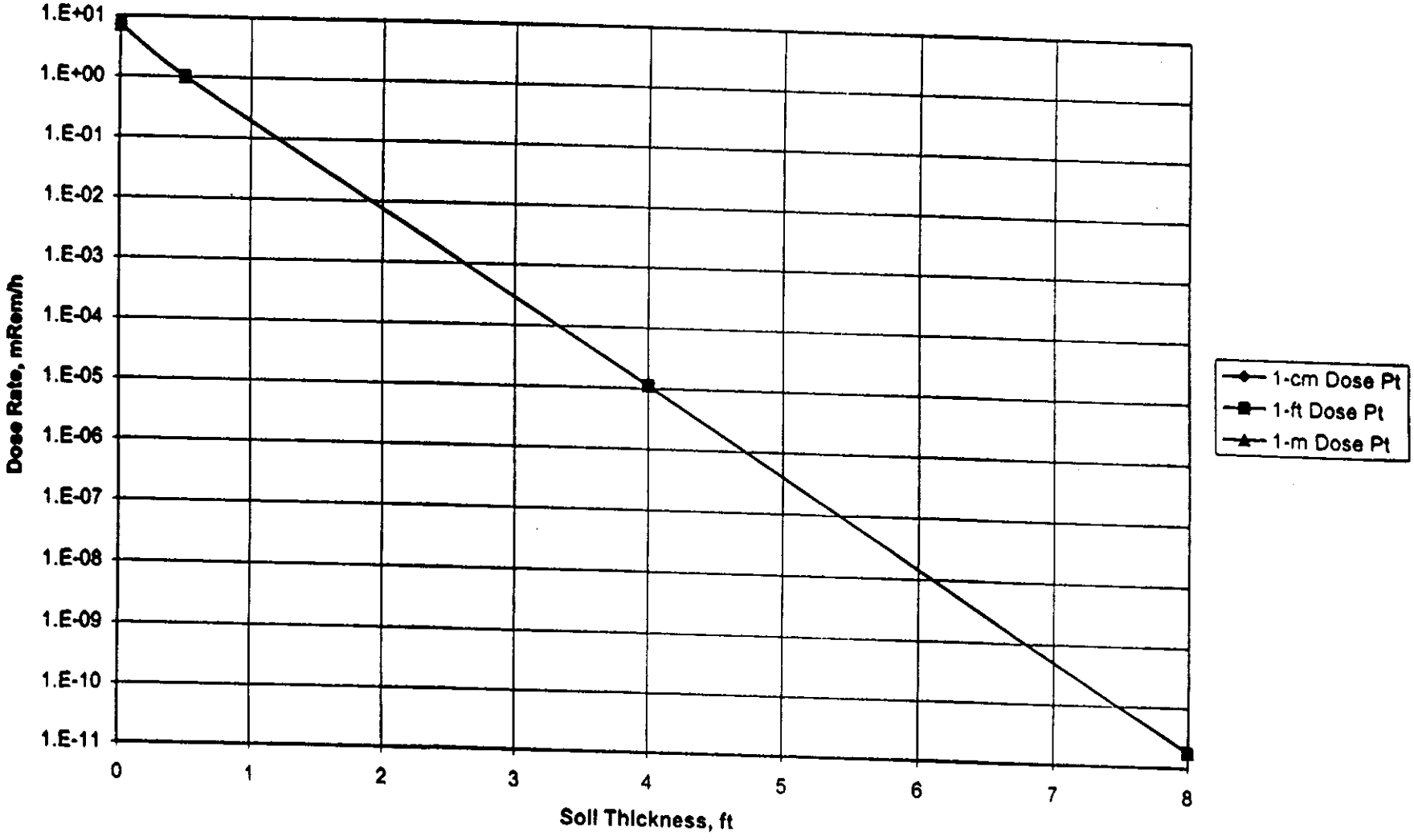
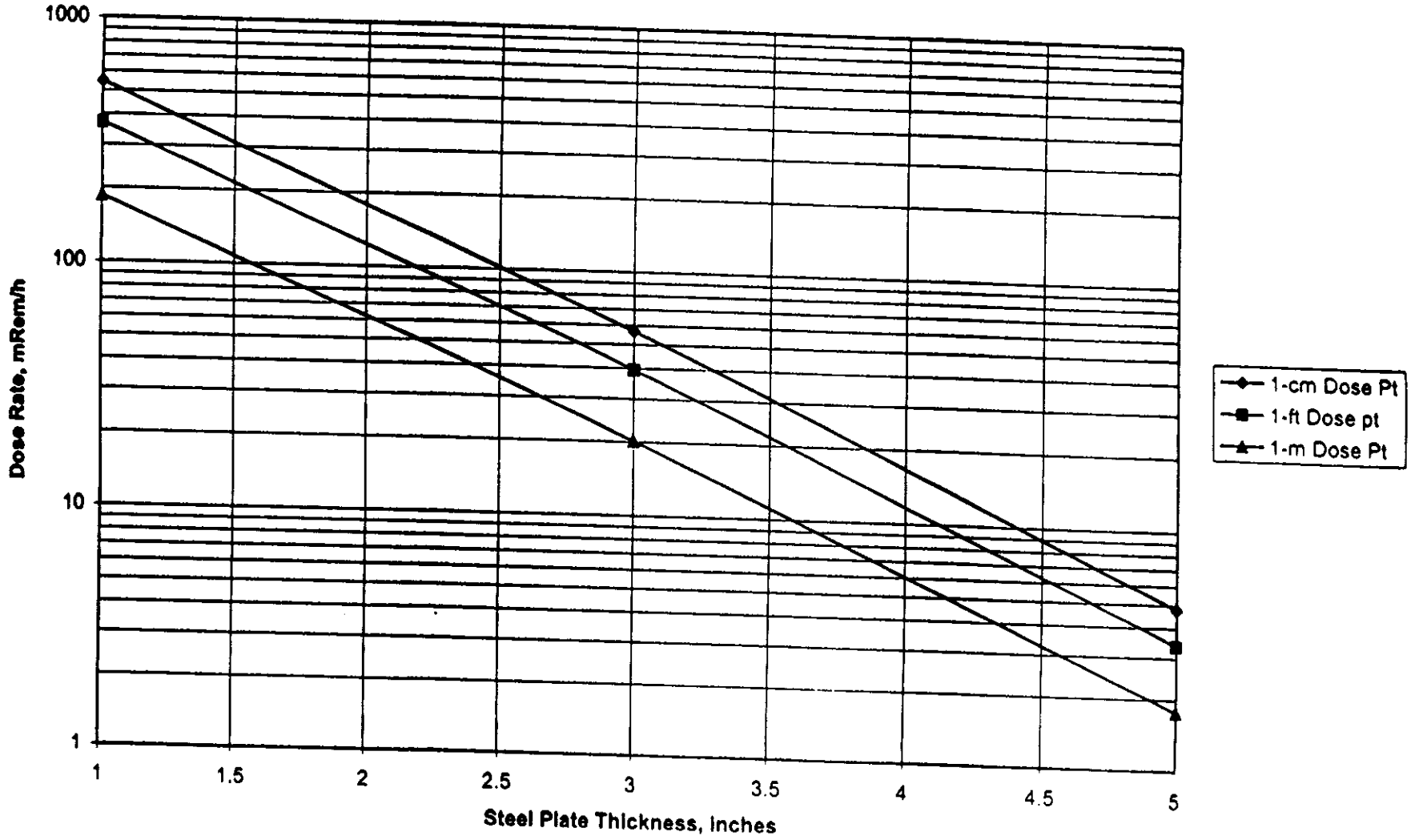


FIGURE 3: 241 S-102 30-gal Accumulator in Pit
(Steel Plate Cover Thickness for 344 uCi/ml Waste)

RB Swanson 6/27/01
6/27/01



DESIGN CALCULATION SHEET		
Design Calculation Title: Radiation Shielding Analysis for S-102 System Components.	Orig: R. Spencer Print & Initial	Date:6/27/01
Project No. & Title: 4412-091 - 241-S-102 Waste Retrieval.	Checker: C. Kidd Print & Initial	Date:6/27/01

ATTACHMENT A

CALCULATION #1
Over Grade Transfer Line

Page : 1
DOS File : W3SS4P1A.MS5
Run Date : June 27, 2001
R· Time: 1:06:34 PM
ation : 00:00:27

RPP-8381, Rev. 0

File Ref: _____
Date: 6/27/01
By: L. Sum
Checked: C. Kidd

Case Title: Case 1S4B
Description: 241 S-102 Transfer Hose -20-ft Src (1-in. R) 1-in.Fe
Geometry: 7 - Cylinder Volume - Side Shields

Source Dimensions

Height	609.6 cm	20 ft 0.0 in
Radius	2.54 cm	1.0 in

Dose Points

	X	Y	Z
# 1	25.60625 cm	304.8 cm	0 cm
	10.1 in	10 ft 0.0 in	0.0 in

Shields

Shield Name	Dimension	Material	Density
Source	1.24e+04 cm³	Water	1.4
Shield 1	.794 cm	Mixed ->	2
		Carbon	1
		Water	1
Shield 2	1.746 cm	Air	0.00122
Shield 3	.794 cm	Mixed ->	2
		Carbon	1
		Water	1
Shield 4	2.54 cm	Air	0.00122
Transition	13.653 cm	Hanford Soil	1.46
Shield 6	2.54 cm	Iron	7.86
Air Gap		Air	0.00122

Source Input
Grouping Method : Actual Photon Energies

Nuclide	curies	becquerels	µCi/cm³	Bq/cm³
Ba-137m	4.0836e+000	1.5109e+011	3.3051e+002	1.2229e+007
Cs-137	4.2503e+000	1.5726e+011	3.4400e+002	1.2728e+007

Buildup
The material reference is : Shield 6

Integration Parameters

Radial	10
Circumferential	10
Y Direction (axial)	40

Results

DOS File : W3SS4PTA.MS5
Run Date: June 27, 2001
Run Time: 1:06:34 PM
Duration : 00:00:27

ergy MeV	Activity photons/sec	Fluence Rate MeV/cm²/sec No Buildup	Fluence Rate MeV/cm²/sec With Buildup	Exposure Rate mR/hr No Buildup	Exposure Rate mR/hr With Buildup
0.0045	1.569e+09	0.000e+00	9.413e-25	0.000e+00	6.452e-25
0.0318	3.128e+09	2.548e-72	1.461e-23	2.122e-74	1.217e-25
0.0322	5.771e+09	1.251e-69	2.739e-23	1.007e-71	2.204e-25
0.0364	2.100e+09	3.726e-49	1.200e-23	2.117e-51	6.820e-26
0.6616	1.360e+11	1.574e+04	8.984e+04	3.051e+01	1.742e+02
TOTALS:	1.485e+11	1.574e+04	8.984e+04	3.051e+01	1.742e+02
	Sensitivity	Variable	X Dose Point 1	(1 of 2)	(55.09 cm)
0.0045	1.569e+09	0.000e+00	4.092e-25	0.000e+00	2.805e-25
0.0318	3.128e+09	1.261e-72	6.350e-24	1.051e-74	5.289e-26
0.0322	5.771e+09	6.218e-70	1.190e-23	5.004e-72	9.580e-26
0.0364	2.100e+09	1.884e-49	5.218e-24	1.070e-51	2.964e-26
0.6616	1.360e+11	7.286e+03	4.162e+04	1.412e+01	8.069e+01
TOTALS:	1.485e+11	7.286e+03	4.162e+04	1.412e+01	8.069e+01
	Sensitivity	Variable	X Dose Point 1	(2 of 2)	(124.61 cm)
0.0045	1.569e+09	0.000e+00	1.537e-25	0.000e+00	1.053e-25
0.0318	3.128e+09	5.405e-73	2.385e-24	4.502e-75	1.986e-26
22	5.771e+09	2.666e-70	4.470e-24	2.145e-72	3.598e-26
.364	2.100e+09	8.130e-50	1.959e-24	4.619e-52	1.113e-26
0.6616	1.360e+11	3.193e+03	1.827e+04	6.189e+00	3.542e+01
TOTALS:	1.485e+11	3.193e+03	1.827e+04	6.189e+00	3.542e+01

Page : 1
DOS File : W3SS4P3A.MS5
Run Date : June 27, 2001
Run Time: 1:11:26 PM
Duration : 00:00:27

RPP-8381, Rev. 0

File Ref: _____
Date: 6/27/01
By: [illegible]
Checked: C. Kidd

Case Title: Case 1S4C
Description: 241 S-102 Transfer Hose -20-ft Src (1-in. R) 3-in.Fe
Geometry: 7 - Cylinder Volume - Side Shields

Source Dimensions

Height	609.6 cm	20 ft 0.0 in
Radius	2.54 cm	1.0 in

Dose Points

	X	Y	Z
# 1	30.686 cm	304.8 cm	0 cm
	1 ft 0.1 in	10 ft 0.0 in	0.0 in

Shields

Shield Name	Dimension	Material	Density
Source	1.24e+04 cm³	Water	1.4
Shield 1	.794 cm	Mixed ->	2
		Carbon	1
		Water	1
Shield 2	1.746 cm	Air	0.00122
Shield 3	.794 cm	Mixed ->	2
		Carbon	1
		Water	1
Shield 4	2.54 cm	Air	0.00122
Transition	13.653 cm	Hanford Soil	1.46
Shield 6	7.62 cm	Iron	7.86
Air Gap		Air	0.00122

Source Input
Grouping Method : Actual Photon Energies

Nuclide	curies	becquerels	µCi/cm³	Bq/cm³
Ba-137m	4.0836e+000	1.5109e+011	3.3051e+002	1.2229e+007
Cs-137	4.2503e+000	1.5726e+011	3.4400e+002	1.2728e+007

Buildup
The material reference is : Shield 6

Integration Parameters

Radial	10
Circumferential	10
Y Direction (axial)	40

Results

DOS File : W3SS4P3A.MS5
Run Date: June 27, 2001
Run Time: 1:11:26 PM
Duration : 00:00:27

ergy MeV	Activity photons/sec	Fluence Rate MeV/cm²/sec No Buildup	Fluence Rate MeV/cm²/sec With Buildup	Exposure Rate mR/hr No Buildup	Exposure Rate mR/hr With Buildup
0.0045	1.569e+09	0.000e+00	7.765e-25	0.000e+00	5.322e-25
0.0318	3.128e+09	9.306e-189	1.205e-23	7.751e-191	1.004e-25
0.0322	5.771e+09	3.326e-182	2.259e-23	2.677e-184	1.818e-25
0.0364	2.100e+09	2.058e-128	9.901e-24	1.170e-130	5.625e-26
0.6616	1.360e+11	5.610e+02	6.250e+03	1.088e+00	1.212e+01
TOTALS:	1.485e+11	5.610e+02	6.250e+03	1.088e+00	1.212e+01
	Sensitivity	Variable	X Dose Point 1	(1 of 2)	(60.17 cm)
0.0045	1.569e+09	0.000e+00	3.703e-25	0.000e+00	2.538e-25
0.0318	3.128e+09	4.677e-189	5.746e-24	3.896e-191	4.787e-26
0.0322	5.771e+09	1.682e-182	1.077e-23	1.354e-184	8.669e-26
0.0364	2.100e+09	1.118e-128	4.722e-24	6.349e-131	2.683e-26
0.6616	1.360e+11	2.855e+02	3.182e+03	5.535e-01	6.168e+00
TOTALS:	1.485e+11	2.855e+02	3.182e+03	5.535e-01	6.168e+00
	Sensitivity	Variable	X Dose Point 1	(2 of 2)	(129.17 cm)
0.0045	1.569e+09	0.000e+00	1.466e-25	0.000e+00	1.005e-25
0.0318	3.128e+09	2.261e-189	2.276e-24	1.883e-191	1.896e-26
0.0322	5.771e+09	8.111e-183	4.266e-24	6.528e-185	3.433e-26
0.0364	2.100e+09	5.245e-129	1.870e-24	2.980e-131	1.062e-26
0.6616	1.360e+11	1.320e+02	1.473e+03	2.559e-01	2.855e+00
TOTALS:	1.485e+11	1.320e+02	1.473e+03	2.559e-01	2.855e+00

Page : 1
DOS File : W3CS4P5A.MS5
Run Date : June 27, 2001
P Time: 2:20:13 PM
ation : 00:00:34

RPP-8381, Rev. 0

File Ref:
Date: 6/27/01
By:
Checked:

Case Title: Case 1C4D
Description: 241 C-104 Transfer Hose -20-ft Src (1-in. R) 5-in.Fe
Geometry: 7 - Cylinder Volume - Side Shields

Source Dimensions

Height	609.6 cm	20 ft 0.0 in
Radius	2.54 cm	1.0 in

Dose Points

	X	Y	Z
# 1	35.76625 cm	304.8 cm	0 cm
	1 ft 2.1 in	10 ft 0.0 in	0.0 in

Shields

Shield Name	Dimension	Material	Density
Source	1.24e+04 cm³	Water	1.4
Shield 1	.794 cm	Mixed ->	2
		Carbon	1
		Water	1
Shield 2	1.746 cm	Air	0.00122
Shield 3	.794 cm	Mixed ->	2
		Carbon	1
		Water	1
Shield 4	2.54 cm	Air	0.00122
Transition	13.653 cm	Hanford Soil	1.46
Shield 6	12.7 cm	Iron	7.86
Air Gap		Air	0.00122

Source Input
Grouping Method : Actual Photon Energies

Nuclide	curies	becquerels	µCi/cm³	Bq/cm³
Ba-137m	4.0836e+000	1.5109e+011	3.3051e+002	1.2229e+007
Cs-137	4.2503e+000	1.5726e+011	3.4400e+002	1.2728e+007

Buildup
The material reference is : Shield 6

Integration Parameters

Radial	10
Circumferential	10
Y Direction (axial)	40

Results

DOS File : W3CS4P5A.MS5
Run Date: June 27, 2001
Run Time: 2:20:13 PM
Duration : 00:00:34

ergy MeV	Activity photons/sec	Fluence Rate MeV/cm²/sec No Buildup	Fluence Rate MeV/cm²/sec With Buildup	Exposure Rate mR/hr No Buildup	Exposure Rate mR/hr With Buildup
0.0045	1.569e+09	0.000e+00	6.586e-25	0.000e+00	4.514e-25
0.0318	3.128e+09	4.338e-305	1.022e-23	3.613e-307	8.513e-26
0.0322	5.771e+09	1.130e-294	1.916e-23	9.093e-297	1.542e-25
0.0364	2.100e+09	1.495e-207	8.398e-24	8.492e-210	4.771e-26
0.6616	1.360e+11	2.239e+01	4.047e+02	4.340e-02	7.845e-01
TOTALS:	1.485e+11	2.239e+01	4.047e+02	4.340e-02	7.845e-01
	Sensitivity	Variable	X Dose Point 1	(1 of 2)	(65.25 cm)
0.0045	1.569e+09	0.000e+00	3.375e-25	0.000e+00	2.313e-25
0.0318	3.128e+09	2.289e-305	5.237e-24	1.906e-307	4.362e-26
0.0322	5.771e+09	5.978e-295	9.818e-24	4.811e-297	7.901e-26
0.0364	2.100e+09	8.386e-208	4.303e-24	4.764e-210	2.445e-26
0.6616	1.360e+11	1.226e+01	2.216e+02	2.376e-02	4.295e-01
TOTALS:	1.485e+11	1.226e+01	2.216e+02	2.376e-02	4.295e-01
	Sensitivity	Variable	X Dose Point 1	(2 of 2)	(134.77 cm)
0.0045	1.569e+09	0.000e+00	1.387e-25	0.000e+00	9.506e-26
0.0318	3.128e+09	1.192e-305	2.152e-24	9.932e-308	1.793e-26
0.0322	5.771e+09	3.109e-295	4.035e-24	2.502e-297	3.247e-26
0.0364	2.100e+09	4.237e-208	1.768e-24	2.407e-210	1.005e-26
0.6616	1.360e+11	5.892e+00	1.066e+02	1.142e-02	2.067e-01
TOTALS:	1.485e+11	5.892e+00	1.066e+02	1.142e-02	2.067e-01

ATTACHMENT A

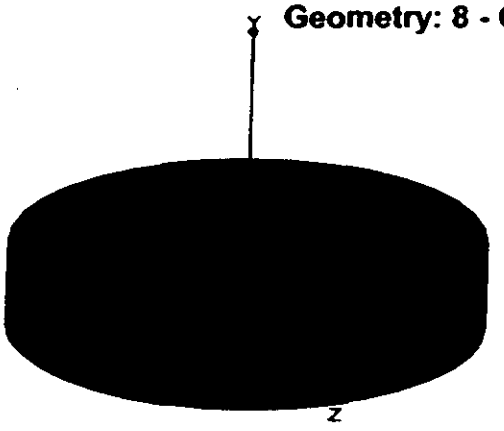
CALCULATION #2
Excavation of Manhole in Pump Pit

Page : 1
DOS File : W3SEX001.MS5
Run Date : June 27, 2001
P· Time: 1:02:43 PM
..ion : 00:00:06

RPP-8381, Rev. 0

File Ref: _____
Date: 6/27/01
By: [illegible]
Checked: C.K.D.

Case Title: Case 1E
Description: S-102 Excavation New Source (Cs-137/Ba-137m)
Geometry: 8 - Cylinder Volume - End Shields



Source Dimensions

Height	426.72 cm	14 ft 0.0 in
Radius	1.1e+3 cm	37 ft 6.0 in

Dose Points

	X	Y	Z
# 1	0 cm	1493.52 cm	0 cm
	0.0 in	49 ft	0.0 in

Shields

Shield Name	Dimension	Material	Density
Source	1.75e+09 cm³	Water	1.4
Air Gap		Air	0.00122

Source Input
Grouping Method : Actual Photon Energies

Nuclide	curies	becquerels	µCi/cm³	Bq/cm³
Ba-137m	6.2138e+003	2.2991e+014	3.5479e+000	1.3127e+005
Cs-137	6.4675e+003	2.3930e+014	3.6927e+000	1.3663e+005

Buildup
The material reference is : Source

Integration Parameters

Radial	40
Circumferential	40
Y Direction (axial)	40

Results

Energy MeV	Activity photons/sec	Fluence Rate MeV/cm²/sec No Buildup	Fluence Rate MeV/cm²/sec With Buildup	Exposure Rate mR/hr No Buildup	Exposure Rate mR/hr With Buildup
0.0045	2.387e+12	4.098e-02	5.527e-02	2.809e-02	3.788e-02
0.0318	4.760e+12	1.927e+01	5.945e+01	1.606e-01	4.952e-01
0.0322	8.782e+12	3.680e+01	1.157e+02	2.962e-01	9.313e-01
0.0364	3.196e+12	1.854e+01	7.167e+01	1.053e-01	4.072e-01
0.6616	2.069e+14	9.122e+04	2.570e+05	1.768e+02	4.982e+02

Run Date: June 27, 2001
Run Time: 1:02:43 PM
Duration : 00:00:06

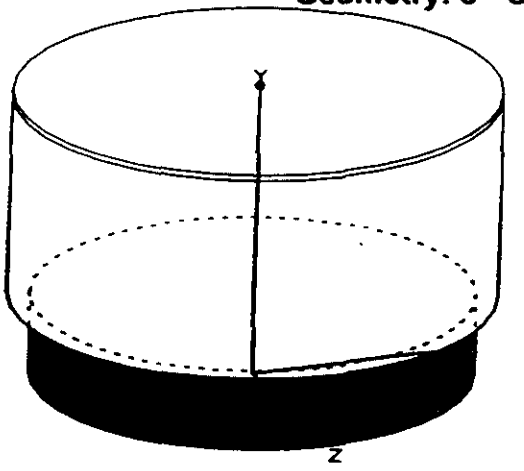
ergy MeV	Activity photons/sec	Fluence Rate MeV/cm²/sec No Buildup	Fluence Rate MeV/cm²/sec With Buildup	Exposure Rate mR/hr No Buildup	Exposure Rate mR/hr With Buildup
TOTALS:	2.260e+14	9.129e+04	2.572e+05	1.774e+02	5.000e+02

Page : 1
DOS File : W3SEX100.MS5
Run Date : June 27, 2001
Time: 1:00:41 PM
Duration : 00:00:19

RPP-8381, Rev. 0

File Ref:
Date: 6/27/01
By: RBSumm
Checked: C.K.

Case Title: Case 1E100
Description: S-102 Excavation Conc + Soil (Cs/Ba-137), 1'+ 0"
Geometry: 8 - Cylinder Volume - End Shields



Source Dimensions

Height	426.72 cm	14 ft 0.0 in
Radius	1.1e+3 cm	37 ft 6.0 in

Dose Points

	X	Y	Z
# 1	0 cm	1554.48 cm	0 cm
	0.0 in	51 ft	0.0 in

Shields

Shield Name	Dimension	Material	Density
Source	1.75e+09 cm³	Water	1.4
Shield 1	1066.8 cm	Air	0.00122
Shield 2	30.48 cm	Concrete	2.35
Air Gap		Air	0.00122

Source Input
Grouping Method : Actual Photon Energies

Nuclide	curies	becquerels	µCi/cm³	Bq/cm³
Ba-137m	6.2138e+003	2.2991e+014	3.5479e+000	1.3127e+005
Cs-137	6.4675e+003	2.3930e+014	3.6927e+000	1.3663e+005

Buildup
The material reference is : Shield 1

Integration Parameters

Radial	40
Circumferential	40
Y Direction (axial)	40

Results

Energy MeV	Activity photons/sec	Fluence Rate MeV/cm²/sec No Buildup	Fluence Rate MeV/cm²/sec With Buildup	Exposure Rate mR/hr No Buildup	Exposure Rate mR/hr With Buildup
0.0045	2.387e+12	1.947e-255	5.869e-24	1.334e-255	4.023e-24
0.0318	4.760e+12	2.678e-31	3.234e-21	2.230e-33	2.694e-23
0.0322	8.782e+12	4.173e-30	6.489e-21	3.358e-32	5.222e-23
0.0364	3.196e+12	1.387e-22	2.576e-20	7.879e-25	1.463e-22

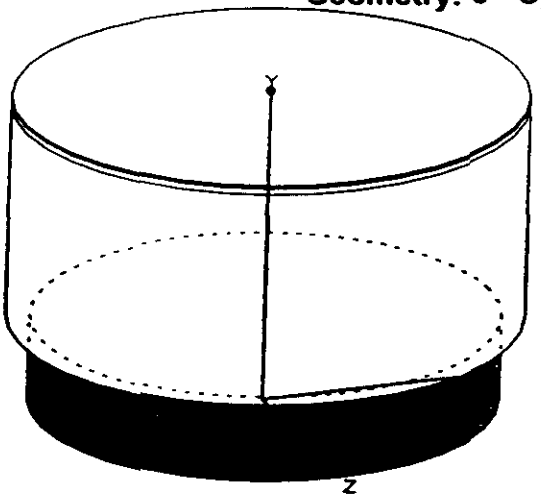
ıergy MeV	Activity photons/sec	Fluence Rate MeV/cm²/sec No Buildup	Fluence Rate MeV/cm²/sec With Buildup	Exposure Rate mR/hr No Buildup	Exposure Rate mR/hr With Buildup
0.6616	2.069e+14	1.486e+02	3.784e+03	2.880e-01	7.337e+00
TOTALS:	2.260e+14	1.486e+02	3.784e+03	2.880e-01	7.337e+00
	Sensitivity	Variable	Y Dose Point 1	(1 of 2)	(1525 cm)
0.0045	2.387e+12	2.056e-255	6.073e-24	1.410e-255	4.163e-24
0.0318	4.760e+12	2.707e-31	3.347e-21	2.255e-33	2.788e-23
0.0322	8.782e+12	4.217e-30	6.715e-21	3.394e-32	5.404e-23
0.0364	3.196e+12	1.400e-22	2.614e-20	7.952e-25	1.485e-22
0.6616	2.069e+14	1.500e+02	3.829e+03	2.908e-01	7.423e+00
TOTALS:	2.260e+14	1.500e+02	3.829e+03	2.908e-01	7.423e+00
	Sensitivity	Variable	Y Dose Point 1	(2 of 2)	(1624 cm)
0.0045	2.387e+12	1.710e-255	5.424e-24	1.172e-255	3.718e-24
0.0318	4.760e+12	2.610e-31	2.989e-21	2.174e-33	2.490e-23
0.0322	8.782e+12	4.068e-30	5.997e-21	3.274e-32	4.826e-23
0.0364	3.196e+12	1.357e-22	2.490e-20	7.708e-25	1.415e-22
0.6616	2.069e+14	1.449e+02	3.674e+03	2.810e-01	7.122e+00
ALS:	2.260e+14	1.449e+02	3.674e+03	2.810e-01	7.122e+00

Page : 1
DOS File : W3SEX106.MS5
Run Date : June 27, 2001
Time : 12:59:00 PM
ation : 00:00:19

RPP-8381, Rev. 0

File Ref:
Date: 6/27/01
By:
Checked: C. K. Ide

Case Title: Case 1E106
Description: S-102 Excavation Conc + Soil (Cs/Ba-137), 1'+ 6"
Geometry: 8 - Cylinder Volume - End Shields



Source Dimensions

Height	426.72 cm	14 ft 0.0 in
Radius	1.1e+3 cm	37 ft 6.0 in

Dose Points

	X	Y	Z
# 1	0 cm	1569.72 cm	0 cm
	0.0 in	51 ft 6.0 in	0.0 in

Shields

Shield Name	Dimension	Material	Density
Source	1.75e+09 cm³	Water	1.4
Shield 1	1066.8 cm	Air	0.00122
Shield 2	30.48 cm	Concrete	2.35
Shield 3	15.24 cm	Hanford Soil	1.46
Air Gap		Air	0.00122

Source Input
Grouping Method : Actual Photon Energies

Nuclide	curies	becquerels	µCi/cm³	Bq/cm³
Ba-137m	6.2138e+003	2.2991e+014	3.5479e+000	1.3127e+005
Cs-137	6.4675e+003	2.3930e+014	3.6927e+000	1.3663e+005

Buildup
The material reference is : Shield 3

Integration Parameters

Radial	40
Circumferential	40
Y Direction (axial)	40

Results

Energy MeV	Activity photons/sec	Fluence Rate MeV/cm²/sec No Buildup	Fluence Rate MeV/cm²/sec With Buildup	Exposure Rate mR/hr No Buildup	Exposure Rate mR/hr With Buildup
0.0045	2.387e+12	0.000e+00	3.122e-24	0.000e+00	2.140e-24
0.0318	4.760e+12	8.277e-48	7.048e-23	6.894e-50	5.871e-25
0.0322	8.782e+12	4.341e-46	1.331e-22	3.493e-48	1.071e-24

DOS File : W3SEX106.MS5
Run Date : June 27, 2001
Run Time: 12:59:00 PM
Duration : 00:00:19

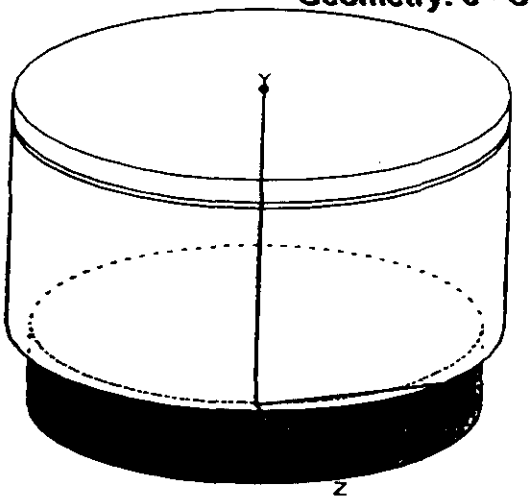
ergy MeV	Activity photons/sec	Fluence Rate MeV/cm²/sec No Buildup	Fluence Rate MeV/cm²/sec With Buildup	Exposure Rate mR/hr No Buildup	Exposure Rate mR/hr With Buildup
0.0364	3.196e+12	4.575e-34	6.388e-23	2.599e-36	3.630e-25
0.6616	2.069e+14	2.213e+01	5.221e+02	4.290e-02	1.012e+00
TOTALS:	2.260e+14	2.213e+01	5.221e+02	4.290e-02	1.012e+00
	Sensitivity	Variable	Y Dose Point 1	(1 of 2)	(1540.24 cm)
0.0045	2.387e+12	0.000e+00	3.230e-24	0.000e+00	2.214e-24
0.0318	4.760e+12	8.367e-48	7.292e-23	6.970e-50	6.074e-25
0.0322	8.782e+12	4.387e-46	1.377e-22	3.531e-48	1.108e-24
0.0364	3.196e+12	4.618e-34	6.609e-23	2.623e-36	3.755e-25
0.6616	2.069e+14	2.228e+01	5.264e+02	4.320e-02	1.021e+00
TOTALS:	2.260e+14	2.228e+01	5.264e+02	4.320e-02	1.021e+00
	Sensitivity	Variable	Y Dose Point 1	(2 of 2)	(1639.24 cm)
0.0045	2.387e+12	0.000e+00	2.887e-24	0.000e+00	1.979e-24
0.0318	4.760e+12	8.068e-48	6.518e-23	6.720e-50	5.429e-25
0.0322	8.782e+12	4.233e-46	1.231e-22	3.406e-48	9.906e-25
0.0364	3.196e+12	4.476e-34	5.908e-23	2.543e-36	3.357e-25
0.6616	2.069e+14	2.173e+01	5.110e+02	4.213e-02	9.907e-01
TALS:	2.260e+14	2.173e+01	5.110e+02	4.213e-02	9.907e-01

Page : 1
DOS File : W3SEX148.MS5
Run Date : June 27, 2001
Run Time : 12:57:46 PM
Duration : 00:00:18

RPP-8381, Rev. 0

File Ref:
Date: 6/27/01
By: [illegible]
Checked: C. K[illegible]

Case Title: Case 1E148
Description: S-102 Excavation Conc + Soil (Cs/Ba-137), 1'+ 48"
Geometry: 8 - Cylinder Volume - End Shields



Source Dimensions

Height	426.72 cm	14 ft 0.0 in
Radius	1.1e+3 cm	37 ft 6.0 in

Dose Points

	X	Y	Z
# 1	0 cm	1676.4 cm	0 cm
	0.0 in	55 ft 0.0 in	0.0 in

Shields

Shield Name	Dimension	Material	Density
Source	1.75e+09 cm³	Water	1.4
Shield 1	1066.8 cm	Air	0.00122
Shield 2	30.48 cm	Concrete	2.35
Shield 3	121.92 cm	Hanford Soil	1.46
Air Gap		Air	0.00122

Source Input
Grouping Method : Actual Photon Energies

Nuclide	curies	becquerels	µCi/cm³	Bq/cm³
Ba-137m	6.2138e+003	2.2991e+014	3.5479e+000	1.3127e+005
Cs-137	6.4675e+003	2.3930e+014	3.6927e+000	1.3663e+005

Buildup
The material reference is : Shield 3

Integration Parameters

Radial	40
Circumferential	40
Y Direction (axial)	40

Results

Energy MeV	Activity photons/sec	Fluence Rate MeV/cm²/sec No Buildup	Fluence Rate MeV/cm²/sec With Buildup	Exposure Rate mR/hr No Buildup	Exposure Rate mR/hr With Buildup
0.0045	2.387e+12	0.000e+00	2.771e-24	0.000e+00	1.899e-24
0.0318	4.760e+12	1.222e-162	6.254e-23	1.018e-164	5.210e-25
0.0322	8.782e+12	3.110e-157	1.181e-22	2.503e-159	9.505e-25

DOS File : W3SEX148.MS5
Run Date: June 27, 2001
Run Time: 12:57:46 PM
Duration : 00:00:18

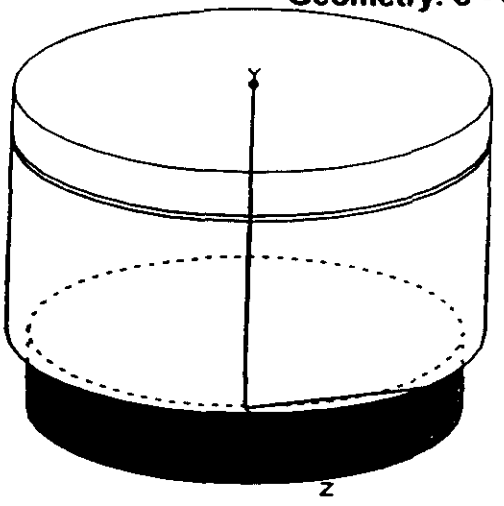
ergy MeV	Activity photons/sec	Fluence Rate MeV/cm²/sec No Buildup	Fluence Rate MeV/cm²/sec With Buildup	Exposure Rate mR/hr No Buildup	Exposure Rate mR/hr With Buildup
0.0364	3.196e+12	9.736e-114	5.669e-23	5.532e-116	3.221e-25
0.6616	2.069e+14	5.911e-05	5.704e-03	1.146e-07	1.106e-05
TOTALS:	2.260e+14	5.911e-05	5.704e-03	1.146e-07	1.106e-05
	Sensitivity	Variable	Y Dose Point 1	(1 of 2)	(1646.92 cm)
0.0045	2.387e+12	0.000e+00	2.863e-24	0.000e+00	1.962e-24
0.0318	4.760e+12	1.235e-162	6.463e-23	1.029e-164	5.384e-25
0.0322	8.782e+12	3.143e-157	1.220e-22	2.530e-159	9.822e-25
0.0364	3.196e+12	9.826e-114	5.858e-23	5.583e-116	3.328e-25
0.6616	2.069e+14	5.929e-05	5.721e-03	1.149e-07	1.109e-05
TOTALS:	2.260e+14	5.929e-05	5.721e-03	1.149e-07	1.109e-05
	Sensitivity	Variable	Y Dose Point 1	(2 of 2)	(1745.92 cm)
0.0045	2.387e+12	0.000e+00	2.568e-24	0.000e+00	1.760e-24
0.0318	4.760e+12	1.191e-162	5.798e-23	9.921e-165	4.829e-25
0.0322	8.782e+12	3.034e-157	1.095e-22	2.441e-159	8.811e-25
0.0364	3.196e+12	9.529e-114	5.255e-23	5.414e-116	2.986e-25
0.6616	2.069e+14	5.868e-05	5.663e-03	1.138e-07	1.098e-05
ALS:	2.260e+14	5.868e-05	5.663e-03	1.138e-07	1.098e-05

Page : 1
DOS File : W3SEX196.MS5
Run Date : June 27, 2001
Time : 12:56:20 PM
Duration : 00:00:19

RPP-8381, Rev. 0

File Ref: _____
Date: 6/27/01
By: [illegible]
Checked: [illegible]

Case Title: Case 1E196
Description: S-102 Excavation Conc + Soil (Cs/Ba-137), 1'+ 96"
Geometry: 8 - Cylinder Volume - End Shields



Source Dimensions

Height	426.72 cm	14 ft 0.0 in
Radius	1.1e+3 cm	37 ft 6.0 in

Dose Points

	X	Y	Z
# 1	0 cm	1798.32 cm	0 cm
	0.0 in	59 ft	0.0 in

Shields

Shield Name	Dimension	Material	Density
Source	1.75e+09 cm³	Water	1.4
Shield 1	1066.8 cm	Air	0.00122
Shield 2	30.48 cm	Concrete	2.35
Shield 3	243.84 cm	Hanford Soil	1.46
Air Gap		Air	0.00122

Source Input
Grouping Method : Actual Photon Energies

Nuclide	curies	becquerels	µCi/cm³	Bq/cm³
Ba-137m	6.2138e+003	2.2991e+014	3.5479e+000	1.3127e+005
Cs-137	6.4675e+003	2.3930e+014	3.6927e+000	1.3663e+005

Buildup
The material reference is : Shield 3

Integration Parameters

Radial	40
Circumferential	40
Y Direction (axial)	40

Results

Energy MeV	Activity photons/sec	Fluence Rate MeV/cm²/sec No Buildup	Fluence Rate MeV/cm²/sec With Buildup	Exposure Rate mR/hr No Buildup	Exposure Rate mR/hr With Buildup
0.0045	2.387e+12	0.000e+00	2.430e-24	0.000e+00	1.665e-24
0.0318	4.760e+12	1.587e-293	5.485e-23	1.322e-295	4.569e-25
0.0322	8.782e+12	6.583e-284	1.036e-22	5.298e-286	8.336e-25

DOS File : W35EX196.MS5
Run Date: June 27, 2001
Run Time: 12:56:20 PM
Duration : 00:00:19

nergy MeV	Activity photons/sec	Fluence Rate MeV/cm²/sec No Buildup	Fluence Rate MeV/cm²/sec With Buildup	Exposure Rate mR/hr No Buildup	Exposure Rate mR/hr With Buildup
0.0364	3.196e+12	1.881e-204	4.971e-23	1.069e-206	2.825e-25
0.6616	2.069e+14	3.899e-11	9.132e-09	7.560e-14	1.770e-11
TOTALS:	2.260e+14	3.899e-11	9.132e-09	7.560e-14	1.770e-11
	Sensitivity	Variable	Y Dose Point 1	(1 of 2)	(1768.84 cm)
0.0045	2.387e+12	0.000e+00	2.506e-24	0.000e+00	1.718e-24
0.0318	4.760e+12	1.604e-293	5.658e-23	1.336e-295	4.713e-25
0.0322	8.782e+12	6.654e-284	1.068e-22	5.355e-286	8.599e-25
0.0364	3.196e+12	1.898e-204	5.128e-23	1.078e-206	2.914e-25
0.6616	2.069e+14	3.911e-11	9.156e-09	7.581e-14	1.775e-11
TOTALS:	2.260e+14	3.911e-11	9.156e-09	7.581e-14	1.775e-11
	Sensitivity	Variable	Y Dose Point 1	(2 of 2)	(1867.84 cm)
0.0045	2.387e+12	0.000e+00	2.262e-24	0.000e+00	1.551e-24
0.0318	4.760e+12	1.547e-293	5.107e-23	1.289e-295	4.254e-25
0.0322	8.782e+12	6.421e-284	9.643e-23	5.168e-286	7.761e-25
0.0364	3.196e+12	1.841e-204	4.628e-23	1.046e-206	2.630e-25
0.6616	2.069e+14	3.873e-11	9.073e-09	7.509e-14	1.759e-11
TALS:	2.260e+14	3.873e-11	9.073e-09	7.509e-14	1.759e-11

ATTACHMENT A

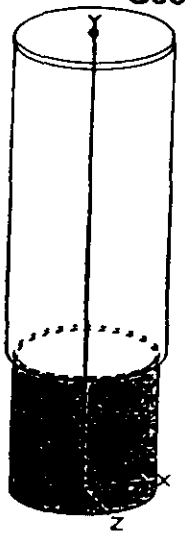
CALCULATION #3
Accumulator Pit Cover Plate

Page : 1
DOS File : W3S344A1.MS5
Run Date : June 19, 2001
Run Time : 5:04:54 PM
Duration : 00:00:04

RPP-8381, Rev. 0

File Ref: _____
Date: 6/27/01
By: [illegible]
Checked: C.K. [illegible]

Case Title: Case s344A1
Description: W-523-S-102 30-gal Accumulator - 344 uCi/ml, 1" of Fe Plate
Geometry: 8 - Cylinder Volume - End Shields



Source Dimensions

Height	52.487 cm	1 ft 8.7 in
Radius	26.243 cm	10.3 in

Dose Points

	X	Y	Z
# 1	0 cm	179.217 cm	0 cm
	0.0 in	5 ft 10.6 in	0.0 in

Shields

Shield Name	Dimension	Material	Density
Source	1.14e+05 cm³	Water	1.4
Shield 1	121.92 cm	Air	0.00122
Shield 2	2.54 cm	Iron	7.86
Air Gap		Air	0.00122
Wall Clad	1.27 cm	Iron	7.86
Top Clad	1.27 cm	Iron	7.86

Source Input
Grouping Method : Actual Photon Energies

Nuclide	curies	becquerels	µCi/cm³	Bq/cm³
Ba-137m	3.7533e+001	1.3887e+012	3.3051e+002	1.2229e+007
Cs-137	3.9065e+001	1.4454e+012	3.4400e+002	1.2728e+007

Buildup
The material reference is : Shield 2

Integration Parameters

Radial	20
Circumferential	20
Y Direction (axial)	20

Results

Energy MeV	Activity photons/sec	Fluence Rate MeV/cm²/sec No Buildup	Fluence Rate MeV/cm²/sec With Buildup	Exposure Rate mR/hr No Buildup	Exposure Rate mR/hr With Buildup
0.0045	1.442e+10	0.000e+00	1.963e-24	0.000e+00	1.346e-24
0.0318	2.875e+10	3.218e-86	3.047e-23	2.681e-88	2.538e-25

DOS File : W3S344A1.MS5
Run Date : June 19, 2001
Run Time: 5:04:54 PM
Duration : 00:00:04

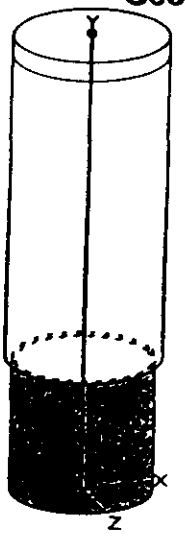
ergy MeV	Activity photons/sec	Fluence Rate MeV/cm²/sec No Buildup	Fluence Rate MeV/cm²/sec With Buildup	Exposure Rate mR/hr No Buildup	Exposure Rate mR/hr With Buildup
0.0322	5.305e+10	4.958e-83	5.711e-23	3.990e-85	4.596e-25
0.0364	1.930e+10	3.147e-58	2.503e-23	1.788e-60	1.422e-25
0.6616	1.250e+12	6.178e+04	2.813e+05	1.198e+02	5.453e+02
TOTALS:	1.365e+12	6.178e+04	2.813e+05	1.198e+02	5.453e+02
	Sensitivity	Variable	Y Dose Point 1	(1 of 2)	(208.69 cm)
0.0045	1.442e+10	0.000e+00	1.380e-24	0.000e+00	9.459e-25
0.0318	2.875e+10	3.030e-86	2.141e-23	2.524e-88	1.784e-25
0.0322	5.305e+10	4.650e-83	4.014e-23	3.742e-85	3.231e-25
0.0364	1.930e+10	2.809e-58	1.760e-23	1.596e-60	9.997e-26
0.6616	1.250e+12	4.202e+04	1.920e+05	8.146e+01	3.723e+02
TOTALS:	1.365e+12	4.202e+04	1.920e+05	8.146e+01	3.723e+02
	Sensitivity	Variable	Y Dose Point 1	(2 of 2)	(278.21 cm)
0.0045	1.442e+10	0.000e+00	7.196e-25	0.000e+00	4.932e-25
0.0318	2.875e+10	2.327e-86	1.117e-23	1.938e-88	9.301e-26
0.0322	5.305e+10	3.537e-83	2.093e-23	2.846e-85	1.685e-25
0.0364	1.930e+10	1.941e-58	9.175e-24	1.103e-60	5.213e-26
16	1.250e+12	2.089e+04	9.615e+04	4.050e+01	1.864e+02
TOTALS:	1.365e+12	2.089e+04	9.615e+04	4.050e+01	1.864e+02

Page : 1
DOS File : W3S344A3.MS5
Run Date : June 19, 2001
Run Time : 5:10:51 PM
Duration : 00:00:04

RPP-8381, Rev. 0

File Ref: _____
Date: 6/27/01
By: [illegible]
Checked: C. Kirk

Case Title: Case s344A3
Description: W-523-S-102 30-gal Accumulator - 344 uCi/ml, 3" of Fe Plate
Geometry: 8 - Cylinder Volume - End Shields



Source Dimensions

Height	52.487 cm	1 ft 8.7 in
Radius	26.243 cm	10.3 in

Dose Points

	X	Y	Z
# 1	0 cm	184.2966 cm	0 cm
	0.0 in	6 ft 0.6 in	0.0 in

Shields

Shield Name	Dimension	Material	Density
Source	1.14e+05 cm³	Water	1.4
Shield 1	121.92 cm	Air	0.00122
Shield 2	7.62 cm	Iron	7.86
Air Gap		Air	0.00122
Wall Clad	1.27 cm	Iron	7.86
Top Clad	1.27 cm	Iron	7.86

Source Input
Grouping Method : Actual Photon Energies

Nuclide	curies	becquerels	µCi/cm³	Bq/cm³
Ba-137m	3.7533e+001	1.3887e+012	3.3051e+002	1.2229e+007
Cs-137	3.9065e+001	1.4454e+012	3.4400e+002	1.2728e+007

Buildup
The material reference is : Shield 2

Integration Parameters

Radial	20
Circumferential	20
Y Direction (axial)	20

Results

Energy MeV	Activity photons/sec	Fluence Rate MeV/cm²/sec No Buildup	Fluence Rate MeV/cm²/sec With Buildup	Exposure Rate mR/hr No Buildup	Exposure Rate mR/hr With Buildup
0.0045	1.442e+10	0.000e+00	1.837e-24	0.000e+00	1.259e-24
0.0318	2.875e+10	9.912e-203	2.850e-23	8.256e-205	2.374e-25

DOS File : W3S344A3.MS5
Run Date: June 19, 2001
Run Time: 5:10:51 PM
Duration : 00:00:04

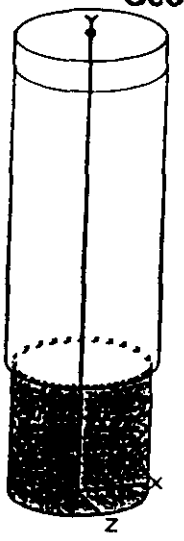
ergy MeV	Activity photons/sec	Fluence Rate MeV/cm²/sec No Buildup	Fluence Rate MeV/cm²/sec With Buildup	Exposure Rate mR/hr No Buildup	Exposure Rate mR/hr With Buildup
0.0322	5.305e+10	1.113e-195	5.343e-23	8.956e-198	4.300e-25
0.0364	1.930e+10	1.555e-137	2.342e-23	8.832e-140	1.331e-25
0.6616	1.250e+12	3.076e+03	2.927e+04	5.964e+00	5.675e+01
TOTALS:	1.365e+12	3.076e+03	2.927e+04	5.964e+00	5.675e+01
	Sensitivity	Variable	Y Dose Point 1	(1 of 2)	(213.77 cm)
0.0045	1.442e+10	0.000e+00	1.306e-24	0.000e+00	8.955e-25
0.0318	2.875e+10	9.783e-203	2.027e-23	8.149e-205	1.689e-25
0.0322	5.305e+10	1.098e-195	3.801e-23	8.837e-198	3.059e-25
0.0364	1.930e+10	1.518e-137	1.666e-23	8.624e-140	9.465e-26
0.6616	1.250e+12	2.134e+03	2.032e+04	4.138e+00	3.940e+01
TOTALS:	1.365e+12	2.134e+03	2.032e+04	4.138e+00	3.940e+01
	Sensitivity	Variable	Y Dose Point 1	(2 of 2)	(283.29 cm)
0.0045	1.442e+10	0.000e+00	6.921e-25	0.000e+00	4.744e-25
0.0318	2.875e+10	9.071e-203	1.074e-23	7.556e-205	8.946e-26
0.0322	5.305e+10	1.013e-195	2.013e-23	8.156e-198	1.620e-25
0.0364	1.930e+10	1.310e-137	8.825e-24	7.444e-140	5.014e-26
.16	1.250e+12	1.089e+03	1.039e+04	2.110e+00	2.015e+01
TOTALS:	1.365e+12	1.089e+03	1.039e+04	2.110e+00	2.015e+01

Page : 1
DOS File : W3S344A5.MS5
Run Date : June 19, 2001
Run Time : 5:13:24 PM
Duration : 00:00:04

RPP-8381, Rev. 0

File Ref:
Date: 6/27/01
By:
Checked: C.K.

Case Title: Case s344A5
Description: W-523-S-102 30-gal Accumulator - 344 uCi/ml, 5" of Fe Plate
Geometry: 8 - Cylinder Volume - End Shields



Source Dimensions

Height	52.487 cm	1 ft 8.7 in
Radius	26.243 cm	10.3 in

Dose Points

	X	Y	Z
# 1	0 cm	189.3766 cm	0 cm
	0.0 in	6 ft 2.6 in	0.0 in

Shields

Shield Name	Dimension	Material	Density
Source	1.14e+05 cm³	Water	1.4
Shield 1	121.92 cm	Air	0.00122
Shield 2	12.7 cm	Iron	7.86
Air Gap		Air	0.00122
Wall Clad	1.27 cm	Iron	7.86
Top Clad	1.27 cm	Iron	7.86

Source Input
Grouping Method : Actual Photon Energies

Nuclide	curies	becquerels	µCi/cm³	Bq/cm³
Ba-137m	3.7533e+001	1.3887e+012	3.3051e+002	1.2229e+007
Cs-137	3.9065e+001	1.4454e+012	3.4400e+002	1.2728e+007

Buildup
The material reference is : Shield 2

Integration Parameters

Radial	20
Circumferential	20
Y Direction (axial)	20

Results

Energy MeV	Activity photons/sec	Fluence Rate MeV/cm²/sec No Buildup	Fluence Rate MeV/cm²/sec With Buildup	Exposure Rate mR/hr No Buildup	Exposure Rate mR/hr With Buildup
0.0045	1.442e+10	0.000e+00	1.723e-24	0.000e+00	1.181e-24
0.0318	2.875e+10	4.378e-319	2.673e-23	3.646e-321	2.227e-25

DOS File : W3S344A5.MS5
Run Date: June 19, 2001
Run Time: 5:13:24 PM
Duration : 00:00:04

ıergy MeV	Activity photons/sec	Fluence Rate MeV/cm²/sec No Buildup	Fluence Rate MeV/cm²/sec With Buildup	Exposure Rate mR/hr No Buildup	Exposure Rate mR/hr With Buildup
0.0322	5.305e+10	3.628e-308	5.012e-23	2.919e-310	4.033e-25
0.0364	1.930e+10	1.071e-216	2.197e-23	6.082e-219	1.248e-25
0.6616	1.250e+12	1.541e+02	2.475e+03	2.988e-01	4.798e+00
TOTALS:	1.365e+12	1.541e+02	2.475e+03	2.988e-01	4.798e+00
	Sensitivity	Variable	Y Dose Point 1	(1 of 2)	(218.85 cm)
0.0045	1.442e+10	0.000e+00	1.236e-24	0.000e+00	8.471e-25
0.0318	2.875e+10	4.378e-319	1.918e-23	3.646e-321	1.597e-25
0.0322	5.305e+10	3.589e-308	3.595e-23	2.888e-310	2.893e-25
0.0364	1.930e+10	1.058e-216	1.576e-23	6.013e-219	8.953e-26
0.6616	1.250e+12	1.088e+02	1.746e+03	2.110e-01	3.385e+00
TOTALS:	1.365e+12	1.088e+02	1.746e+03	2.110e-01	3.385e+00
	Sensitivity	Variable	Y Dose Point 1	(2 of 2)	(288.37 cm)
0.0045	1.442e+10	0.000e+00	6.657e-25	0.000e+00	4.563e-25
0.0318	2.875e+10	3.582e-319	1.033e-23	2.984e-321	8.605e-26
0.0322	5.305e+10	3.454e-308	1.937e-23	2.780e-310	1.559e-25
0.0364	1.930e+10	9.882e-217	8.488e-24	5.614e-219	4.823e-26
316	1.250e+12	5.682e+01	9.123e+02	1.101e-01	1.769e+00
TOTALS:	1.365e+12	5.682e+01	9.123e+02	1.101e-01	1.769e+00

Holmes & Narver | D M J M

CALCULATION COVER SHEET

Date: 6/29/01

Calculation No: 4412.091.PCAL.001
Calculation Title: Tank 241-S-102 Retrieval Times and Volumes
Project No. & Title: 4412.091, Development of the Pre-Conceptual/Preliminary Engineering Documents For Tank S-102 Waste Retrieval

ORIGINAL AND REVISED CALCULATION/ANALYSIS APPROVAL

	Rev. 0 Name/Signature/Date	Rev. 1 Name/Signature/Date	Rev. ____ Name/Signature/Date
Originator:	R. A. Sexton	L.M. Swanson 6/29/01	
Checked By:	Lynn Swanson/Mark Currey	Mark Currey 6/29/01	
Approved By:	Jim Frederickson	Jim Frederickson 6/29/01	
Other:	Greg Bogen	Greg Bogen 6/29/01	

AFFECTED DOCUMENTS

Document Number	Document Title	Rev. Number
4412.091-PER-001	Preliminary Engineering Report for the 241-S-102 Waste Retrieval System	Rev. A

RECORD OF REVISION

Rev.	*Reason for Revision*
1	Add assumption of 20,000 gallon batch size for water addition and update calculation to reflect this change.

HND Hoffman & Northwest | D M J M

Project No. 4412.091

DESIGN CALCULATION SHEET

Calculation No. 4412.091.PCAL.001 Rev. No. 1	Performed By: L.M. Swanson Date: June 29, 2001
Calculation Title Tank 241-S-102 Retrieval Times and Volumes and Material Balance	Checked By: Mark Currey Date: June 29, 2001

INTRODUCTION

Purpose The purpose of this calculation is to:

- Estimate the time required and the volume of waste transferred for Phase I and Phase II batch retrieval operations of sludge/saltcake waste from tank 241-S-102 to tank 241-SY-102.
- Provide the inventory basis used for the total mass and volumes applied to the material balance on the Process Flow Diagram.

Scope This calculation addresses processing times and transfer volumes once introduction of water to the tank for retrieval purposes begins, until the objectives of 99% (by volume) retrieval and removal of 490 curies are achieved.

DESIGN BASIS

Design Inputs

1. Tank S-102 will be retrieved by first introducing a fluidic transfer system, adding water in a batch process and removing each batch with the fluidic transfer system, until about half of the saltcake is removed (Phase I operations). During the second phase, three mixing pumps will be deployed to facilitate mobilization and dissolution of the saltcake/sludge waste for retrieval. As the saturated salt solution moves to the middle of the tank, the fluidic transfer system will remove the waste slurry.
2. Water is added to the tank at the rate of 140 gpm.
3. The rate of transfer from the transfer system is 100 gpm .
4. Following each transfer, a water back flush of 400 ft. of 2"D piping is required. This results in a volume of 65 gal (246 L) of flush water per transfer. Raw water will be added through the back flush.
5. During Phase II operations, the mixing pumps and fluidic transfer system will operate separately, and the mixing pumps will be operated out-of-phase. During this second phase, raw water 55°F (13°C) will be added to the tank, mixing will be done, and material will be transferred and back flushed.
6. The mixing pumps each have a charge vessel that is 24"D and 24 ft. long, resulting in a vessel volume of 560 gal. (2,130 L).
7. Each charge vessel has the following cycle times:
   Drive time (time to empty charge vessel) = 37 seconds
   Vent time (reduction of vessel pressure before it empties) = 70 seconds
   Suction time (time to fill vessel) = 217 seconds.

DESIGN CALCULATION SHEET

Calculation No. 4412.091.PCAL.001 Rev. No. 1	Performed By: L.M. Swanson Date: June 29, 2001
Calculation Title Tank 241-S-102 Retrieval Times and Volumes and Material Balance	Checked By: Mark Currey Date: June 29, 2001

8. Air requirements for the mixer pumps are 600 scfm during the drive phase and 150 scfm during the evacuation cycle.

Criteria *As a goal, retrieve 99% of the tank 241-S-102 contents by volume (per the U.S. Department of Energy [DOE] Best-Basis Inventory [BBI] data of August 1, 2000.* (RPP-7512, Rev.0).

As a goal, retrieve approximately 490 curies of mobile long-lived radioisotopes. (RPP-7512, Rev.0).

Assumptions

1. During the first phase, approximately 50% of the saltcake will be removed by a multiple batch process of adding raw water (55°F) to the center cavity of the tank, allowing enough time to form a saturated salt solution. The dwell time to dissolve the solution is an unknown that dominates the calculation of total retrieval time. One day of dwell time per batch is assumed. A maximum addition of 20,000 gallons raw water is assumed during both Phase I and Phase II operations. An initial water addition of 2,000 gallons is assumed to facilitate removal of the saltwell pump and screen.
2. During the second phase of operation, most of the remaining 50% of the saltcake/sludge will be removed by operating the mixing pumps and fluidic transfer system.
3. During the mixing phase, some tank waste material will be dissolved without going through a mixer and some will be mixed more than once. For this calculation, it is assumed that tank waste material will average one time through the mixer.
4. Dissolution of saltcake will be done at a rate of 150% by mass. The resulting solution specific gravity, based on Herting, 1999, is 1.285.
5. The 26,000 gallons of sludge estimated to be present in the tank is assumed to be mixed with an equal volume of water to facilitate transfer during Phase II operations.

The best basis inventory as of 8/01/2000 for the estimated tank volumes and the radionuclide inventory for the contaminents of concern are provided in Tables 1 and 2.

DESIGN CALCULATION SHEET

Calculation No. 4412.091.PCAL.001 Rev. No. 1	Performed By: L.M. Swanson Date: June 29, 2001
Calculation Title Tank 241-S-102 Retrieval Times and Volumes and Material Balance	Checked By: Mark Currey Date: June 29, 2001

Table 1 – Tank S-102 Starting Volumes

Phase	Type	Density	Volume (gal.)
Saltcake	Solids	1.68	290,000
	Liquid	1.39	40,000
	Retained Gas	N/A	116,000
	Subtotal – Saltcake Phase Volume		446,000
Sludge	Solids	1.88	16,000
	Liquid	1.39	3,000
	Retained Gas	N/A	7,000
	Subtotal – Sludge Phase Volume		26,000
Total Volume			472,000

Table 2 - Tank S-102 Radionuclide Inventory for Mobile, Long-Lived Radionuclides (Best-Basis Inventory, 8/01/2000)

Analyte	Inventory (Ci)	Basis[a] (S,E, or C)	Comment
^{14}C	6.04E+01	E	
^{79}Se	3.70E+00	E	
^{99}Tc	4.12E+02	E	
^{232}U	1.37E+00	C	Based on UTOTAL and HDW model isotopic distribution.
^{233}U	5.26E+00	C	Based on UTOTAL and HDW model isotopic distribution.
^{234}U	1.63E+00	C	Based on UTOTAL and HDW model isotopic distribution.
^{235}U	6.63E-02	C	Based on UTOTAL and HDW model isotopic distribution.
^{236}U	5.07E-02	C	Based on UTOTAL and HDW model isotopic distribution.
^{238}U	1.49E+00	S/C	Based on UTOTAL and HDW model isotopic distribution as well as sample data.
TOTAL	4.86E+02		

[a] Source: Best-Basis Inventory Estimate for Radioactive Components in Tank 241-S-102 Decayed to January 1, 1994 (Effective August 1, 2000)

S=Sample concentration from the tank of interest

C=Calculated from other analyte data (e.g., ^{90}Y from ^{90}Sr, U isotopes from U_{TOTAL}, etc.)

E=Derived from engineering assessment or process knowledge including application of sample data from other tanks of interest

DESIGN CALCULATION SHEET

Calculation No. 4412.091.PCAL.001 Rev. No. 1	Performed By: L.M. Swanson Date: June 29, 2001
Calculation Title Tank 241-S-102 Retrieval Times and Volumes and Material Balance	Checked By: Mark Currey Date: June 29, 2001

REFERENCES

Herting, D. L., 1999, *Saltcake Dissolution FY 1999 Status Report*, HNF-5193, Rev. 0, Numatec Hanford Corporation, Richland, WA.

Best Basis Inventory and Tank Characterization Database, Internet at http://twins.pnl.gov/twins3/twins.html.

Tank 241-S-102 Waste Retrieval System Level 2 Specification, RPP-7512, Rev. 0 (Draft).

METHODS

A spreadsheet calculation was used for phase 1 operations, as described below. The remaining calculations were hand calculations as described below.

RESULTS AND CONCLUSIONS

A total retrieval time of 46 days is estimated, but this estimate is heavily influenced by two assumptions for which there is little data.

1. A dwell time of one day is assumed for batch wise dissolution of saltcake by water addition to the center cavity.
2. Mixing pumps can be installed after 50% of the saltcake has been retrieved.

The total volume transferred is estimated at:
504,000 gallons (Phase 1)+ 547,000 gallons (Phase 2)= 1,051,000 gallons.

The maximum batch transfer for Phase 1 is 27,000 gallons.
The maximum batch transfer for Phase 2 is 27,400 gallons.

CALCULATION/ ANALYSIS

Using the assumptions given:
One gram of saltcake occupies:

Unit mass saltcake/density of saltcake * Volume of saltcake phase/Volume of saltcake only =

1 g/1.68 g/ml * 446,000 gallon saltcake phase/290,000 gallons saltcake= 0.915 ml saltcake phase.

DESIGN CALCULATION SHEET

Calculation No. 4412.091.PCAL.001 Rev. No. 1	Performed By: L.M. Swanson Date: June 29, 2001
Calculation Title Tank 241-S-102 Retrieval Times and Volumes and Material Balance	Checked By: Mark Currey Date: June 29, 2001

One gram of saltcake is accompanied by:

Unit volume of saltcake * Total volume interstitial liquid/Total volume saltcake phase =

0.915 ml saltcake phase * 40,000 gallons interstitial liquid/446,000 gallons saltcake phase= 0.082 ml interstitial liquid.

Therefore, assuming 150%, by mass, dissolution of saltcake, 1 gram of saltcake requires 1.5 grams of water = 1.5 ml water

1 g saltcake = 0.915 ml (as shown above)
1.5 ml water + 0.915 ml saltcake phase will produce:
2.5 g saturated solution @ 1.285 g/ml = 1.95 ml saturated solution
plus 0.082 ml interstitial liquid @ 1.39 g/ml = 0.114 g
total mass = 2.5 g + 0.114 g = 2.614 g
total volume = 1.95 ml + 0.082 ml = 2.03 ml
specific gravity = 2.614 g / 2.03 ml = 1.29 g/ml

The following spreadsheet simulates a multiple batch process for dissolution of 50% of the saltcake phase = 446,000 gallons * 0.5 = 223,000 gallons

The back flush volume is: (400 ft. of 2"D piping)

$V = \pi * r^2 * l$
$= \pi * (1/12\ ft)^2 * 400\ ft. = 8.7\ ft^3 * 7.48\ gal/ft^3 = 65$ gallons
The backflush time and volume are therefore neglected.

Subsequent batches are based on the increased size of the cavity to a maximum addition of 20,000 gallons.

Project No. 4412.091

DESIGN CALCULATION SHEET

Calculation No. 4412.091.PCAL.001 Rev. No. 1	Performed By: L.M. Swanson Date: June 29, 2001
Calculation Title Tank 241-S-102 Retrieval Times and Volumes and Material Balance	Checked By: Mark Currey Date: June 29, 2001

Phase I Operations

A	B	C	D	E	F	G
Water added (gallons)	Saltcake Removed (gallons)	Liquid Transferred (gallons)	Time (minutes) Addition Time	Dwell Time	Transfer Time	Total Batch
2,000	1,220	2,707	14	1,440	27	1,481
3,220	1,964	4,358	23	1,440	44	1,507
5,184	3,162	7,016	37	1,440	70	1,547
8,347	5,091	11,296	60	1,440	113	1,613
13,438	8,197	18,186	96	1,440	182	1,718
20,000	12,200	27,067	143	1,440	271	1,854
20,000	12,200	27,067	143	1,440	271	1,854
20,000	12,200	27,067	143	1,440	271	1,854
20,000	12,200	27,067	143	1,440	271	1,854
20,000	12,200	27,067	143	1,440	271	1,854
20,000	12,200	27,067	143	1,440	271	1,854
20,000	12,200	27,067	143	1,440	271	1,854
20,000	12,200	27,067	143	1,440	271	1,854
20,000	12,200	27,067	143	1,440	271	1,854
20,000	12,200	27,067	143	1,440	271	1,854
20,000	12,200	27,067	143	1,440	271	1,854
20,000	12,200	27,067	143	1,440	271	1,854
20,000	12,200	27,067	143	1,440	271	1,854
20,000	12,200	27,067	143	1,440	271	1,854
20,000	12,200	27,067	143	1,440	271	1,854
20,000	12,200	27,067	143	1,440	271	1,854
TOTAL	227,035	503,695		31,680		39,375
			Days	22		27

Note: The above table is displayed in whole numbers, but the spreadsheet calculation includes decimal fractions. Since many of the steps in the calculation are identical, roundoff differences are repeated, so adding whole numbers from the table will result in different values from the more accurate totals shown above.

DESIGN CALCULATION SHEET

Calculation No. 4412.091.PCAL.001 Rev. No. 1	Performed By: L.M. Swanson Date: June 29, 2001
Calculation Title Tank 241-S-102 Retrieval Times and Volumes and Material Balance	Checked By: Mark Currey Date: June 29, 2001

Phase I Operations

Phase I batch wise dissolution requires 27 days, 22 days of which is dwell time. From the spreadsheet, an average batch transfer is 27,000 gallons.

Explanation of table columns:
Column A (Water Addition): Assumes initial addition of 2,000 gallons. Water addition increases by the amount of saltcake removed (column B) to a maximum assumed addition of 20,000 gallons.

Column B (Saltcake Removed): Water addition (Column A) * (0.915 ml /1.5 ml), based on previous calculation of volume of saltcake dissolved per water addition

Column C (Liquid Transferred): Water addition (Column A) * (2.03 ml /1.5 ml), based on previous calculation of volume of solution produced per water addition.

Column D (Addition Time): Water addition (Column A) / 140 gpm.

Column E (Dwell Time): 24 hours (1440 minutes) is assumed.

Column F (Transfer Time): Liquid Transferred (Column C) / 100 gpm.

Column G (Total Batch Time): Sum of Columns D, E, and F.

Phase II Operations:

The remaining saltcake/sludge is 446,000 gallons / 2 = 223,000 gallons.

For dissolution of the remaining saltcake, this will produce:

223,000 gallons * 2.03 ml /0.915 ml = 495,000 gallons of solution to be transferred.

The water addition for saltcake dissolution will be 223,000 gallons * 1.5 ml/0.915 ml = 366,000 gallons.

DESIGN CALCULATION SHEET

Calculation No. 4412.091.PCAL.001 Rev. No. 1	Performed By: L.M. Swanson Date: June 29, 2001
Calculation Title Tank 241-S-102 Retrieval Times and Volumes and Material Balance	Checked By: Mark Currey Date: June 29, 2001

The 26,000 gallons of sludge will be mixed with an equal volume of water (see assumption #5) producing 52,000 gallons to be transferred.

Therefore, the total volume transfer for Phase II is:
495,000 gal (saltcake slurry) + 52,000 gal. (sludge slurry) = **547,000 gal.**

Water Addition Time (Phase II Operations)

Total water added = 366,000 gallons added to dissolve saltcake + 26,000 gallons added to move sludge = 392,000 gallons
At 140 gpm this will require 2,800 minutes to add.
Number of batches = 392,000 gal./20,000 gal/batch ≅ 20 batches

Mixing Time (Phase II Operations)

The mixing rate per mixing pump is the volume of the mixing charge vessel divided by the cycle time. The total mixing rate is the rate per vessel times three vessels.

Charge vessel volume = $\pi * r^2 * h = \pi * (1\ ft)^2 * 24\ ft. = 75.4\ ft^3 * 7.48\ gal/ft^3 = 564$ gallons

The cycle time = 37 + 70 + 217 seconds = 324 seconds = 5.4 minutes

Mixing rate per pump = 564 gallons / 5.4 minutes = 104 gpm

Total mixing rate = 104 gpm * 3 pumps = 312 gpm

The total mixing time is the total volume of solution in Phase II operations divided by the total mixing rate.

Mixing time = 495,000 gallons solution + 52,000 gallons sludge and water = 547,000 gallons / 312 gpm = 1,800 minutes

Transfer Time (Phase II Operations)

The transfer time is the total volume transferred divided by the transfer rate.

DESIGN CALCULATION SHEET

Calculation No. 4412.091.PCAL.001 Rev. No. 1	Performed By: L.M. Swanson Date: June 29, 2001
Calculation Title Tank 241-S-102 Retrieval Times and Volumes and Material Balance	Checked By: Mark Currey Date: June 29, 2001

547,000 gallons / 100 gpm = 5,500 minutes

Phase II Total Transfer Time

Total Phase 2 Time is:

2,800 min (water addition) +1,800 min (mixing) + 5,500 min (transfer) = 10,100 min = 7 days

Phase II Batch Size

Based on a total volume of 547,000 gallons saltcake/sludge slurry for retrieval, and assuming 20 transfers, produces a batch transfer size of 27,350 gal/batch.

Total Retrieval Time

If a 75% availability is assumed, the total retrieval time is:

(27 days + 7 days) / 0.75 = 45.3 ~ **46 days**.

Total Volume Retrieved

The total volume transferred is estimated at:
504,000 gallons (Phase 1)+ 547,000 gallons (Phase 2)= 1,051,000 gallons.

The maximum batch transfer for Phase 1 is 27,000 gallons.
The maximum batch transfer for Phase 2 is 27,400 gallons.

HNDTEAM

CALCULATION COVER SHEET

Date: 6/19/01

Calculation No: 4412.091.SCAL.001
Calculation Title: Dome Load Summary
Project No. & Title: 4412-091, S-102 Preliminary Engineering Report

ORIGINAL AND REVISED CALCULATION/ANALYSIS APPROVAL

	Rev. A Name/Signature/Date	Rev. ____ Name/Signature/Date	Rev. ____ Name/Signature/Date
Originator:	Michael R Custer Michael R. Custer 6/26/01		
Checked By:	John Elsen 6/26/01 John Elsen		
Approved By:			
Other:			

AFFECTED DOCUMENTS

Document Number	Document Title	Rev. Number

RECORD OF REVISION

Rev.	*Reason for Revision*
A	Preliminary Issue

Attachment A (1 Sheet)

HNDTEAM DESIGN CALCULATION SHEET	Project No 4412-091 Sheet 2 of 4
Calculation No 4412.091.SCAL.001 Rev. No A Calculation Title Dome Load Summary	PERFORMED BY M.R Custer DATE 6/19/01 Print & Sign Name CHECKED BY J Elsen DATE 6/26/01 Print & Sign Name

INTRODUCTION

Purpose

The purpose of this calculation is to determine and document the preliminary Dome Loads, which will be added to the domes of Tank S-102 and Tank SY-102 by the implementation of the Project.

Scope

This calculation documents the preliminary, additional Dome Loads to be added to Tank S-102 and Tank SY-102.

DESIGN BASIS

Design Inputs

Design input information provided by the References.

Criteria

None required.

Assumptions

None

REFERENCES

1. Hanford Site Documents:
   a. RPP-8367, Rev. A

METHODS

Hand Calculation

RESULTS AND CONCLUSIONS

The calculation provides a preliminary summary of the additional loads, which will be added to the top of the tank dome at Tank S-102 and Tank SY-102, as result of the implementation of the project.

HNDTEAM	DESIGN CALCULATION SHEET	Calc.#: 4412.091.SCAL.001 Rev: A Page 3 of 4

Design Calculation Title: Dome Load Summary	Orig: M.R Custer	Date: 6/19/01
Project No. & Title: 4412-091, S-102 Preliminary Engineering Report	Checker: J. Elsen	Date: 6/26/01

DESIGN/ ANALYSIS:

This calculation is performed to define the additional dome loads and proposed locations due to the installation of equipment and components, as a result of the implementation of the project.

Dome Load Summary - Tank S-102			
Type of Load	Item Description	Weight (lbs)	Comments
CS shielding plate for the OGT Transfer Line	3"x 4.0 ft x 58 ft x 490 pcf	28400	Over the OGT, Line (from center of tank to 20 ft from wall)
CS cover plate	3" x 8.0 ft x 8.0 ft x 490 pcf	7900	Over S-102 pit
Equipment	Fluidic Pump	9200	Location, Pit at center of tank, (weight full)
Equipment	Fluidic Mixer	9300	Location, manhole due west of tank center, 0°(wt. full)
Equipment	Fluidic Mixer	9300	Location, manhole at 120°, (wt. full)
Equipment	Fluidic Mixer	9300	Location, manhole at 240°(wt. full)
Fluidic Mixer foundation	(4), 5 ft x 5 ft x 8"/12 x 150 lb/ cubic ft	10000	Location per Attachment A
Fluidic Mixer foundation	(4), 5 ft x 5 ft x 8"/12 x 150 lb/ cubic ft	10000	Location per Attachment A
Fluidic Mixer foundation	(4), 5 ft x 5 ft x 8"/12 x 150 lb/ cubic ft	10000	Location per Attachment A
Equipment	Valve Skid	2000	Location per Attachment A
Valve Skid foundation	4 ft x 16 ft x 6"/12 x 150 lb/ cubic ft	4800	Location per Attachment A
Equipment	Off-Gas Skid	4000	Location per Attachment A
Steel Pipe	(3) Manhole extensions	9000	See Fluidic Mixer locations
CS Plate Shield Box	3" x 2.0 ft x 4.0 ft x 490 pcf	3400	OGT Shielding

HNDTEAM	DESIGN CALCULATION SHEET	Calc.#: 4412.091.SCAL.001 Rev: A Page 4 of 4

Design Calculation Title: Dome Load Summary	Orig: M.R Custer	Date: 6/19/01
Project No. & Title: 4412-091, S-102 Preliminary Engineering Report	Checker: J. Elsen	Date: 6/26/01

Dome Load Summary – Tank SY-102			
Type of Load	Item Description	Weight (lbs)	Comments
CS shielding plate for the OGT Transfer Line	3" x 4.0 ft x 58 ft x 490 pcf	28400	Over the OGT Line (from center of tank to 20 ft from wall
CS cover plate	3" x 8.0 ft x 14.0 ft x 490 pcf	13700	Over SY-102 pit
CS Plate Shield Box	3" x 2.0 ft x 4.0 ft x 490 pcf	3400	OGT Shielding
Concrete Cover Block	8.0 ft x 14.0 ft x 1.0 ft x 150 pcf	-16800	To be Removed

AEA Technology 4-Diode Pump Simulation

Date: 6/6/2001

Outline Design Information

AEAT Optimal Performance Waste Retrieval System

- 4-Diode pump installed in central 42" diameter riser
- 3 off RFD/Washer units, each installed in 42" diameter manways

4-Diode Pump

Charge Vessel:	2 off 18" diameter x 16 ft long
Cycle Times: Drive Time Refill Time	 26 secs 26 secs
Air Consumption:	650 SCFM (continuous)

RFD/Washer unit

Note: The values below relate to a single unit.

Charge Vessel:	24" diameter x 24 ft long
Cycle Times: Drive Time Vent Time Suction Time	 37 secs 70 secs 217 secs
Air Consumption: Peak air flow to Jet Pumps (i.e. during the drive phase) Average air flow to Jet Pumps (averaged over the cycle)	 590 SCFM 150 SCFM

Total Air flow Requirements

From the above:

- Total average air flow requirement = 650 SCFM + 3x150 SCFM = 1100 SCFM.
- Total peak airflow requirement = 650 SCFM + 3x590 SCFM = 2420 SCFM

The alternative arrangements for meeting the compressed air demand are:

a) Supply compressors with sufficient capacity to meet the maximum demand (2420 SCFM)

b) Supply smaller compressors (say 1500 SCFM??) together with an accumulator

In addition it would be possible to phase the operations such that the peak flow requirements of the RFD/Washer units do not occur simultaneously.

S. A. Taylor

6th June 2001

4 DIODE PUMP
SIMULATION INPUT DESIGN DATA

Design stored on disk as data file 2208_003
DU characteristics stored on disk as data file 2208JPP3
0 Date30/4/2001
1 Pump referenceSST_03
2 Designers referenceSAT

3 Liquid relative density= 1.3
4 Liquid vapour pressure (psia)= .2
5 Liquid viscosity (Ns/m2)= .03
6 Displacement vessel height (m)= 5
7 Displacement vessel diameter (mm)= 457
8 Operating gas temperature (K)= 300
9 Air pipe length DU to vessel (m)= 10
10 Air pipe diameter (mm)= 50
11 Feed tank level (m)= 1
12 gas sp ht ratio= 1.4
13 ht trans coef (m2w/K)= 15
14 gas density (kg/m3)= 1.2
15 Feed pipe length (m)= 2
16 Feed pipe diameter (mm)= 75
17 spare input= 0
18 spare input= 0
19 spare input= 0

Delivery pipe geometry, up to 20 segments plus a resistance

	Length (m)	Angle (deg)	Diameter (mm)
1	12.192	90	77.93
2	109.63	1.115	77.93

Resistive load, psi drop at 1 l/min flowrate = 0

Diode sizes are:
23 Inlet diode diameter axial port (mm)= 50
24 outlet diode diameter (mm)= 50

Diode characteristics, Outlet diode 0-9, Inlet diode 10-19
0 Re= 0 Eu= .45
1 Re= 100000 Eu= .4
2 Re= 200000 Eu= .39
3 Re= 500000 Eu= .38
4 Re= 0 Eu= 1.47
5 Re= 0 Eu= 10
6 Re= 20000 Eu= 20
7 Re= 40000 Eu= 28
8 Re= 60000 Eu= 30
9 Re= 60000 Eu= 24
10 Re= 0 Eu= .45
11 Re= 100000 Eu= .4
12 Re= 200000 Eu= .39
13 Re= 500000 Eu= .38
14 Re= 0 Eu= 1.47
15 Re= 0 Eu= 10
16 Re= 20000 Eu= 20
17 Re= 40000 Eu= 28
18 Re= 60000 Eu= 30
19 Re= 60000 Eu= 24

Drive unit characteristics are:
Drive unit reference :Scaled standard H25S

```
 1  Supply pressure drive, psig        P5 = 68.50205
 2  Supply drive flow, SLM             Q5 = 4000
 3  Supply pressure refill, psig       P2 = 56.24942
 4  Supply refill flow, SLM            Q2 = 4000
 5  Drive maximum pressure, psig       B0 = 67.81703
 6  Drive pressure point 1, psig       B1 = 60.96683
 7  Drive pressure point 2, psig       B2 = 46.58139
 8  Drive flow point 1, SLM            O1 = 36252.32
 9  Drive flow point 2, SLM            O2 = 41348.8
10  Drive flow maximum, SLM            O0 = 41589.2
11  Refill pressure point 3, psig      B3 =-6
12  Refill pressure point 4, psig      B4 = 0
13  Refill pressure point 5, psig      B5 = 11.24988
14  Refill flow point 3, SLM           O3 =-7897.175
15  Refill flow point 4, SLM           O4 =-13959
16  Refill flow point 5, SLM           O5 =-33605
17  Refill blowdown threshold, psig    B7 = 56.24942
18  Refill maximum suction, psig       B9 =-12


Linear scale factors, drive and refill = 0                0
Target values of PR, QR, PD, QD = 0  0  0  0
Steady state pump rate estimate l/min = 0

                 4 Diode Pump Simulation Program
                Design data file    2208_003
                Drive unit file     2208JPP3
                Drive unit ref.     Scaled standard H25S
                Date                30/4/2001
                Pump reference      SST_03
                Designer name       SAT

Step time (sec)=  .1
How many pump cycles do you want to simulate  20
Do you want cycle output (1 or 0) 1
How many cycles before output ? 18
Pump operates with top level detection on each vesselThe displacement vessel height is (m), 5
Select maximum vessel operating level, above mid point (m) 5
Do you wish to change operating pressures, yes=1, no=0  1
Current drive and refill supply presures in psig are; 39.5              56
Select new values for these pressures  39.5              56
The pipe can start empty but this can cause start-up problems
as the low pipe head gives increased outflow and the danger of
bottom blowout, unless reduced start-up drive pressure is used.
Total delivery pipe volume when full, litres =  580.7494
Select the initial volume of liquid in the pipe, litres ! 570
Do you want diagnostic output, yes=1, no=0 0
```

Cycle	Side	Stroke Time	L & Stroke(ft)	R	Pumprate (l/min)	Drive P	Drive Q	Suck P	Suck Q
0	L	5.42	2.79	3.29	219.8	37.18	4924.1	-11.47	-398.2
0	R	11.58	6.12	6.80	414.6	37.08	5186.7	-11.48	-397.2
1	L	12.51	7.28	6.44	409.7	37.05	5243.2	-11.48	-396.7
1	R	13.40	6.92	7.74	405.1	37.05	5249.9	-11.48	-396.4
2	L	14.25	8.20	7.38	406.2	37.03	5292.8	-11.48	-396.1
2	R	15.11	7.85	8.67	405.5	37.02	5339.6	-11.48	-395.5
3	L	15.98	9.12	8.32	403.4	37.01	5356.2	-11.48	-395.0
3	R	16.82	8.78	9.57	402.1	37.00	5374.6	-11.48	-394.5
4	L	17.60	9.98	9.22	399.5	37.00	5371.7	-11.48	-394.5
4	R	18.36	9.63	10.38	398.2	36.99	5395.0	-11.48	-394.1
5	L	19.10	10.78	10.04	399.4	36.98	5426.2	-11.48	-393.5
5	R	19.82	10.44	11.15	398.2	36.98	5428.8	-11.48	-393.3
6	L	20.49	11.48	10.81	393.2	36.98	5432.3	-11.48	-392.9
6	R	21.10	11.15	11.81	393.4	36.98	5436.4	-11.48	-392.6
7	L	21.66	12.09	11.47	391.1	36.98	5434.8	-11.48	-392.7
7	R	22.18	11.75	12.36	391.4	36.98	5441.4	-11.48	-392.4
8	L	22.67	12.61	12.03	389.7	36.98	5439.1	-11.48	-392.3
8	R	23.12	12.28	12.86	391.4	36.97	5443.8	-11.48	-391.8
9	L	23.57	13.08	12.53	388.3	36.97	5452.1	-11.48	-391.7
9	R	23.94	12.75	13.27	387.4	36.97	5448.0	-11.48	-391.4
10	L	24.28	13.45	12.94	387.9	36.97	5447.9	-11.48	-391.5

10	R	24.60	13.12	13.59	384.3	36.97	5444.9	-11.48	-391.3
11	L	24.85	13.73	13.26	384.2	36.97	5452.6	-11.48	-391.2
11	R	25.08	13.40	13.86	385.9	36.97	5451.3	-11.48	-391.2
12	L	25.33	13.96	13.53	383.0	36.97	5443.9	-11.48	-391.1
12	R	25.52	13.64	14.06	383.4	36.97	5446.1	-11.48	-391.0
13	L	25.69	14.15	13.74	382.6	36.97	5445.4	-11.48	-390.8
13	R	25.84	13.83	14.24	382.9	36.97	5447.1	-11.48	-390.8
14	L	25.98	14.31	13.91	383.7	36.98	5439.5	-11.48	-390.8
14	R	26.12	13.99	14.40	384.9	36.97	5443.6	-11.48	-390.6
15	L	26.27	14.45	14.08	381.0	36.98	5439.6	-11.48	-390.6
15	R	26.36	14.12	14.51	382.8	36.98	5441.0	-11.48	-390.5
16	L	26.46	14.56	14.19	382.2	36.98	5429.6	-11.48	-390.5
16	R	26.54	14.23	14.58	380.5	36.98	5422.8	-11.48	-390.5
17	L	26.58	14.63	14.26	383.1	36.97	5444.9	-11.48	-390.6
17	R	26.68	14.31	14.67	382.2	36.98	5438.4	-11.48	-390.3

T	Pl	Pr	Ll	Lr	Qp	Pp	Qin	Eri	Ero	Eli	Elo
770.87	-6.67	36.75	16.67	2.11	331.6	36.26	%-693.4	15.40	0.44	11.01	15.18
770.88	4.41	36.42	16.78	2.11	335.1	36.47	%-946.5	15.37	0.44	13.32	14.34
770.91	29.99	35.80	16.57	2.10	354.0	37.63	%-1174.1	15.33	11.33	15.48	0.45
771.20	37.68	30.18	16.26	2.08	425.2	42.57	%-1180.1	14.95	13.50	15.92	0.44
771.61	37.91	23.82	16.05	2.06	496.2	48.39	%-1127.4	14.45	14.12	15.93	0.44
772.05	34.77	17.51	15.78	2.07	441.4	43.82	%-1044.6	13.88	14.40	15.75	0.44
772.55	39.60	12.83	15.51	2.09	445.4	44.14	%-1017.0	13.34	15.08	16.01	0.44
773.15	39.53	8.45	15.19	2.13	474.5	46.51	%-949.6	12.74	15.33	15.99	0.44
773.76	38.66	5.09	14.86	2.20	456.1	44.99	%-876.4	12.13	15.48	15.94	0.44
774.26	37.36	2.85	14.58	2.26	427.6	42.75	%-804.9	11.56	15.53	15.86	0.44
774.76	37.38	0.98	14.30	2.35	439.8	43.69	%-712.4	10.73	15.63	15.85	0.44
775.26	37.31	-0.53	14.02	2.50	411.4	41.54	-61.3	0.44	15.71	15.83	0.44
775.76	37.31	-1.75	13.75	2.73	383.2	39.55	199.0	0.44	15.77	15.83	0.44
776.26	37.26	-2.79	13.47	2.99	427.7	42.76	364.5	0.44	15.79	15.81	0.44
776.76	37.24	-3.69	13.19	3.27	378.4	39.22	483.0	0.44	15.84	15.80	0.44
777.26	37.22	-4.46	12.91	3.57	428.4	42.81	571.8	0.44	15.85	15.79	0.44
777.76	37.19	-5.13	12.63	3.89	373.1	38.87	641.2	0.44	15.88	15.78	0.44
778.26	37.20	-5.73	12.35	4.21	386.0	39.74	653.0	0.47	15.89	15.77	0.44
778.76	37.16	-6.27	12.07	4.53	376.5	39.09	654.2	0.50	15.90	15.76	0.44
779.26	37.17	-6.77	11.79	4.85	436.5	43.44	655.2	0.53	15.89	15.75	0.44
779.76	37.16	-7.22	11.51	5.17	435.5	43.36	656.2	0.55	15.90	15.74	0.44
780.26	37.14	-7.64	11.24	5.49	382.2	39.48	657.3	0.57	15.92	15.73	0.44
780.76	37.12	-8.03	10.96	5.81	374.8	38.98	658.4	0.59	15.92	15.72	0.44
781.26	37.12	-8.38	10.69	6.13	409.0	41.36	659.4	0.61	15.91	15.71	0.44
781.76	37.12	-8.71	10.41	6.45	417.4	41.99	660.4	0.62	15.91	15.71	0.44
782.26	37.08	-9.02	10.13	6.77	393.9	40.29	661.6	0.63	15.92	15.69	0.44
782.76	37.08	-9.30	9.86	7.09	380.8	39.38	662.6	0.64	15.92	15.68	0.44
783.26	37.06	-9.56	9.58	7.41	369.4	38.62	663.7	0.65	15.92	15.67	0.44
783.76	37.07	-9.79	9.31	7.73	388.3	39.90	664.7	0.65	15.90	15.67	0.44
784.25	37.06	%-10.01	9.04	8.05	375.1	39.00	665.7	0.66	15.90	15.66	0.44
784.75	37.06	%-10.21	8.77	8.37	380.1	39.34	666.7	0.66	15.89	15.65	0.44
785.25	37.04	%-10.38	8.49	8.69	346.3	37.15	667.9	0.66	15.89	15.64	0.44
785.75	37.04	%-10.54	8.22	9.01	391.8	40.14	668.8	0.66	15.87	15.63	0.44
786.25	37.03	%-10.69	7.95	9.33	357.4	37.85	669.9	0.65	15.87	15.62	0.44
786.75	37.03	%-10.81	7.68	9.65	384.0	39.60	670.9	0.65	15.85	15.61	0.44
787.25	37.04	%-10.92	7.41	9.97	349.3	37.34	671.8	0.64	15.85	15.60	0.44
787.75	37.03	%-11.02	7.14	10.29	383.7	39.58	672.8	0.63	15.83	15.59	0.44
788.25	37.03	%-11.10	6.88	10.61	354.8	37.68	673.8	0.63	15.82	15.58	0.44
788.75	37.03	%-11.17	6.61	10.92	372.2	38.81	674.8	0.62	15.80	15.57	0.44
789.25	37.02	%-11.23	6.34	11.24	352.2	37.52	675.9	0.61	15.79	15.56	0.44
789.75	37.02	%-11.28	6.08	11.56	384.0	39.60	676.9	0.59	15.77	15.55	0.44
790.25	37.02	%-11.32	5.82	11.88	354.0	37.63	677.8	0.58	15.76	15.54	0.44
790.75	37.02	%-11.35	5.55	12.20	320.5	35.62	678.8	0.57	15.75	15.54	0.44
791.25	37.02	%-11.38	5.29	12.51	373.6	38.90	679.8	0.56	15.72	15.53	0.44
791.75	37.02	%-11.40	5.03	12.83	329.9	36.16	680.8	0.54	15.72	15.52	0.44
792.25	37.01	%-11.42	4.77	13.15	358.7	37.93	681.8	0.53	15.69	15.51	0.44
792.75	37.01	%-11.43	4.50	13.46	344.5	37.04	682.9	0.51	15.68	15.50	0.44
793.25	37.01	%-11.44	4.24	13.78	324.5	35.85	683.8	0.50	15.66	15.49	0.44
793.75	37.01	%-11.45	3.99	14.09	313.8	35.24	684.8	0.48	15.65	15.48	0.44
794.25	37.01	%-11.45	3.73	14.41	321.2	35.66	685.8	0.47	15.63	15.47	0.44
794.75	37.02	%-11.46	3.47	14.72	355.1	37.70	686.7	0.45	15.60	15.46	0.44
795.25	37.02	%-11.46	3.21	15.04	333.5	36.38	683.0	0.44	15.59	15.45	0.44
795.75	37.02	%-11.47	2.96	15.35	353.1	37.58	661.2	0.44	15.56	15.44	0.44
796.25	37.02	%-11.47	2.70	15.66	306.5	34.84	639.6	0.44	15.56	15.44	0.44

797.16	36.96	%-11.48	2.28	16.16	335.8	36.52	599.1	0.44	15.51	15.41	0.44
18	L	26.75	14.72	14.35	383.7	36.97	5448.4	-11.48	-390.3		
T	Pl	Pr	Ll	Lr	Qp	Pp	Qin	Eri	Ero	Eli	Elo
797.61	36.90	%-10.73	2.06	16.47	306.2	34.82	461.0	0.44	15.46	15.40	0.44
797.62	36.70	-5.14	2.06	16.70	347.8	37.24	%-759.5	11.60	15.07	15.39	0.44
797.64	36.32	8.00	2.05	16.79	346.4	37.16	%-990.2	13.72	14.01	15.37	0.44
797.67	35.49	37.17	2.04	16.40	448.6	44.39	%-1216.7	15.90	0.44	15.31	12.78
797.98	28.21	38.89	2.02	16.20	435.0	43.32	%-1171.3	15.99	0.44	14.80	13.84
798.46	22.33	38.44	2.01	16.00	433.5	43.20	%-1116.3	15.96	0.44	14.33	14.32
798.87	16.78	33.93	2.02	15.75	417.2	41.97	%-1030.7	15.69	0.44	13.80	14.40
799.38	12.20	38.69	2.04	15.48	435.6	43.36	%-1002.6	15.96	0.44	13.26	15.07
799.98	8.03	39.52	2.09	15.16	433.8	43.23	%-941.7	15.99	0.44	12.67	15.37
800.60	4.70	38.48	2.15	14.82	455.2	44.92	%-865.0	15.93	0.44	12.04	15.49
801.10	2.53	37.36	2.22	14.54	446.4	44.21	%-792.1	15.85	0.44	11.44	15.55
801.60	0.72	37.35	2.31	14.26	419.6	42.15	%-681.0	15.84	0.44	10.43	15.65
802.10	-0.74	37.34	2.49	13.98	389.2	39.96	-3.2	15.83	0.44	0.44	15.73
802.60	-1.92	37.27	2.72	13.70	430.5	42.97	233.4	15.82	0.44	0.44	15.76
803.10	-2.93	37.29	2.99	13.43	394.2	40.31	388.5	15.81	0.44	0.44	15.81
803.60	-3.81	37.25	3.27	13.15	416.6	41.93	501.0	15.80	0.44	0.44	15.83
804.10	-4.56	37.21	3.58	12.87	416.9	41.95	586.2	15.79	0.44	0.44	15.85
804.60	-5.22	37.21	3.89	12.59	399.5	40.69	652.0	15.78	0.44	0.44	15.88
805.10	-5.81	37.18	4.21	12.31	383.6	39.58	653.2	15.77	0.44	0.48	15.90
805.60	-6.34	37.19	4.53	12.03	401.4	40.82	654.1	15.76	0.44	0.51	15.90
806.10	-6.83	37.16	4.85	11.75	435.0	43.32	655.3	15.75	0.44	0.53	15.90
806.60	-7.28	37.14	5.17	11.48	420.6	42.22	656.5	15.74	0.44	0.56	15.91
807.10	-7.69	37.15	5.49	11.20	402.0	40.86	657.4	15.73	0.44	0.58	15.92
807.60	-8.08	37.11	5.81	10.92	420.6	42.22	658.6	15.72	0.44	0.60	15.91
808.10	-8.43	37.12	6.13	10.65	369.3	38.61	659.5	15.71	0.44	0.61	15.93
808.59	-8.75	37.09	6.45	10.37	402.8	40.92	660.7	15.70	0.44	0.63	15.92
809.09	-9.05	37.09	6.77	10.09	401.9	40.86	661.7	15.69	0.44	0.64	15.91
809.59	-9.33	37.08	7.09	9.82	393.1	40.23	662.8	15.68	0.44	0.64	15.91
810.09	-9.58	37.07	7.41	9.54	395.2	40.38	663.8	15.67	0.44	0.65	15.91
810.59	-9.82	37.07	7.73	9.27	398.3	40.60	664.8	15.66	0.44	0.66	15.90
811.09	%-10.03	37.06	8.06	9.00	390.4	40.04	665.8	15.66	0.44	0.66	15.90
811.59	%-10.23	37.05	8.37	8.72	401.6	40.84	666.9	15.65	0.44	0.66	15.88
812.09	%-10.40	37.06	8.69	8.46	365.8	38.39	667.9	15.64	0.44	0.66	15.89
812.59	%-10.56	37.06	9.01	8.19	380.7	39.38	668.8	15.63	0.44	0.66	15.87
813.09	%-10.70	37.05	9.33	7.92	359.9	38.00	669.9	15.62	0.44	0.65	15.87
813.59	%-10.82	37.05	9.65	7.65	346.7	37.18	670.9	15.61	0.44	0.65	15.86
814.09	%-10.93	37.04	9.97	7.38	382.1	39.47	671.9	15.60	0.44	0.64	15.84
814.59	%-11.03	37.03	10.29	7.11	371.9	38.79	673.0	15.59	0.44	0.64	15.83
815.09	%-11.11	37.03	10.61	6.85	362.7	38.19	673.9	15.58	0.44	0.63	15.82
815.59	%-11.18	37.02	10.93	6.58	358.0	37.88	675.0	15.57	0.44	0.62	15.80
816.09	%-11.24	37.02	11.25	6.31	334.0	36.41	676.0	15.56	0.44	0.61	15.80
816.59	%-11.28	37.03	11.57	6.05	339.3	36.73	676.9	15.55	0.44	0.59	15.78
817.09	%-11.32	37.02	11.88	5.79	374.8	38.98	678.0	15.54	0.44	0.58	15.75
817.59	%-11.36	37.01	12.20	5.52	359.2	37.96	679.0	15.53	0.44	0.57	15.74
818.09	%-11.38	37.01	12.52	5.26	357.3	37.84	680.0	15.52	0.44	0.56	15.72
818.59	%-11.40	37.01	12.83	5.00	327.1	36.00	681.0	15.52	0.44	0.54	15.72
819.09	%-11.42	37.02	13.15	4.74	341.9	36.88	681.9	15.51	0.44	0.53	15.69
819.59	%-11.43	37.02	13.47	4.48	370.3	38.68	682.9	15.50	0.44	0.51	15.67
820.09	%-11.44	37.02	13.78	4.22	324.8	35.87	683.9	15.49	0.44	0.50	15.66
820.59	%-11.45	37.02	14.10	3.96	359.3	37.97	684.8	15.48	0.44	0.48	15.64
821.09	%-11.45	37.02	14.41	3.70	352.8	37.55	685.8	15.47	0.44	0.47	15.62
821.59	%-11.46	37.02	14.73	3.44	342.1	36.89	686.8	15.46	0.44	0.45	15.60
822.09	%-11.46	37.02	15.04	3.19	314.0	35.25	682.7	15.45	0.44	0.44	15.59
822.59	%-11.47	37.03	15.35	2.94	306.6	34.84	660.9	15.44	0.44	0.44	15.58
823.09	%-11.47	37.03	15.66	2.68	328.7	36.09	639.3	15.44	0.44	0.44	15.55
823.99	%-11.48	36.97	16.16	2.26	329.9	36.16	598.9	15.41	0.44	0.44	15.52
18	R	26.83	14.40	14.74	380.4	36.98	5434.1	-11.48	-390.3		
T	Pl	Pr	Ll	Lr	Qp	Pp	Qin	Eri	Ero	Eli	Elo
824.45	%-10.73	36.91	16.47	2.05	331.7	36.27	461.0	15.40	0.44	0.44	15.45
824.45	-5.15	36.71	16.70	2.05	327.4	36.02	%-759.5	15.39	0.44	11.60	15.07
824.47	7.99	36.33	16.79	2.04	299.6	34.47	%-990.1	15.37	0.44	13.72	14.03
824.51	37.16	35.50	16.40	2.03	468.7	46.03	%-1216.7	15.31	12.76	15.90	0.44
824.85	38.01	27.71	16.18	2.00	488.8	47.75	%-1161.8	14.76	13.78	15.94	0.44
825.36	34.53	20.61	15.92	1.99	412.0	41.59	%-1075.4	14.17	14.14	15.74	0.44
825.83	39.54	15.61	15.68	2.01	443.3	43.97	%-1051.5	13.65	14.90	16.01	0.44
826.41	37.10	11.34	15.41	2.03	429.0	42.86	%-980.5	13.15	15.02	15.87	0.44
826.86	35.63	7.78	15.12	2.08	374.7	38.98	%-913.3	12.63	15.16	15.77	0.44

827.47	36.77	4.57	14.79	2.14	393.4	40.25	%-851.1	12.00	15.42	15.83	0.44
827.97	37.40	2.43	14.51	2.21	423.2	42.42	%-788.1	11.40	15.56	15.86	0.44
828.47	37.33	0.63	14.23	2.30	447.3	44.29	%-665.8	10.29	15.64	15.84	0.44
828.96	37.32	-0.80	13.96	2.48	414.8	41.79	13.4	0.44	15.72	15.83	0.44
829.46	37.28	-1.97	13.68	2.72	420.8	42.24	242.9	0.44	15.76	15.82	0.44
829.96	37.29	-2.97	13.40	2.99	402.7	40.91	395.2	0.44	15.81	15.81	0.44
830.46	37.23	-3.84	13.11	3.27	435.1	43.33	505.9	0.44	15.83	15.80	0.44
830.96	37.24	-4.58	12.84	3.58	408.7	41.34	589.6	0.44	15.86	15.79	0.44
831.46	37.22	-5.24	12.56	3.89	419.6	42.15	652.1	0.44	15.87	15.78	0.44
831.96	37.18	-5.83	12.28	4.21	423.4	42.44	653.3	0.48	15.88	15.77	0.44
832.46	37.17	-6.36	12.00	4.53	424.2	42.50	654.4	0.51	15.89	15.76	0.44
832.96	37.16	-6.85	11.72	4.85	368.1	38.54	655.4	0.54	15.92	15.75	0.44
833.46	37.14	-7.29	11.44	5.17	376.2	39.07	656.6	0.56	15.92	15.74	0.44
833.96	37.15	-7.71	11.17	5.49	395.0	40.36	657.5	0.58	15.92	15.73	0.44
834.46	37.13	-8.08	10.89	5.81	374.9	38.99	658.6	0.60	15.93	15.72	0.44
834.96	37.12	-8.44	10.62	6.13	394.2	40.31	659.6	0.61	15.92	15.71	0.44
835.46	37.11	-8.76	10.34	6.46	410.3	41.46	660.7	0.63	15.91	15.70	0.44
835.96	37.09	-9.06	10.06	6.78	422.2	42.34	661.8	0.64	15.91	15.69	0.44
836.46	37.08	-9.34	9.79	7.10	364.3	38.29	662.9	0.65	15.92	15.68	0.44
836.96	37.07	-9.59	9.51	7.42	389.5	39.98	663.9	0.65	15.91	15.67	0.44
837.46	37.06	-9.82	9.24	7.74	373.1	38.87	665.0	0.66	15.91	15.66	0.44
837.96	37.07	%-10.04	8.97	8.06	362.6	38.18	665.9	0.66	15.91	15.65	0.44
838.46	37.06	%-10.23	8.70	8.38	405.0	41.08	667.0	0.66	15.88	15.64	0.44
838.96	37.05	%-10.41	8.43	8.70	357.7	37.86	668.0	0.66	15.89	15.64	0.44
839.46	37.05	%-10.56	8.16	9.02	351.1	37.45	669.0	0.66	15.88	15.63	0.44
839.96	37.04	%-10.70	7.89	9.34	397.4	40.54	670.0	0.65	15.86	15.62	0.44
840.46	37.03	%-10.83	7.62	9.65	376.8	39.11	671.1	0.65	15.85	15.61	0.44
840.96	37.04	%-10.94	7.35	9.97	363.5	38.24	672.0	0.64	15.84	15.60	0.44
841.46	37.04	%-11.03	7.08	10.29	382.1	39.47	673.0	0.64	15.82	15.59	0.44
841.96	37.03	%-11.11	6.81	10.61	388.6	39.92	674.1	0.63	15.81	15.58	0.44
842.46	37.03	%-11.18	6.55	10.93	359.6	37.99	675.1	0.62	15.80	15.57	0.44
842.96	37.02	%-11.24	6.28	11.25	325.2	35.89	676.1	0.61	15.80	15.56	0.44
843.46	37.03	%-11.29	6.02	11.57	356.4	37.78	677.1	0.59	15.77	15.55	0.44
843.96	37.02	%-11.33	5.75	11.88	375.3	39.02	678.1	0.58	15.75	15.54	0.44
844.46	37.02	%-11.36	5.49	12.20	382.9	39.53	679.0	0.57	15.73	15.53	0.44
844.96	37.03	%-11.38	5.23	12.52	339.3	36.72	680.0	0.56	15.73	15.52	0.44
845.46	37.02	%-11.40	4.97	12.83	329.9	36.17	681.0	0.54	15.72	15.51	0.44
845.96	37.02	%-11.42	4.71	13.15	317.6	35.45	682.0	0.53	15.70	15.51	0.44
846.46	37.03	%-11.43	4.45	13.47	363.5	38.24	682.9	0.51	15.67	15.50	0.44
846.96	37.02	%-11.44	4.19	13.78	336.7	36.57	684.0	0.50	15.66	15.49	0.44
847.46	37.02	%-11.45	3.93	14.10	349.7	37.36	685.0	0.48	15.64	15.48	0.44
847.96	37.02	%-11.45	3.67	14.41	344.0	37.01	686.0	0.47	15.62	15.47	0.44
848.46	37.02	%-11.46	3.42	14.73	346.5	37.16	686.9	0.45	15.60	15.46	0.44
848.96	37.02	%-11.46	3.16	15.04	352.4	37.53	682.8	0.44	15.58	15.45	0.44
849.46	37.02	%-11.47	2.90	15.35	342.9	36.94	661.0	0.44	15.57	15.44	0.44
849.96	37.02	%-11.47	2.65	15.66	328.2	36.06	639.4	0.44	15.55	15.43	0.44
850.86	36.96	%-11.48	2.23	16.16	329.0	36.11	599.0	0.44	15.52	15.41	0.44
19	L	26.87	14.77	14.42	381.8	36.98	5430.8	-11.48	-390.3		
T	Pl	Pr	Ll	Lr	Qp	Pp	Qin	Eri	Ero	Eli	Elo
851.31	36.91	%-10.73	2.02	16.47	314.0	35.25	461.0	0.44	15.45	15.40	0.44
851.32	36.71	-5.15	2.01	16.70	324.7	35.86	%-759.4	11.60	15.07	15.39	0.44
851.34	36.33	7.99	2.01	16.79	324.3	35.84	%-990.0	13.72	14.02	15.36	0.44
851.37	35.51	37.17	2.00	16.40	429.4	42.89	%-1216.6	15.90	0.44	15.31	12.79
851.68	28.24	38.76	1.97	16.20	461.7	45.45	%-1170.6	15.98	0.44	14.80	13.82
852.15	22.79	30.45	1.96	16.02	380.1	39.33	%-1069.9	15.49	0.44	14.36	13.53
852.58	16.78	34.27	1.97	15.75	428.7	42.83	%-1032.5	15.71	0.44	13.80	14.43
853.12	11.98	38.14	2.00	15.46	410.1	41.45	%-995.8	15.93	0.44	13.22	15.06
853.76	7.61	39.19	2.05	15.11	486.6	47.55	%-931.5	15.97	0.44	12.59	15.36
854.35	4.52	39.02	2.11	14.78	483.1	47.25	%-862.9	15.95	0.44	11.99	15.52
854.85	2.39	37.38	2.18	14.51	443.1	43.95	%-785.6	15.85	0.44	11.38	15.56
855.35	0.60	37.34	2.27	14.23	404.0	41.01	%-651.4	15.84	0.44	10.16	15.66
855.85	-0.82	37.29	2.46	13.95	448.6	44.39	23.7	15.83	0.44	0.44	15.71
856.35	-1.99	37.28	2.69	13.66	431.9	43.08	249.3	15.82	0.44	0.44	15.76
856.85	-2.99	37.27	2.96	13.39	377.7	39.18	400.1	15.81	0.44	0.44	15.82
857.35	-3.85	37.25	3.25	13.11	436.7	43.45	509.6	15.80	0.44	0.44	15.83
857.85	-4.59	37.22	3.55	12.83	405.9	41.14	592.9	15.79	0.44	0.44	15.86
858.35	-5.25	37.21	3.87	12.55	389.1	39.95	652.2	15.78	0.44	0.44	15.88
858.85	-5.83	37.18	4.19	12.27	416.3	41.90	653.4	15.77	0.44	0.48	15.89
859.35	-6.37	37.16	4.51	11.99	372.3	38.81	654.5	15.76	0.44	0.51	15.91
859.85	-6.85	37.17	4.83	11.71	420.9	42.24	655.4	15.75	0.44	0.54	15.90

860.35	-7.30	37.15	5.15	11.43	416.7	41.93	656.5	15.74	0.44	0.56	15.91
860.85	-7.71	37.13	5.47	11.16	415.4	41.83	657.6	15.73	0.44	0.58	15.91
861.35	-8.09	37.12	5.79	10.88	426.1	42.64	658.7	15.72	0.44	0.60	15.91
861.85	-8.44	37.10	6.11	10.60	358.9	37.94	659.8	15.71	0.44	0.61	15.93
862.35	-8.76	37.11	6.43	10.33	371.6	38.77	660.7	15.70	0.44	0.63	15.93
862.85	-9.06	37.08	6.75	10.05	392.3	40.18	661.9	15.69	0.44	0.64	15.92
863.34	-9.34	37.09	7.07	9.78	395.4	40.39	662.9	15.68	0.44	0.65	15.91
863.84	-9.59	37.08	7.39	9.50	381.0	39.40	663.9	15.67	0.44	0.65	15.91
864.34	-9.82	37.07	7.71	9.23	364.5	38.30	664.9	15.66	0.44	0.66	15.91
864.84	%-10.04	37.05	8.03	8.96	406.2	41.17	666.1	15.65	0.44	0.66	15.89
865.34	%-10.23	37.04	8.35	8.68	395.8	40.42	667.1	15.64	0.44	0.66	15.89
865.84	%-10.41	37.05	8.67	8.41	386.8	39.79	668.0	15.63	0.44	0.66	15.88
866.34	%-10.56	37.05	8.99	8.14	381.2	39.41	669.1	15.63	0.44	0.66	15.87
866.84	%-10.70	37.04	9.31	7.87	385.3	39.69	670.1	15.62	0.44	0.66	15.86
867.34	%-10.83	37.03	9.63	7.60	387.5	39.84	671.2	15.61	0.44	0.65	15.85
867.84	%-10.93	37.03	9.95	7.33	378.0	39.20	672.2	15.60	0.44	0.64	15.84
868.34	%-11.03	37.03	10.27	7.06	393.7	40.27	673.2	15.59	0.44	0.64	15.82
868.84	%-11.11	37.02	10.59	6.79	355.2	37.71	674.2	15.58	0.44	0.63	15.82
869.34	%-11.18	37.02	10.91	6.53	357.0	37.82	675.2	15.57	0.44	0.62	15.80
869.84	%-11.24	37.02	11.23	6.26	389.0	39.95	676.2	15.56	0.44	0.61	15.78
870.34	%-11.28	37.01	11.54	5.99	373.6	38.90	677.2	15.55	0.44	0.60	15.77
870.84	%-11.32	37.01	11.86	5.73	348.1	37.26	678.2	15.54	0.44	0.58	15.76
871.34	%-11.36	37.01	12.18	5.47	346.6	37.17	679.2	15.53	0.44	0.57	15.74
871.84	%-11.38	37.02	12.50	5.20	368.8	38.59	680.2	15.52	0.44	0.56	15.72
872.34	%-11.40	37.01	12.81	4.94	354.6	37.67	681.2	15.51	0.44	0.54	15.71
872.84	%-11.42	37.01	13.13	4.68	336.0	36.53	682.2	15.50	0.44	0.53	15.69
873.34	%-11.43	37.01	13.44	4.42	332.2	36.30	683.1	15.50	0.44	0.51	15.68
873.84	%-11.44	37.01	13.76	4.16	341.5	36.86	684.1	15.49	0.44	0.50	15.66
874.34	%-11.45	37.02	14.08	3.90	317.3	35.44	685.1	15.48	0.44	0.48	15.65
874.84	%-11.45	37.02	14.39	3.64	346.3	37.15	686.0	15.47	0.44	0.47	15.62
875.34	%-11.46	37.02	14.71	3.39	312.7	35.18	687.0	15.46	0.44	0.45	15.61
875.84	%-11.46	37.03	15.02	3.13	361.8	38.13	684.5	15.45	0.44	0.44	15.58
876.34	%-11.47	37.03	15.33	2.88	353.8	37.62	662.7	15.44	0.44	0.44	15.56
876.84	%-11.47	37.03	15.64	2.62	348.9	37.32	641.1	15.43	0.44	0.44	15.55
877.76	%-11.48	36.97	16.15	2.20	303.5	34.68	600.0	15.41	0.44	0.44	15.52
19	R	26.91	14.44	14.81	384.2	36.98	5438.1	-11.48	-390.3		

Performance Summary

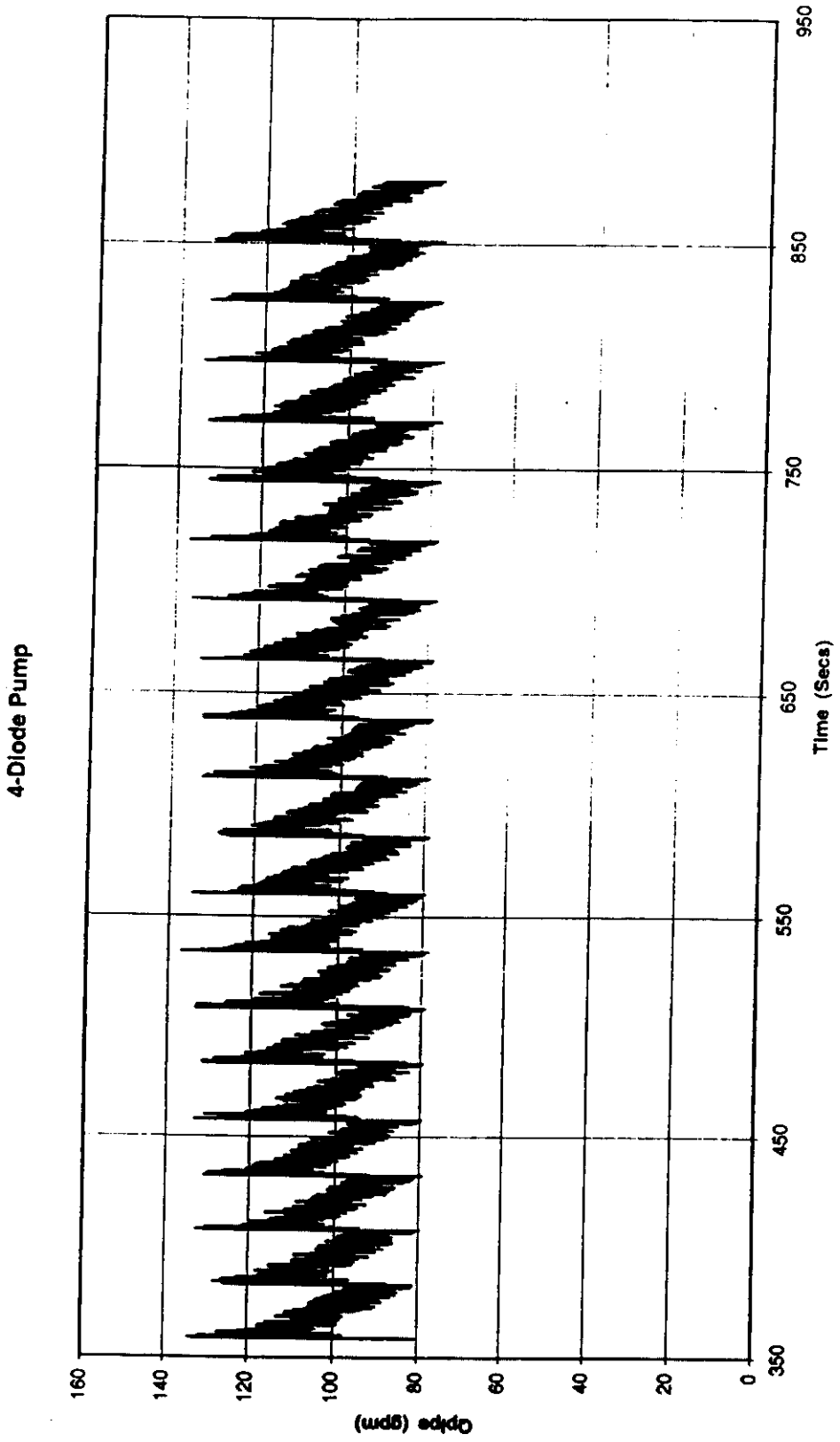
Last left drive time (secs)= 26.87
Last right drive time (secs)= 26.91
Last left stroke length (m) = 4.4
Last right stroke length (m) = 4.51
step time = .1

drive nozzle pressure (psig)= 39.5
suction nozzle pressure (psig)= 56

top liquid level (m)= 5

pumping rate(lts/min)= 384.18
air usage(slm)= 6591.64
a.u.r= 17.16

Do you wish to change operating pressures, yes=1, no=0 0
Simulate another pump ?, YES=1,NO=0 ! 0
END OF 4-DIODE PUMP SIMULATION !


4-Diode Pump
Qpipe (gpm)
160
140
120
100
80
60
40
20
0
350
450
550
650
750
850
950
Time (Secs)

Appendix D

Drawings and Sketches

PROJECT TITLE:

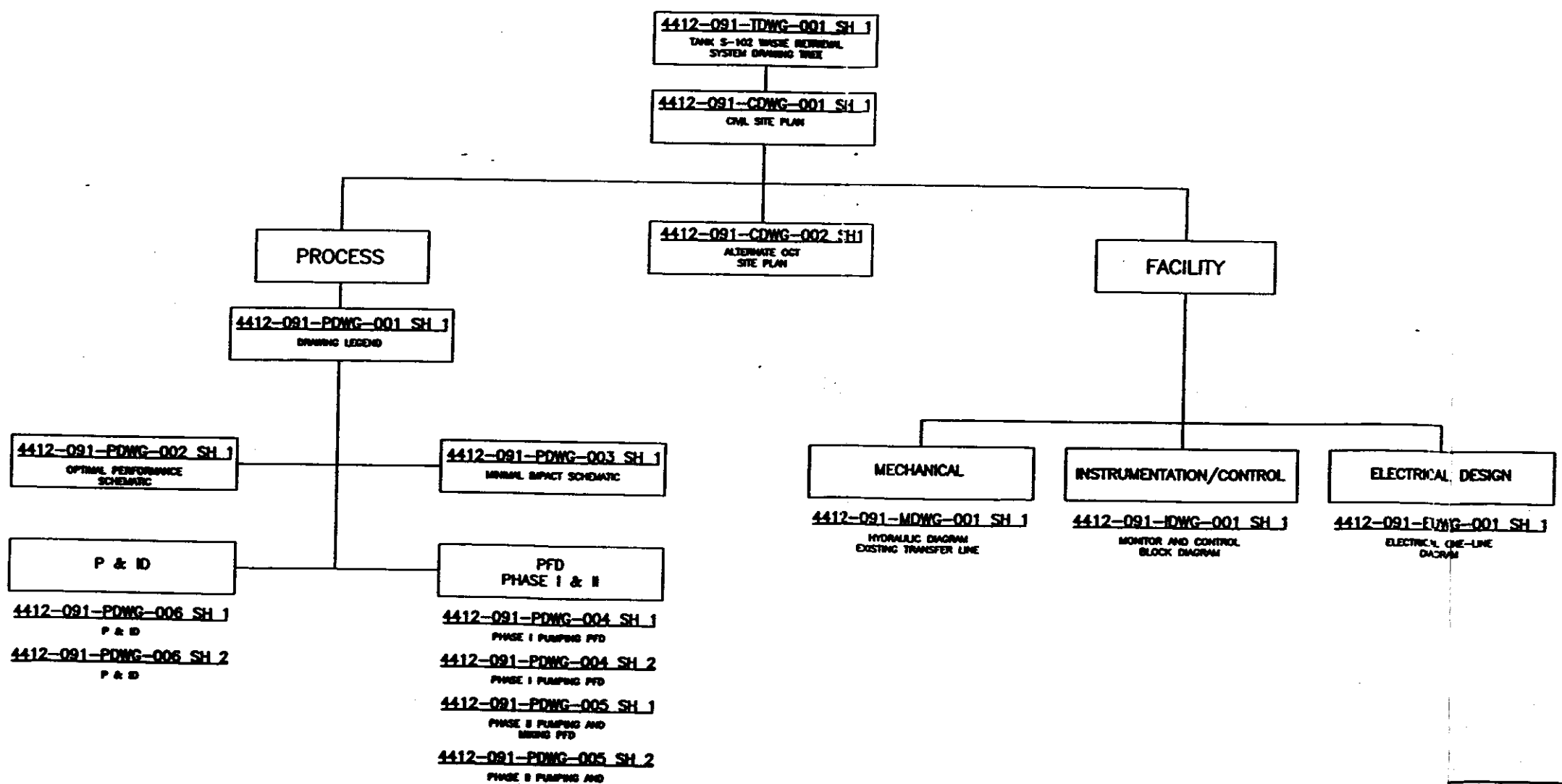
241-S-102 WASTE RETRIEVAL SYSTEM

FOR:

CH2M HILL HANFORD GROUP, INCORPORATED

BY:

HOLMES & NARVER / DMJM

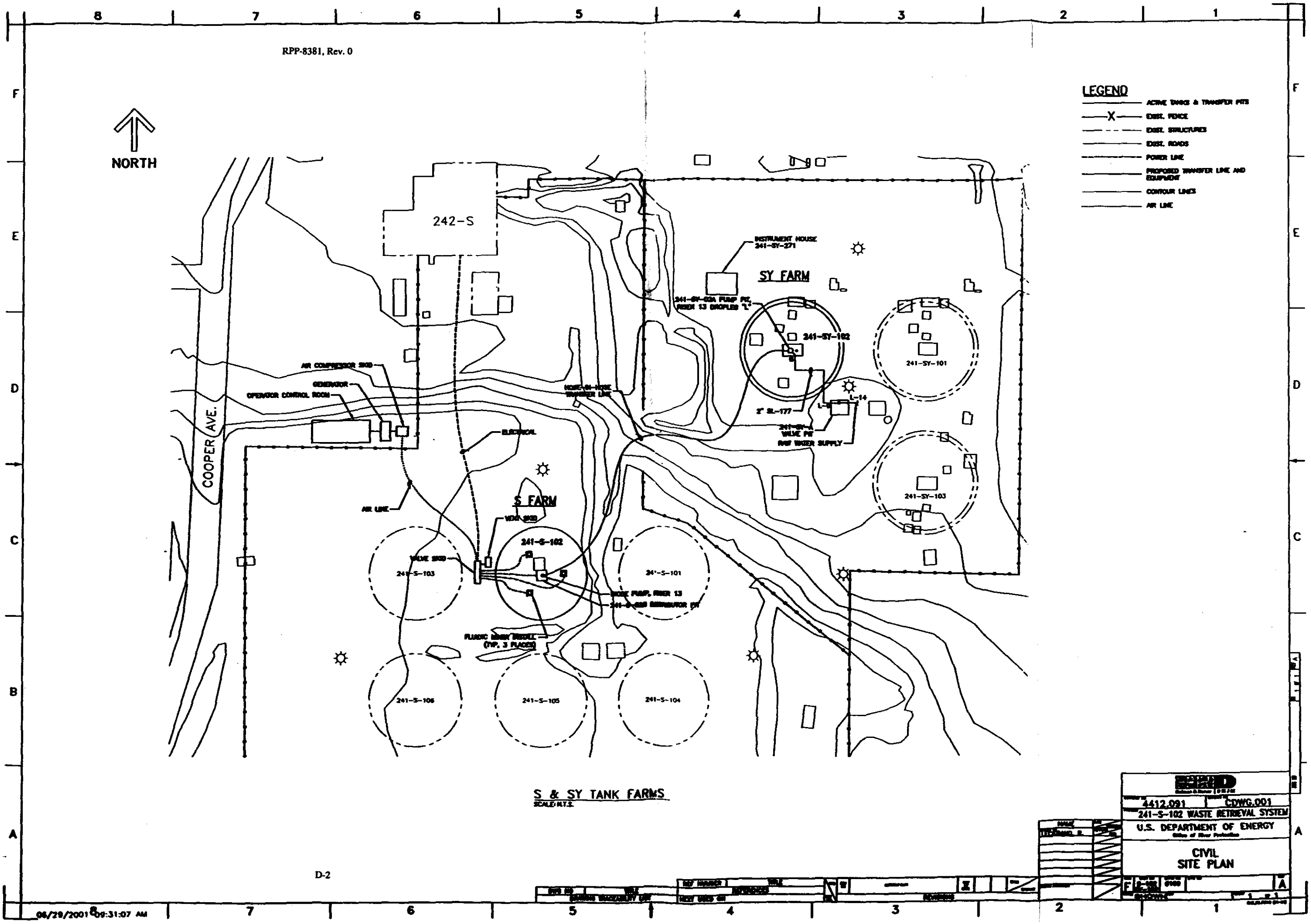


4412.091 TDWG.001

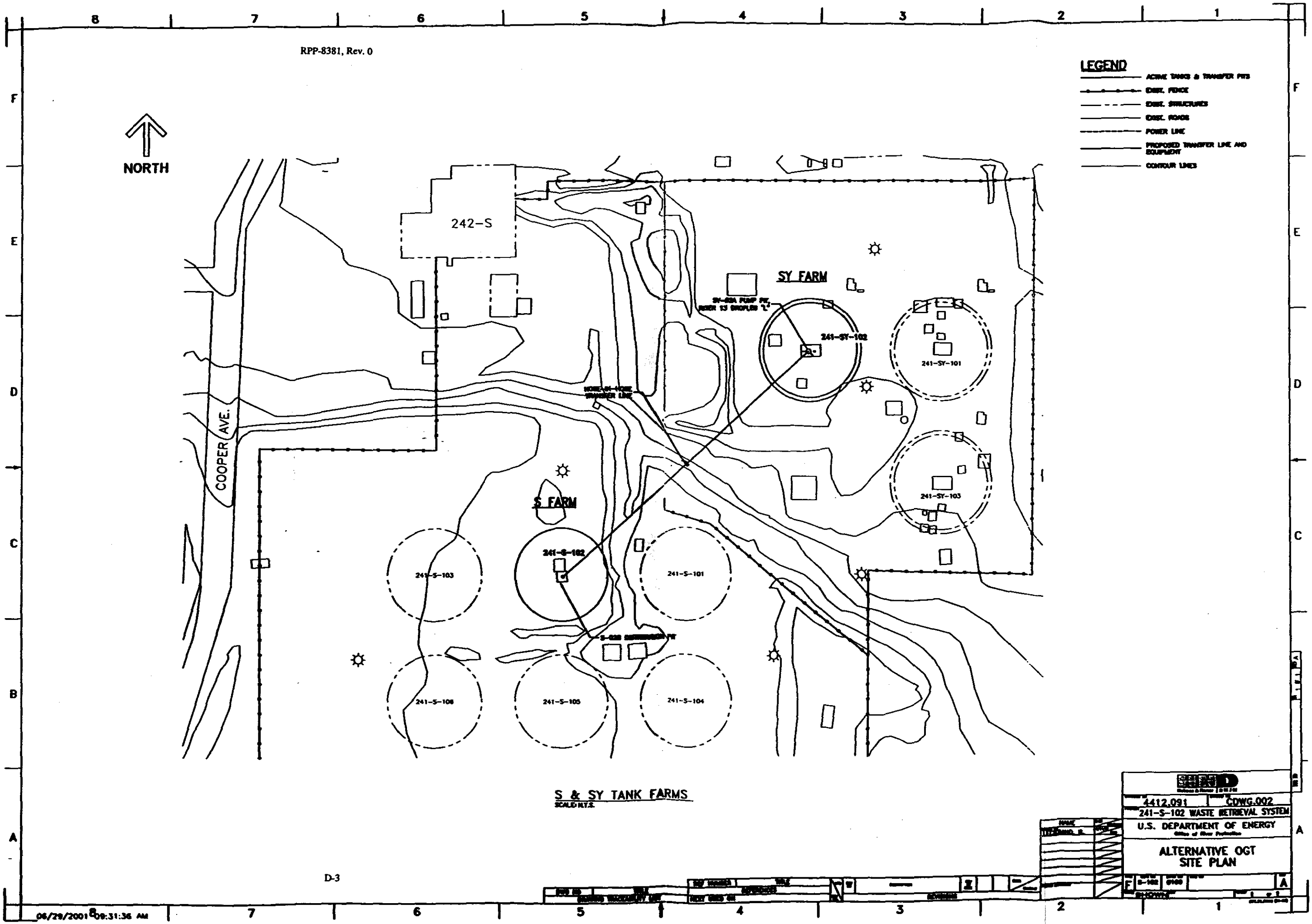
241-S-102 WASTE RETRIEVAL SYSTEM

U.S. DEPARTMENT OF ENERGY

TANK S-102
WASTE RETRIEVAL SYSTEM
DRAWING TREE



S & SY TANK FARMS
SCALE: N.T.S.


LEGEND
ACTIVE TANKS & TRANSFER PITS
EXIST. FENCE
EXIST. STRUCTURES
EXIST. ROADS
POWER LINE
PROPOSED TRANSFER LINE AND EQUIPMENT
CONTOUR LINES
NORTH
242-S
SY FARM
241-SY-102
241-SY-101
241-SY-103
HOSE-IN-HOSE TRANSFER LINE
COOPER AVE.
S FARM
241-S-102
241-S-103
241-S-101
241-S-106
241-S-105
241-S-104
S & SY TANK FARMS
SCALE: N.T.S.
4412.091
CDWG.002
241-S-102 WASTE RETRIEVAL SYSTEM
U.S. DEPARTMENT OF ENERGY
ALTERNATIVE OGT SITE PLAN
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LINES

- ELECTRICAL SIGNAL
- SOFTWARE DATA LINK
- PROCESS LINE

VALVES

- PRESSURE REDUCING VALVE
- SOLENOID OPERATED VALVE
- VALVE
- RELIEF VALVE

SYMBOLS

- CENTRIFUGAL FAN
- CHARGE VESSEL
- REVERSE FLOW DIVERTER
- SPRAY NOZZLE
- EDUCTOR
- DAMPER
- HEATER
- DEMISTER
- HEPA FILTER
- BAG FILTER
- PANEL FILTER
- CAMERA ASSEMBLY
- LEVEL DISPLACER
- MPS — MASTER PUMP SHUTDOWN
- TMACS — TANK MONITORING AND CONTROL SYSTEM

SYMBOLS

- COMPRESSOR
- PUMP
- FLUIDIC DIODE PUMP
- ACCUMULATOR
- STACK
- CONNECTING FLUID — LINE NUMBER — ZONE XX — CONNECTION ARROW

INSTRUMENTATION

- FIELD MOUNTED INSTRUMENT
- MONITOR/CONTROL SYSTEM (MCS) (HMI CONTROL & FIELD PLC CONTROL)

PROCESS FLOW

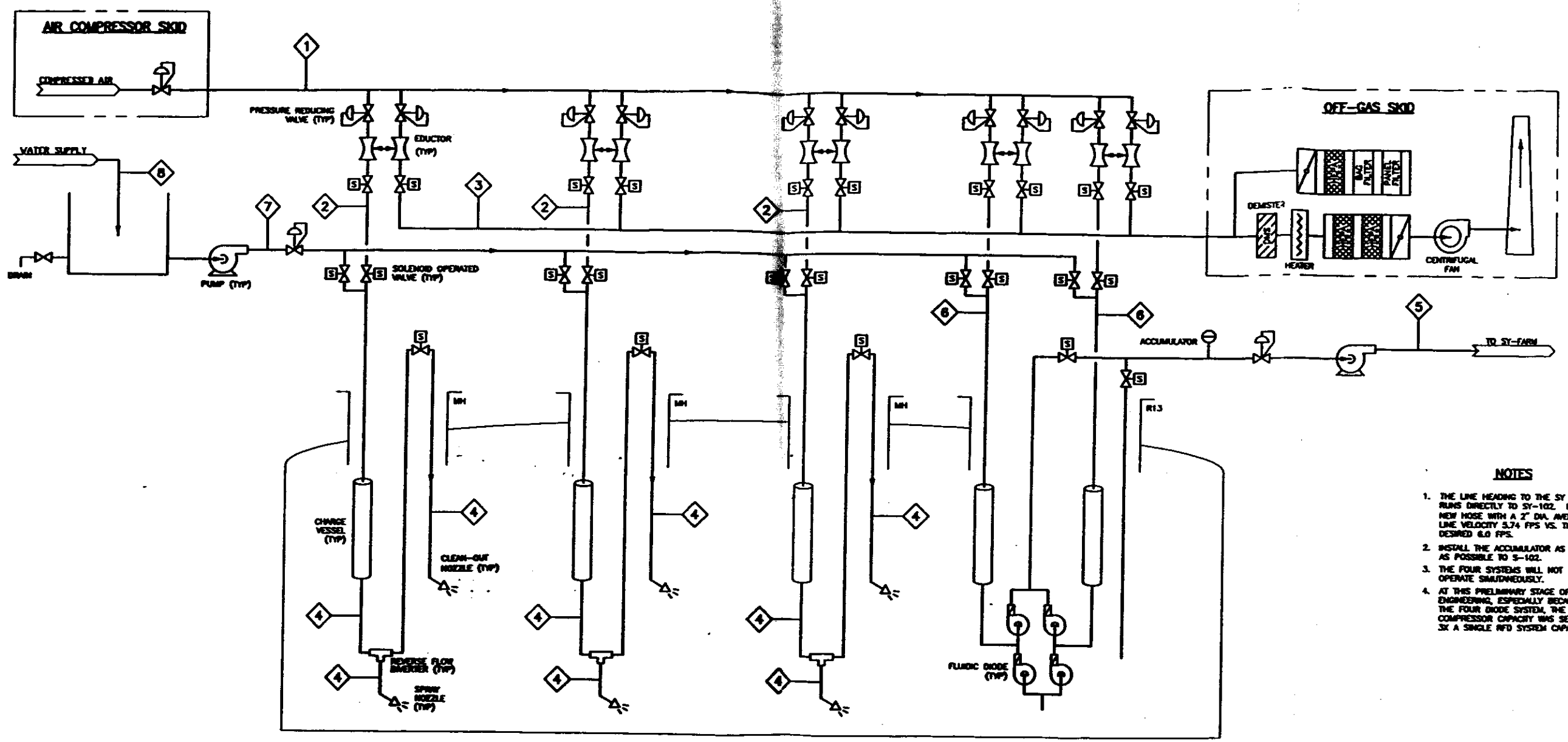
- STREAM IDENTIFIER FOR PHASE I OPERATIONS
- INTERFACE IDENTIFIER
- STREAM IDENTIFIER FOR PHASE II OPERATIONS

ABBREVIATIONS

ATM	ATMOSPHERE
FI	FLOW INDICATOR
FIT	FLOW INDICATING TRANSMITTER
HS	HAND SWITCH
IC	INTERFACE CONTROL
IC-EOX	EXTERNAL INTERFACE
IC-IOX	INTERNAL INTERFACE
LAH	LEVEL ALARM HIGH
LAHH	LEVEL ALARM HIGH HIGH
LAL	LEVEL ALARM LOW
LDA	LEAK DETECTOR ALARM
LDR	LEAK DETECTOR RELAY
LI	LEVEL INDICATOR
LIT	LEVEL INDICATING TRANSMITTER
MH	MAN HOLE
OGT	OVER GROUND TRANSFER
PAH	PRESSURE ALARM HIGH
PAL	PRESSURE ALARM LOW
PDAH	PRESSURE DIFFERENTIAL ALARM HIGH
PDI	PRESSURE DIFFERENTIAL INDICATOR
PDIT	PRESSURE DIFFERENTIAL INDICATING TRANSMITTER
PI	PRESSURE INDICATOR
PIT	PRESSURE INDICATING TRANSMITTER
PLC	PROGRAMMABLE LOGIC CONTROLLER
R*	RISER DESIGNATION
RAH	RADIATION ALARM HIGH
RE	RADIATION SENSING ELEMENT
RI	RADIATION INDICATOR
RIT	RADIATION INDICATING TRANSMITTER
SIC	SPEED/VELOCITY INDICATOR
TE	TEMPERATURE ELEMENT
TIT	TEMPERATURE INDICATING TRANSMITTER
UE	MULTI-VARIABLE ELEMENT
UIT	MULTI-VARIABLE INDICATING TRANSMITTER
UQI	MULTI-VARIABLE TOTALIZER
WFT	WEIGHT FACTOR TRANSMITTER
WRS	WASTE RETRIEVAL SYSTEM

4412.091 | PDWG.001
241-S-102 WASTE RETRIEVAL SYSTEM
U.S. DEPARTMENT OF ENERGY
Office of River Protection

DRAWING LEGEND



S-102

NOTES

1. THE LINE HEADING TO THE SY FARM RUNS DIRECTLY TO SY-102. IT IS A NEW HOSE WITH A 2" DIA. AVERAGE LINE VELOCITY 3.74 FPS VS. THE DESIRED 6.0 FPS.
2. INSTALL THE ACCUMULATOR AS CLOSE AS POSSIBLE TO S-102.
3. THE FOUR SYSTEMS WILL NOT OPERATE SIMUTANEOUSLY.
4. AT THIS PRELIMINARY STAGE OF ENGINEERING, ESPECIALLY BECAUSE THE FOUR DIODE SYSTEM, THE COMPRESSOR CAPACITY WAS SET AT 3X A SINGLE RFD SYSTEM CAPACITY.

DESIGN MASS FLOWS

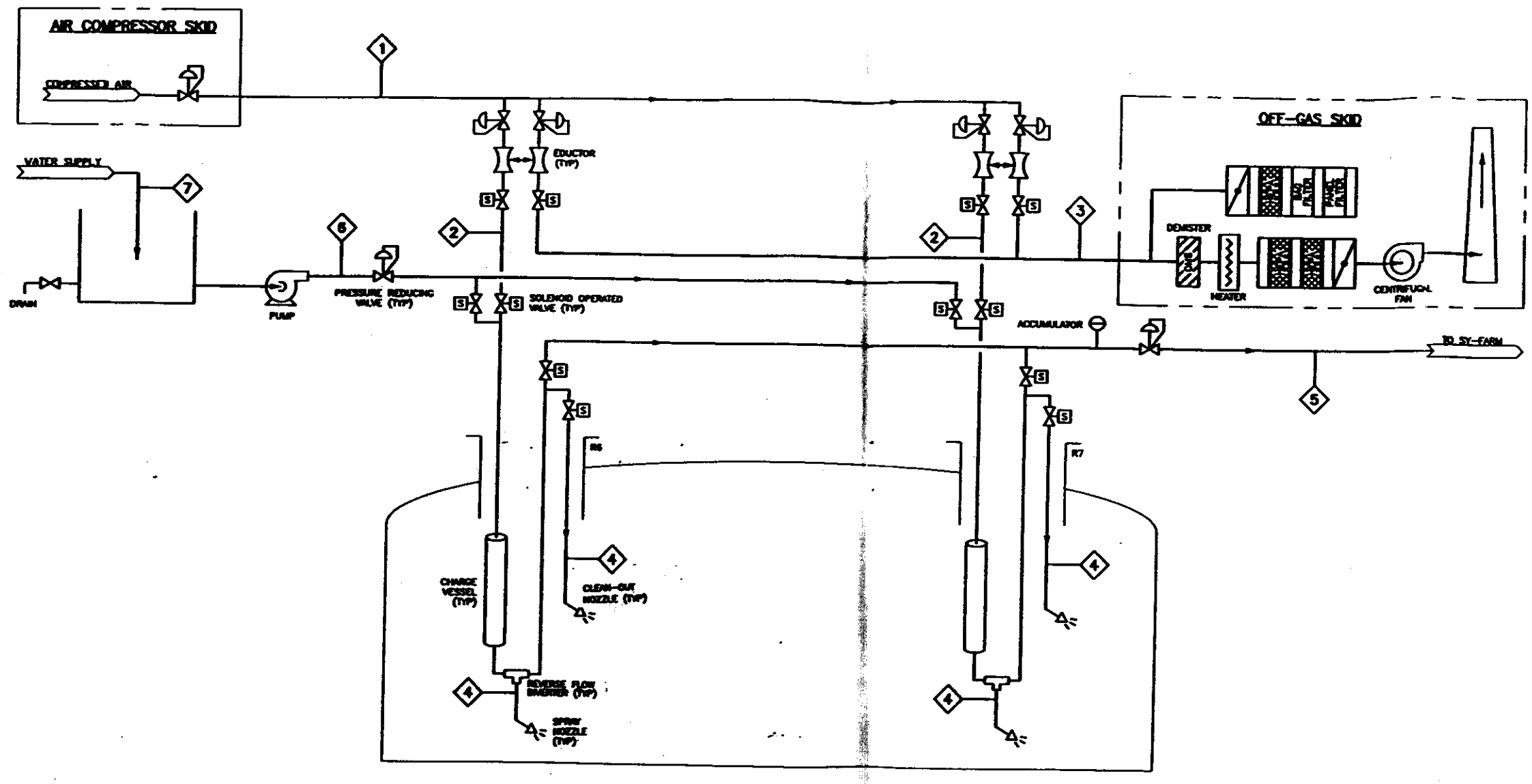
STREAM No.	1	2	3	4	5	6	7	8
STREAM NAME	COMPRESSED AIR FLOW	DRIVE OR SUCTION AIR	VENTING AIR FLOW	SPRAY FLOW	TOTAL PUMPED LIQUID	ONE TANK LIQUID FLOW	WATER FLOW TO SPRAYS	WATER FLOW
OPERATING PRESSURE (PSIG)	60*	-15 TO 60	-	(60)	60±	-15 TO 60	70	WATER SUPPLY PRESSURE
FLOW RATE (GPM OR SCFM)	153	0-50	0 TO 702	60±	60	76.5	60	20
SPECIFIC GRAVITY	AIR	AIR	AIR	1 TO 1.4	1 TO 1.4	AIR	1.0	1.0
TOTAL MASS (LB/MIN)	10.71	3.57	38.43	500 TO 700	500 TO 700	8.36	500	166.85

* 10% ASSUMED LINE DROP ALLOWANCE.
** KEEP DISTANCE FROM TANK TO A MINIMUM.

4412.091	POWG.002
241-S-102 WASTE RETRIEVAL SYSTEM	
U.S. DEPARTMENT OF ENERGY	
OPTIMAL PERFORMANCE SCHEMATIC	

NOTES

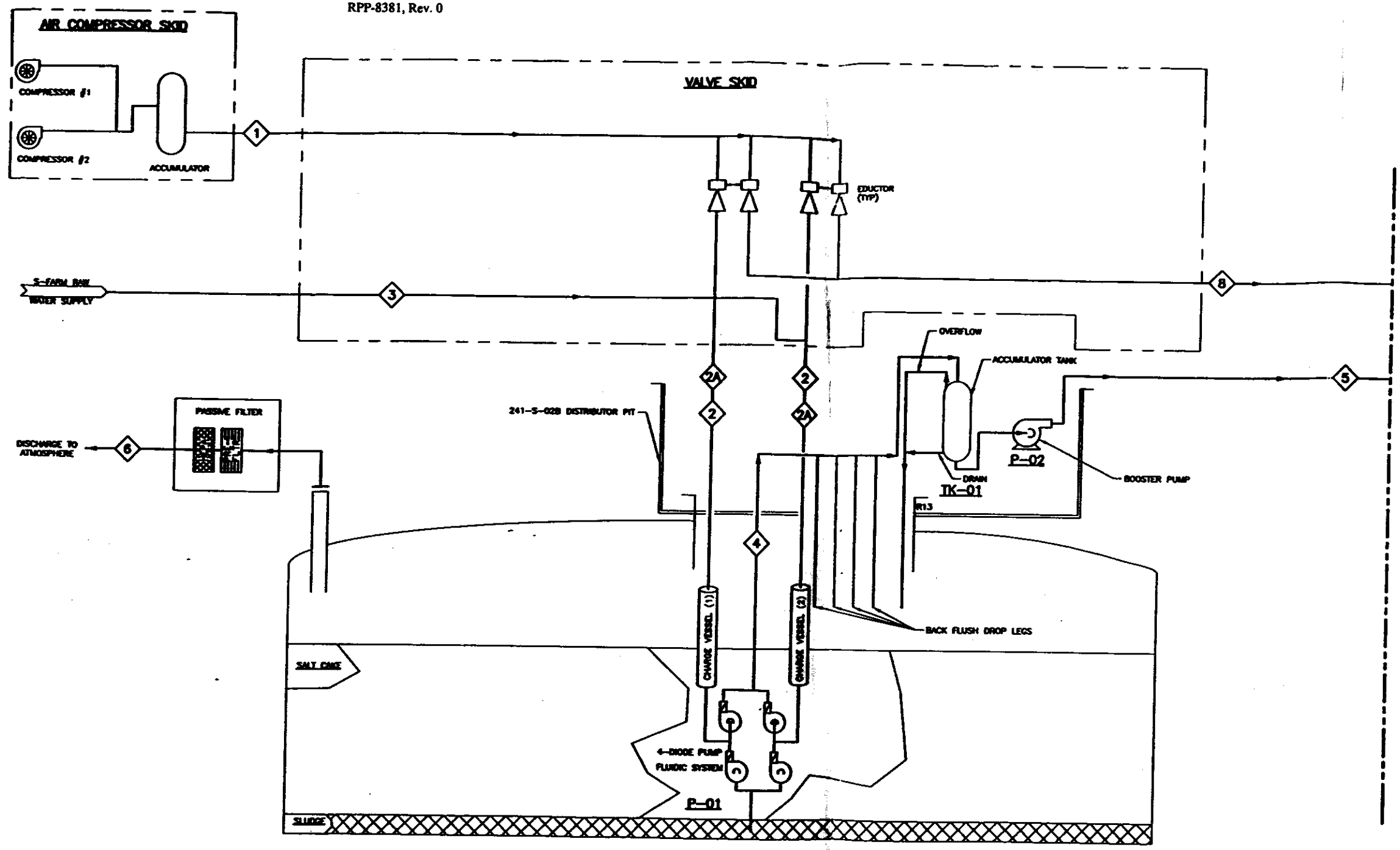
1. THE AVERAGE VELOCITY OF THE LINE HEADING TO THE SY FARM IS 2.6 FPS VS THE DESIRED 6 FPS.
2. INSTALL THE ACCUMULATOR AS CLOSE AS POSSIBLE TO S-102.
3. FOR THIS PRELIMINARY ENGRG THE AIR SINGLE SYSTEM COMPRESSOR CAPACITY WAS ONLY DOUBLED ON THREE SYSTEMS.
4. THE TWO SYSTEMS OPERATE IN SEQUENCE (AT 180° APART)



DESIGN MASS FLOWS

STREAM No.	1	2	3	4	5	6	7
STREAM NAME	COMPRESSED AIR FLOW	DRIVE OR SUCTION AIR	VENTING AIR FLOW PEAK	SPRAY FLOW	TOTAL PUMPED LIQUID	WATER FLOW TO SPRAYERS	WATER FLOW
OPERATING PRESSURE (PSIG)	60	-15 TO 65	-	0-60	60	70	WATER SUPPLY PRESSURE
FLOW RATE (GPM OR SCFM)	102	0-50	0-400 PEAK	60	60	60	20
SPECIFIC GRAVITY	AIR	AIR	AIR	1 TO 1.4	1 TO 1.4	1.0	1.0
TOTAL MASS (LB/MIN)	7	0-3.5	0-32.76 PEAK	500-700	500-700	500	166.65

4412.091	PDWG.003
241-S-102 WASTE RETRIEVAL SYSTEM	
U.S. DEPARTMENT OF ENERGY	
MINIMAL IMPACT SCHEMATIC	



241-S-102

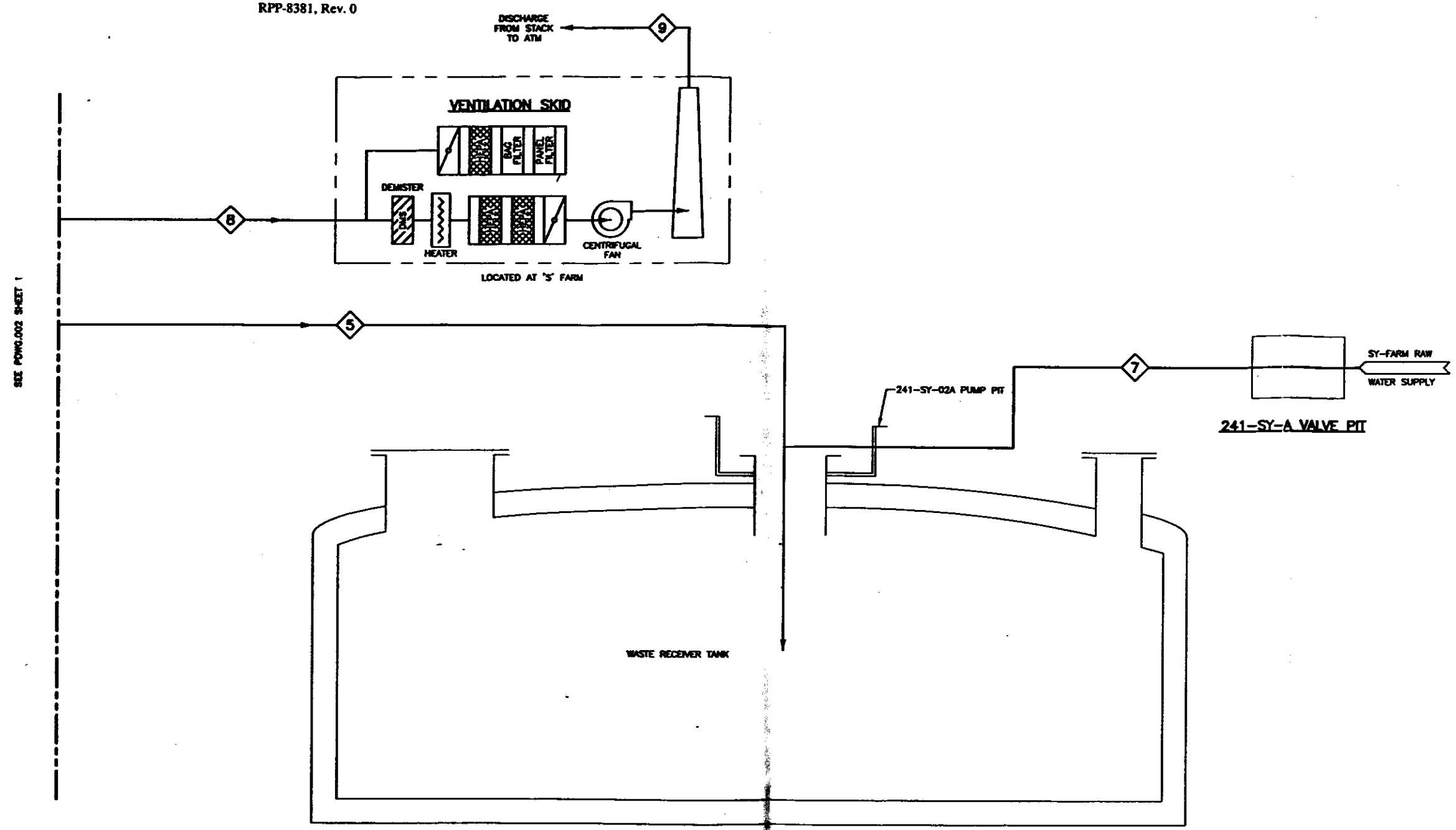
NOTES

1. THE CROSS SITE TRANSFER SYSTEM IS NOT PART OF THIS PROJECT SCOPE.
2. TOTAL CI ONLY INCLUDES THE SUM OF THE MOBILE LONG-LIVED RADIONUCLIDES IDENTIFIED AS:
   - ^{14}C
   - ^{79}Se
   - ^{99}Tc
   - ^{233}U (232, 233, 234, 235, 236, 238)

DESIGN MASS FLOWS

STREAM No. / PHASE I	1	2	2A	3	4	5	6	7	8	9
STREAM NAME	COMPRESSED AIR FLOW	DRIVE AIR	SUCTION AIR	S-FARM RAW WATER SUPPLY	SOLUTION TRANSFER	S-102 SOLUTION TO SY-102	BREATHER FILTER	SY-FARM RAW WATER SUPPLY	EDUCTOR EXHAUST	FILTERED AIR TO ATM
OPERATING PRESSURE (PSIG)	70	70	-13	70	30	65	–	70	70	–
TEMPERATURE (°C)	AMBIENT	AMBIENT	AMBIENT	13	22–38	22–38	–	13	TBD	TBD
SPECIFIC GRAVITY	AIR	AIR	AIR	1.0	1.3	1.3	–	1.0	AIR	AIR
VOLUMETRIC FLOW RATE (GPM OR SCFM)	650–900	325	–325	20	60–130	100	8 SCFM (MAX)	140	300–900	0–900
MAXIMUM BATCH VOLUME (GAL)	–	–	–	–	27,000	27,000	–	20,000	–	–
TOTAL CI (SEE NOTE 2)	–	–	–	–	250 TOTAL	250 TOTAL	–	–	–	–

4412.091 | PDWG.004
241-S-102 WASTE RETRIEVAL SYSTEM
U.S. DEPARTMENT OF ENERGY
Office of River Protection
PHASE I PUMPING PFD



DESIGN MASS FLOWS

STREAM No. PHASE I	1	2	2A	3	4	5	6	7	8	9
STREAM NAME	COMPRESSED AIR FLOW	DRIVE AIR	SUCTION AIR	S-FARM RAW WATER SUPPLY	SOLUTION TRANSFER	S-102 SOLUTION TO SY-102	BREATHER FILTER	SY-FARM RAW WATER SUPPLY	EDUCTOR EXHAUST	FILTERED AIR TO ATM
OPERATING PRESSURE (PSIG)	70	70	-13	70	30	65	–	70	70	–
TEMPERATURE (°C)	AMBIENT	AMBIENT	AMBIENT	13	22–38	22–38	–	13	TBD	TBD
SPECIFIC GRAVITY	AIR	AIR	AIR	1.0	1.3	1.3	–	1.0	AIR	AIR
VOLUMETRIC FLOW RATE (GPM OR SCFM)	650–900	325	–325	20	60–130	100	8 SCFM (MAX)	140	300–900	0–900
MAXIMUM BATCH VOLUME (GAL)	–	–	–	–	27,000	27,000	–	20,000	–	–
TOTAL Ci (SEE NOTE 2)	–	–	–	–	250 TOTAL	250 TOTAL	–	–	–	–

4412.091 | PDWG.004

241-S-102 WASTE RETRIEVAL SYSTEM

U.S. DEPARTMENT OF ENERGY
Office of River Protection

PHASE I
PUMPING
PFD

S-102

NONE

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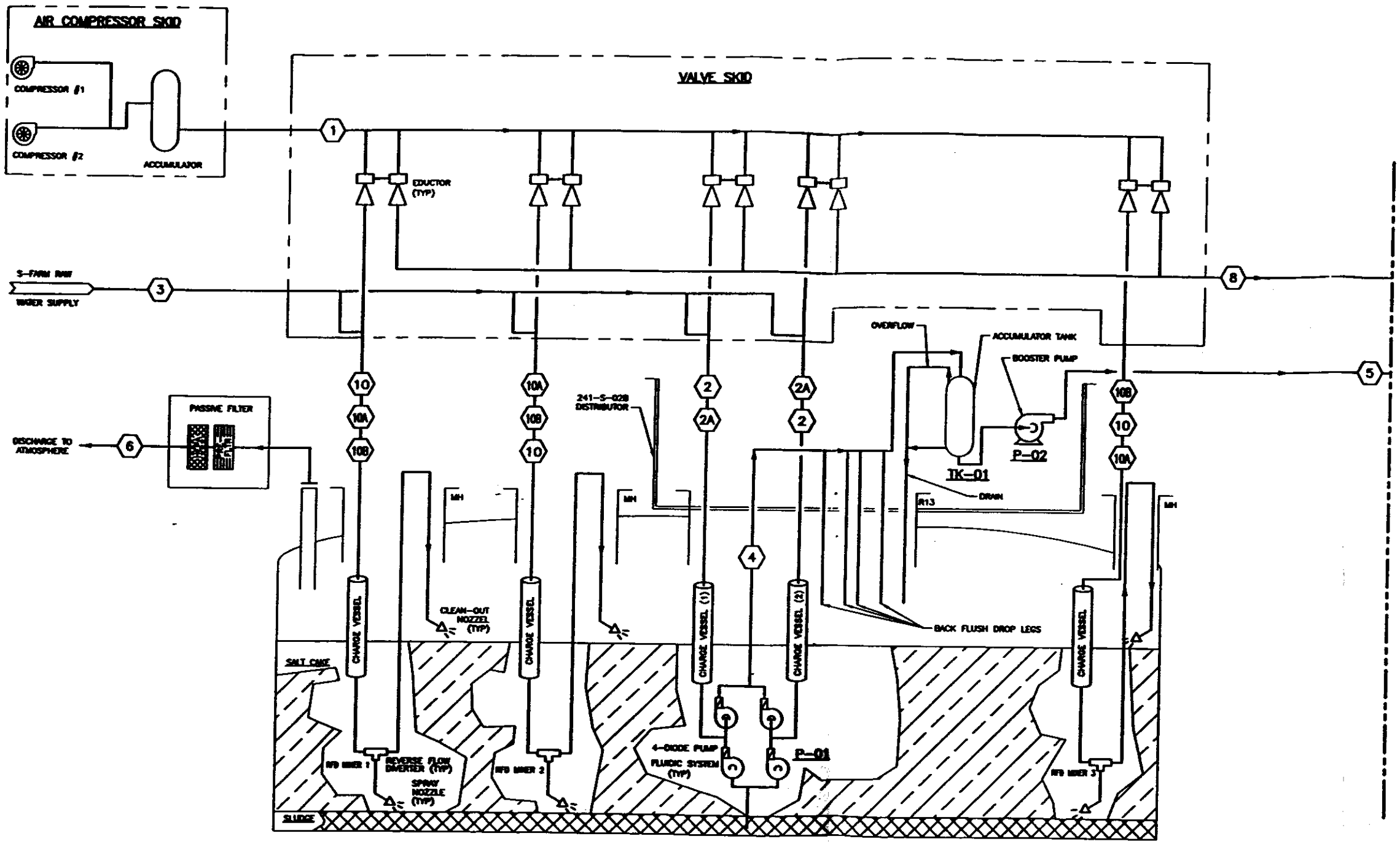

241-S-102

NOTES

1. THE CROSS SITE TRANSFER SYSTEM IS NOT PART OF THIS PROJECT SCOPE.
2. TOTAL CI ONLY INCLUDES THE SUM OF THE MOBILE LONG-LIVED RADIONUCLIDES IDENTIFIED AS:
   ^{14}C
   ^{79}Se
   ^{99}Tc
   ^{233}U (232, 233, 234, 235, 236, 238)

DESIGN MASS FLOWS

STREAM No. / PHASE II	1	2	2A	3	4	5	6	7	8	9	10	10A	10B
STREAM NAME	COMPRESSED AIR FLOW	DRIVE AIR	SUCTION AIR	S-FARM RAW WATER SUPPLY	SLURRY TRANSFER	S-102 SLURRY TO SY-102	BREATHER FILTER	SY-FARM RAW WATER SUPPLY	EDUCTOR EXHAUST	FILTERED AIR TO ATMOSPHERE	RFD MIXER DRIVE	RDF MIXER VENT	RFD MIXER SUCTION
OPERATING PRESSURE (PSIG)	70	70	-13	70	30	65	–	70	70	–	70	70-0	-13
TEMPERATURE (°C)	AMBIENT	AMBIENT	AMBIENT	13	22-38	22-38	–	13	TBD	TBD	AMBIENT	AMBIENT	AMBIENT
SPECIFIC GRAVITY	AIR	AIR	AIR	1.0	1.2-1.4	1.2-1.4	–	1.0	AIR	AIR	AIR	AIR	AIR
VOLUMETRIC FLOW RATE (GPM OR SCFM)	600-800	325	-325	30	80-130	100	8 MAX.	140	300-600	0-600	600	-275	-325
MAXIMUM BATCH VOLUME (GAL)	–	–	–	–	27,400	27,400	–	20,000	–	–	–	–	–
TOTAL CI (SEE NOTE 2)	–	–	–	–	240 TOTAL	240 TOTAL	–	–	–	–	–	–	–

4412.091	POWG.005
241-S-102 WASTE RETRIEVAL SYSTEM	
U.S. DEPARTMENT OF ENERGY	
PHASE II MIXING AND PUMPING PFD	

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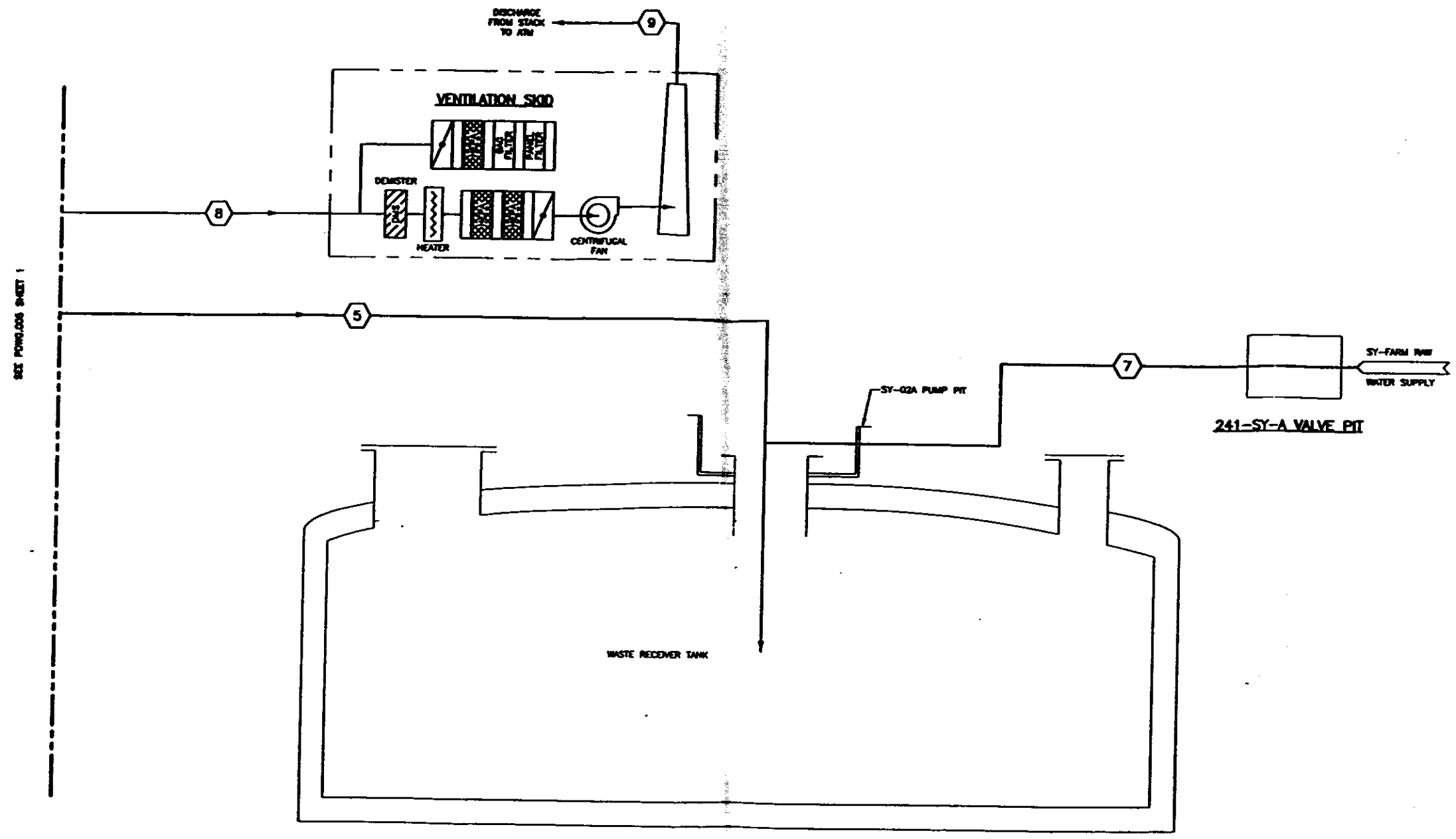

DRAFT DESIGN MASS FLOWS

STREAM No. PHASE II	1	2	2A	3	4	5	6	7	8	9	10	10A	10B
STREAM NAME	COMPRESSED AIR FLOW	DRIVE AIR	SUCTION AIR	S-FARM RAW WATER SUPPLY	SLURRY TRANSFER	S-102 SLURRY TO SY-102	BREATHER FILTER	SY-FARM RAW WATER SUPPLY	EDUCTOR EXHAUST	FILTERED AIR TO ATMOSPHERE	RFD MIXER DRIVE	RDF MIXER VENT	RFD MIXER SUCTION
OPERATING PRESSURE (PSIG)	70	70	-13	70	30	60	–	70	70	–	70	70–0	-13
TEMPERATURE (°C)	AMBIENT	AMBIENT	AMBIENT	13	22–38	22–38	–	13	TBD	TBD	AMBIENT	AMBIENT	AMBIENT
SPECIFIC GRAVITY	AIR	AIR	AIR	1.0	1.2–1.4	1.2–1.4	–	1.0	AIR	AIR	AIR	AIR	AIR
VOLUMETRIC FLOW RATE (GPM OR SCFM)	650–800	325	-325	20	80–130	MID	8 (MAX.)	140	300–600	0–800	600	-275	-325
MAXIMUM BATCH VOLUME (GAL)	–	–	–	–	27,400	27,400	–	20,000	–	–	–	–	–
TOTAL Ci (SEE NOTE 2)	–	–	–	–	240 TOTAL	240 TOTAL	–	–	–	–	–	–	–

4412.091 | PDWG.005
241-S-102 WASTE RETRIEVAL SYSTEM
U.S. DEPARTMENT OF ENERGY
Office of River Protection
PHASE II
MIXING AND PUMPING
PFD

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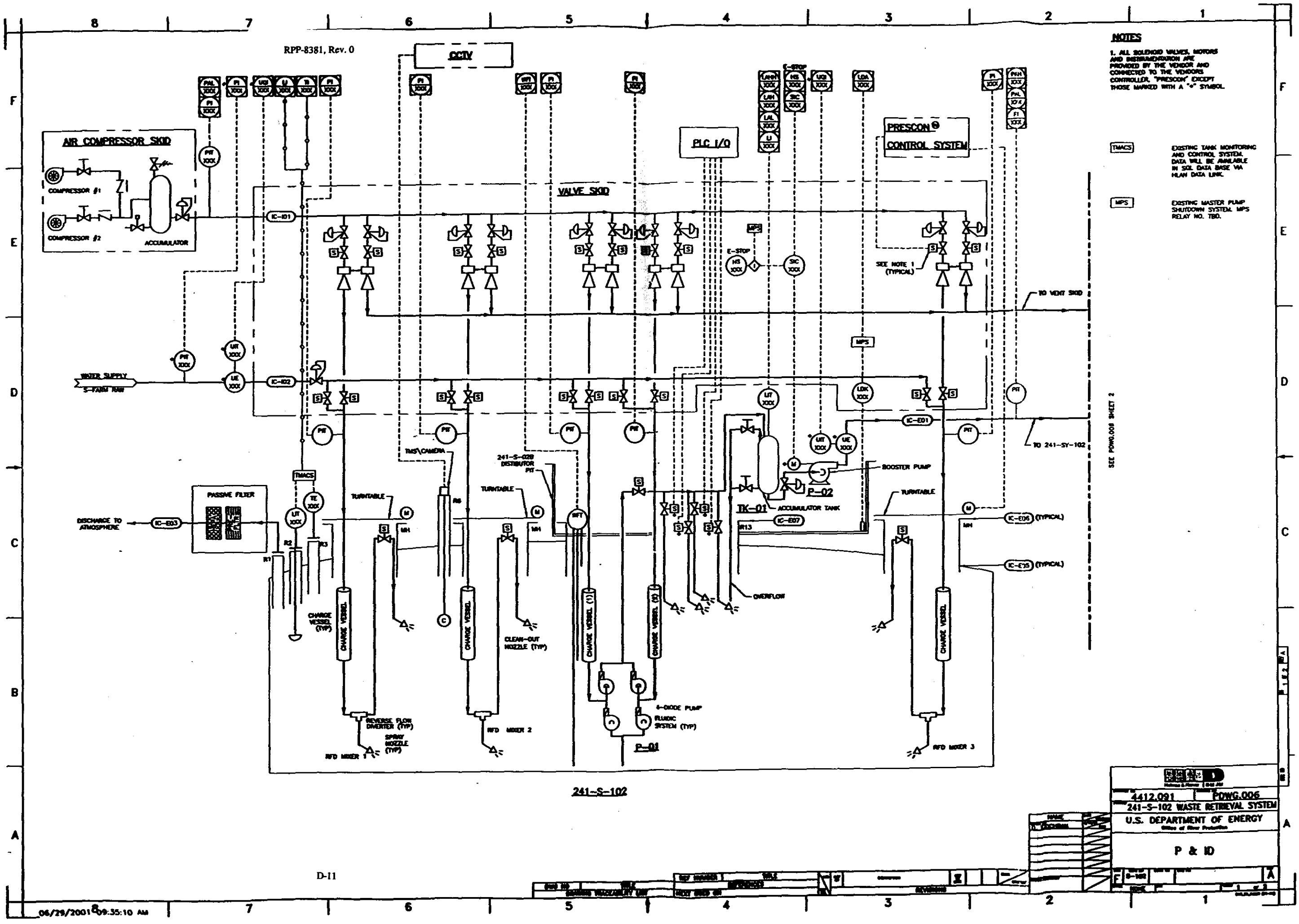
NOTES
1. ALL SOLENOID VALVES, MOTORS AND INSTRUMENTATION ARE PROVIDED BY THE VENDOR AND CONNECTED TO THE VENDORS CONTROLLER, "PRESCON" EXCEPT THOSE MARKED WITH A "*" SYMBOL.
TMACS
EXISTING TANK MONITORING AND CONTROL SYSTEM. DATA WILL BE AVAILABLE IN SOL DATA BASE VIA HLAN DATA LINK.
MPS
EXISTING MASTER PUMP SHUTDOWN SYSTEM. MPS RELAY NO. TBD.
CCTV
AIR COMPRESSOR SKID
COMPRESSOR #1
COMPRESSOR #2
ACCUMULATOR
VALVE SKID
PLC I/O
PRESCON
CONTROL SYSTEM
E-STOP
SEE NOTE 1 (TYPICAL)
TO VENT SKID
WATER SUPPLY
S-FARM RAW
IC-101
IC-102
IC-E01
TO 241-SY-102
SEE POWG.008 SHEET 2
PASSIVE FILTER
DISCHARGE TO ATMOSPHERE
IC-E03
TURNTABLE
TMS\CAMERA
241-S-029 DISTRIBUTOR PIT
BOOSTER PUMP
P-02
TK-01
ACCUMULATOR TANK
IC-E07
OVERFLOW
IC-E06 (TYPICAL)
IC-E05 (TYPICAL)
CHARGE VESSEL (TYP)
CHARGE VESSEL
CLEAN-OUT NOZZLE (TYP)
REVERSE FLOW DIVERTER (TYP)
SPRAY NOZZLE (TYP)
RFD MIXER 1
RFD MIXER 2
RFD MIXER 3
4-DIODE PUMP
FLUIDIC SYSTEM (TYP)
P-01
241-S-102
4412.091
POWG.006
241-S-102 WASTE RETRIEVAL SYSTEM
U.S. DEPARTMENT OF ENERGY
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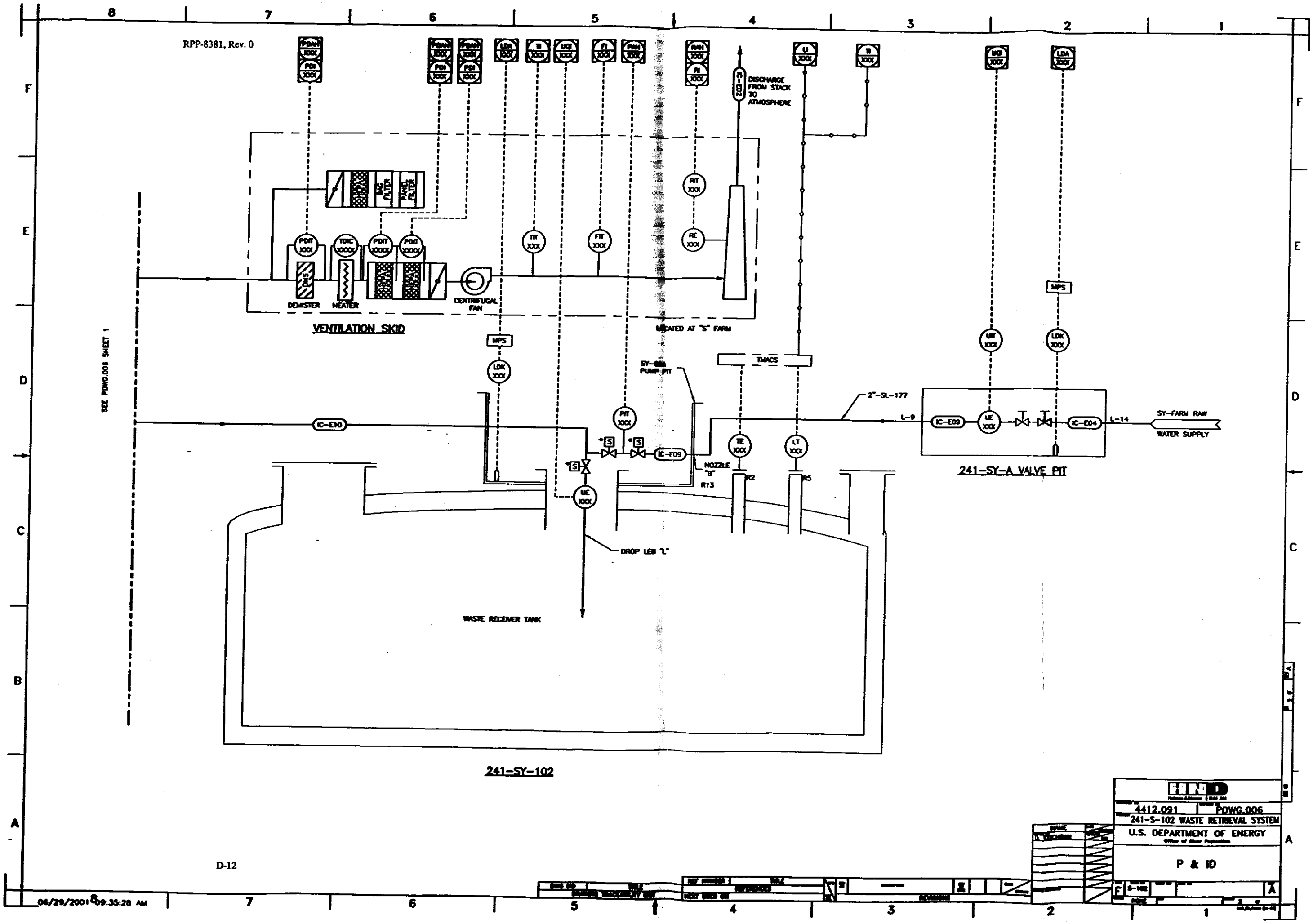
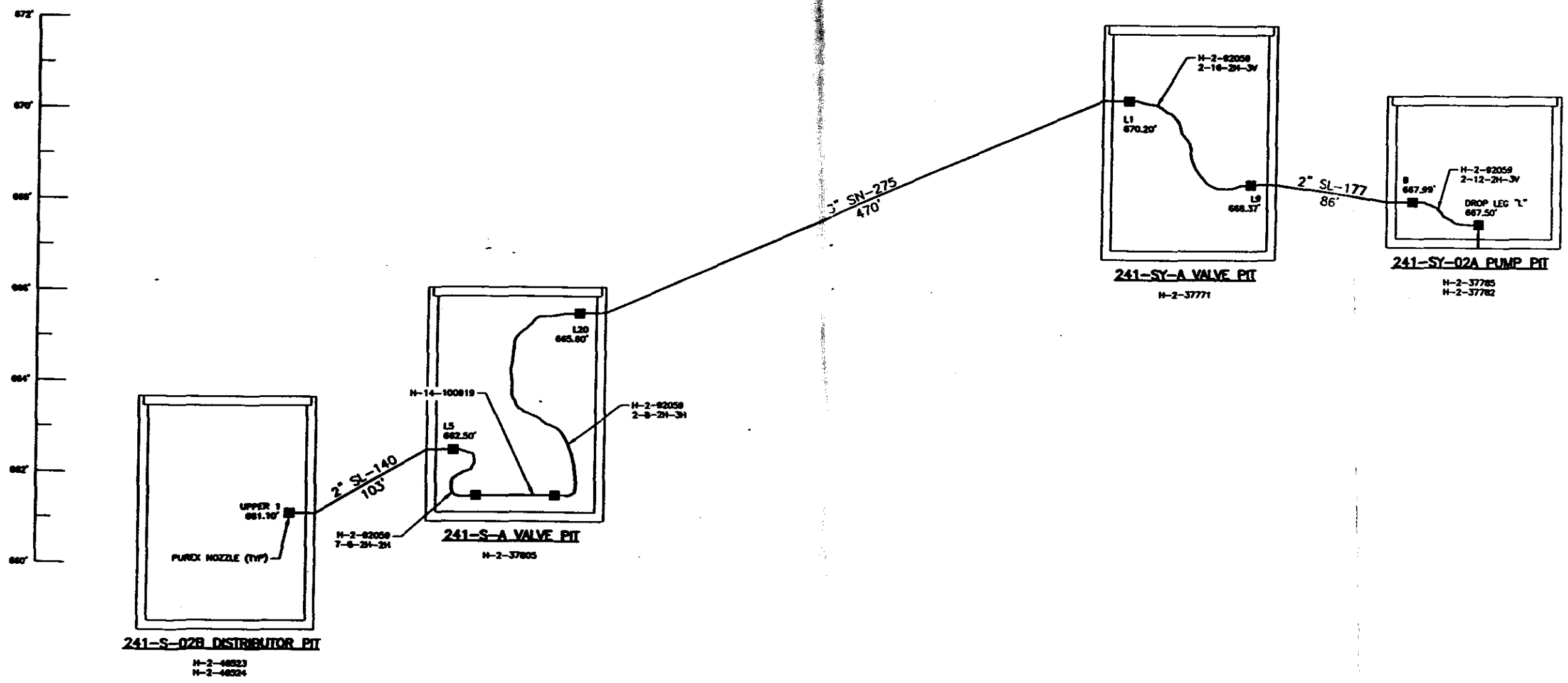

DISCHARGE FROM STACK TO ATMOSPHERE
BAG FILTER
PANEL FILTER
DEMISTER
HEATER
CENTRIFUGAL FAN
VENTILATION SKID
LOCATED AT "S" FARM
SEE PDWG.006 SHEET 1
SY-08A PUMP PIT
TMACS
2"-SL-177
L-9
L-14
SY-FARM RAW WATER SUPPLY
241-SY-A VALVE PIT
NOZZLE "B"
R13
R2
R5
DROP LEG "L"
WASTE RECEIVER TANK
241-SY-102
4412.091
PDWG.006
241-S-102 WASTE RETRIEVAL SYSTEM
U.S. DEPARTMENT OF ENERGY
P & ID

NOTES

1. NOZZLE ELEVATIONS DO NOT CORRESPOND TO PIT ELEVATIONS OR ORIENTATIONS.



4412.091 | MDWG.001

241-S-102 WASTE RETRIEVAL SYSTEM

U.S. DEPARTMENT OF ENERGY

HYDRAULIC DIAGRAM
EXISTING TRANSFER LINE

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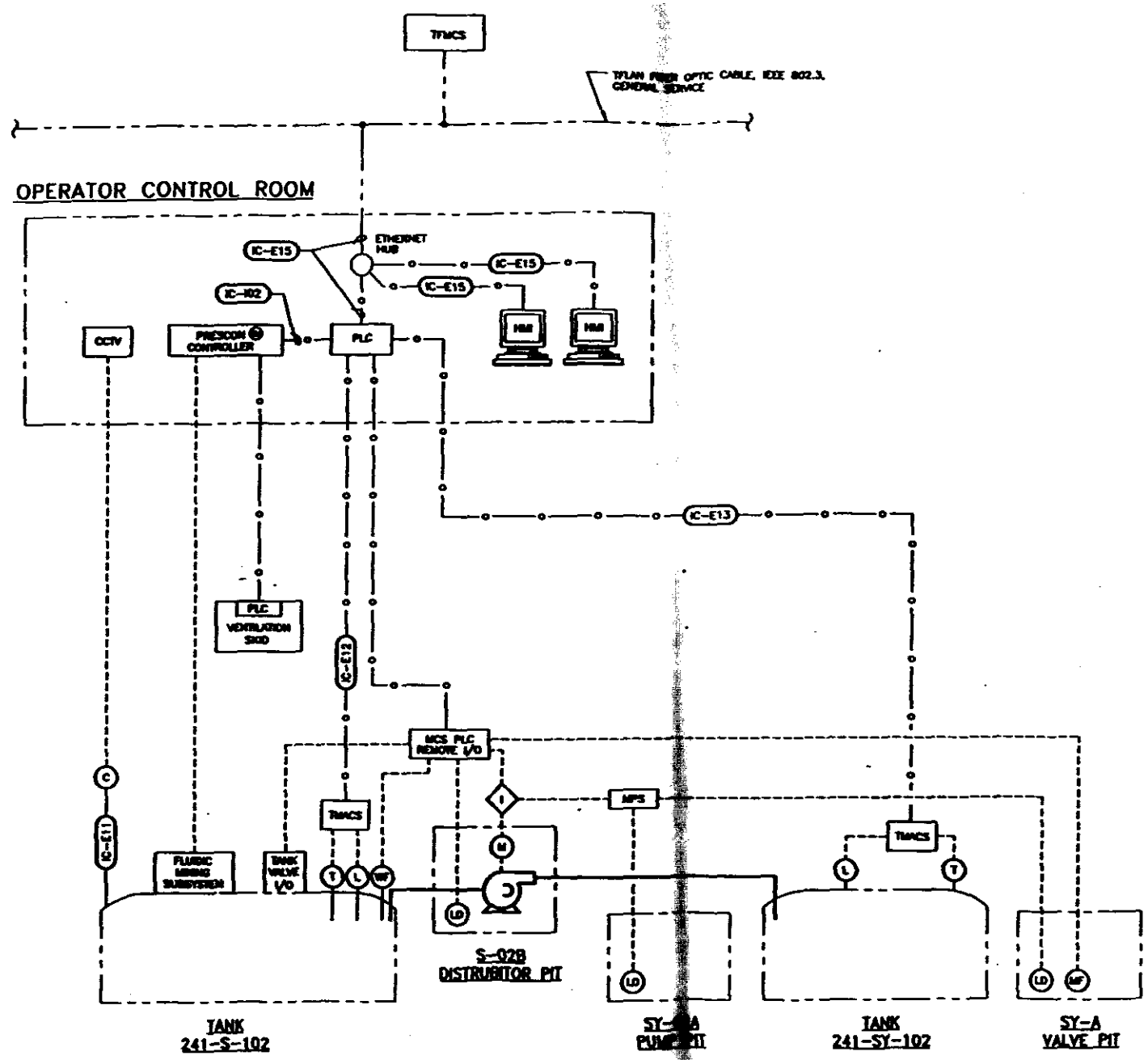

LEGEND

- T – TEMPERATURE TREE
- L – LEVEL INSTRUMENT
- C – CAMERA
- WF – WEIGHT FACTOR
- MF – MASS FLOW
- LD – LEAK DETECTOR
- I – INTERLOCK

HMI – HUMAN MACHINE INTERFACE
PLC – PROGRAMMABLE LOGIC CONTROLLER
I/O – INSTRUMENTATION/CONTROLS INPUTS & OUTPUTS
MPS – MASTER PUMP SHUTDOWN
CCTV – CLOSED CIRCUIT TV
TFMCS – TANK FARM MONITOR AND CONTROL SYSTEM
TFLAN – TANK FARM LAN

DATA LINK
ELECTRICAL POWER OR SIGNAL
EXISTING
NEW

4412.091 | IDWG.001
241-S-102 WASTE RETRIEVAL SYSTEM
U.S. DEPARTMENT OF ENERGY
MONITOR AND CONTROL BLOCK DIAGRAM

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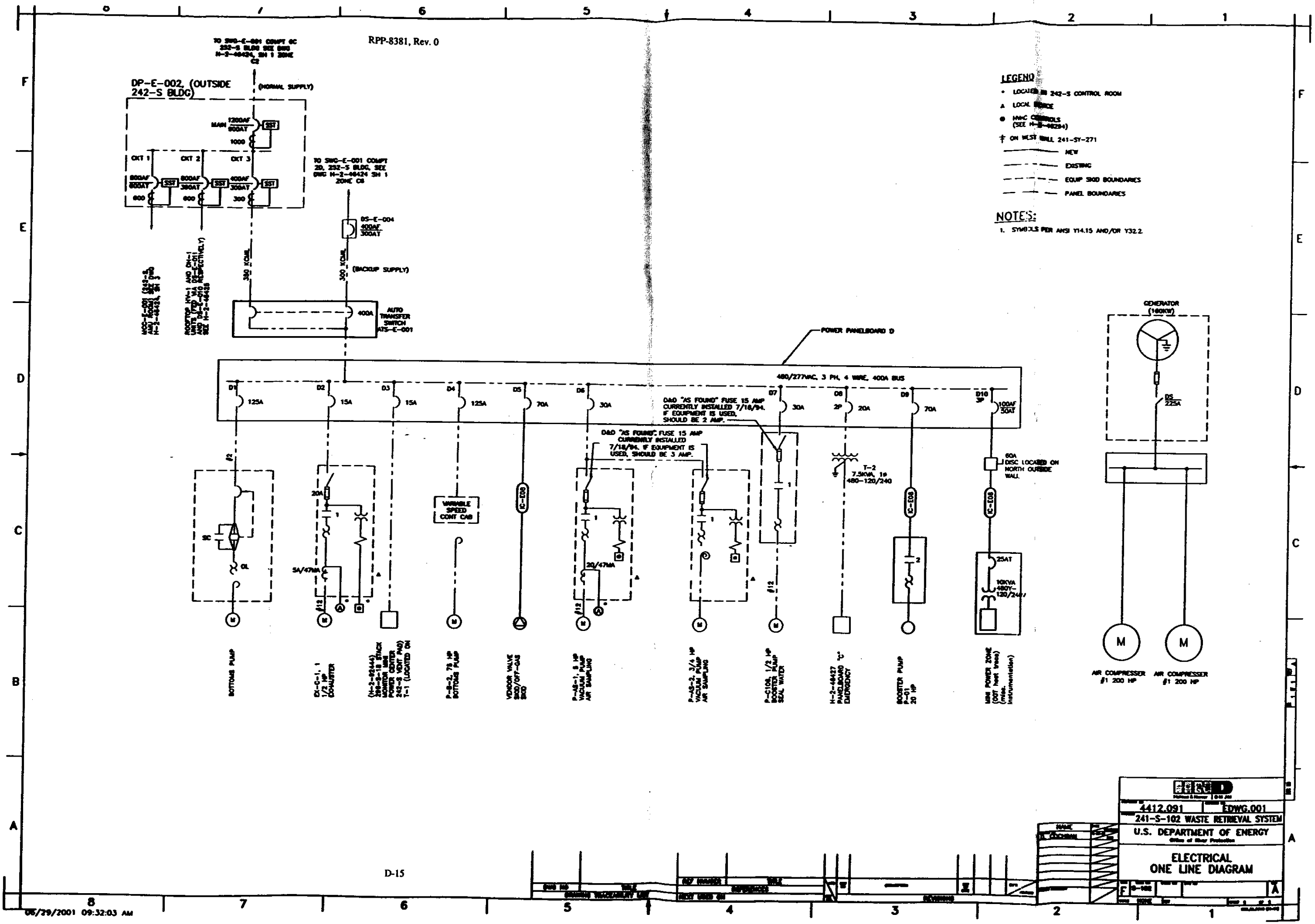
DP-E-002, (OUTSIDE 242-S BLDG)
(NORMAL SUPPLY)
MAIN 1200AF 800AT
SST
1000
CKT 1
CKT 2
CKT 3
800AF 800AT
800AF 300AT
400AF 300AT
600
300
TO SWG-E-001 COMPT 20, 232-S BLDG, SEE DWG H-2-48424 SH 1 ZONE C8
DS-E-004 400AF 300AT
(BACKUP SUPPLY)
AUTO TRANSFER SWITCH ATS-E-001
400A
POWER PANELBOARD D
480/277VAC, 3 PH, 4 WIRE, 400A BUS
D1 125A
D2 15A
D3 15A
D4 125A
D5 70A
D6 30A
D7 30A
D8 2P 20A
D9 70A
D10 3P 100AF 30AT
D&D "AS FOUND" FUSE 15 AMP CURRENTLY INSTALLED 7/18/94. IF EQUIPMENT IS USED, SHOULD BE 2 AMP.
D&D "AS FOUND" FUSE 15 AMP CURRENTLY INSTALLED 7/18/94. IF EQUIPMENT IS USED, SHOULD BE 3 AMP.
T-2 7.5KVA, 1ø 480-120/240
60A DISC LOCATED ON NORTH OUTSIDE WALL
25AT
10KVA 480Y-120/240
GENERATOR (160KW)
DS 225A
BOTTOMS PUMP
DX-C-1, 1 1/2 HP COMPRESSOR
(H-2-82444) 296-S-18 STACK MONITOR MAIN POWER CENTER 242-S VENT PAD) T-1 (LOCATED ON
P-B-2, 75 HP BOTTOMS PUMP
VENDOR VALVE SKID/OFF-GAS SKID
P-AS-1, 5 HP VACUUM PUMP AIR SAMPLING
P-AS-2, 3/4 HP VACUUM PUMP AIR SAMPLING
P-C100, 1/2 HP BOOSTER PUMP SEAL WATER
H-2-48427 PANELBOARD "C" EMERGENCY
BOOSTER PUMP P-01 20 HP
MINI POWER ZONE (DOT heat trace) (misc. instrumentation)
AIR COMPRESSER #1 200 HP
AIR COMPRESSER #1 200 HP
LEGEND
LOCATED IN 242-S CONTROL ROOM
LOCAL PANEL
HVAC CONTROLS (SEE H-2-48294)
ON WEST WALL 241-SY-271
NEW
EXISTING
EQUIP SKID BOUNDARIES
PANEL BOUNDARIES
NOTES:
1. SYMBOLS PER ANSI Y14.15 AND/OR Y32.2.
4412.091
EDWG.001
241-S-102 WASTE RETRIEVAL SYSTEM
U.S. DEPARTMENT OF ENERGY
ELECTRICAL ONE LINE DIAGRAM
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Appendix E

Compliance Matrix

S-102 Compliance Matrix

F&R Section	Requirement or Objective	Comments
3.1.2.1.1	**SST/DST Electrical Power System.** The amount of three-phase 480 V, 60 Hz power available to the 241-S-102 WRS will be determined during preliminary engineering and conceptual design.	**This requirement is met at a preliminary level.** As shown in the Electrical One-Line Diagram (drawing 4412.091.EDWG.001), all of the 241-S-102 WRS electrical loads will be powered by the existing S Farm power system, with the exception of two new air compressors (powered by a temporary electrical generator). A preliminary load analysis (see Calculation 4412.091.ECAL.001) has determined that adequate power is available in the farm to support this configuration.
3.1.2.1.2	**DST Raw Water System.** The raw water available to the 241-S-102 WRS is a 10.1-cm (4-in.) -diameter line in the 241-SY Tank Farm at the SY-A valve-pit at a pressure of 482 kPa (70 lb/in^2 [gauge]) (TBR).	**This requirement is met at a preliminary level.** As shown on the P&ID (drawing 4412.091.PDWG.006, sheets 1 & 2) and Site Plan (drawing 4412.091.CDWG.001), the preliminary design of the WRS includes raw water tie-ins in both the SY and S Tank Farms. A detailed analysis of the WRS water requirements and the available raw water supplies will be performed during Conceptual Design to confirm the approach presented in the PER document.
3.1.2.1.3	**DST Confinement Subsystem.** For the combination of waste currently in tank 241-S-102 and the dilution fluids required for its retrieval, the available volume in the DST System is 3,829 kL (1,011 kgal). If required for retrieval of waste from tank 241-S-102, supernatant liquid may be obtained from tank 241-SY-102. The addition of inhibited water to create supernatant liquid shall be minimized.	**This requirement is met at a preliminary level.** As shown on the Process Flow Diagram (drawing 4412.091.PDWG.004), no supernatant will be obtained from SY-102. Water addition to 241-S-102 will be minimized by optimizing salt dilution and retrieval through a small batch process.
3.1.2.1.4	**Master Monitor and Control System.** The 241-S-102 WRS shall accept control signals from the Master Monitor & Control System to effect the safe shutdown of waste transfer, as appropriate (e.g., leak detection, transfer line/tank pressure excursions). Note that these shutdown signals are safety significant.	**This requirement is met at a preliminary level.** The Monitor and Control Block Diagram (drawing 4412.091.IDWG.001) and P&ID (drawing 4412.091.PDWG.006, sheet 1) illustrate the use of hard-wired interlocks to effect safe shutdown of the 241-S-102 transfer pump upon detection of a leak and/or other off-normal process parameter.

F&R Section	Requirement or Objective	Comments
3.1.2.2.1	**Tank 241-S-102.** The 241-S-102 WRS shall interface with the existing tank 241-S-102 risers, pump pit and distributor pit shown in Drawing H-14-010633, Rev. 0, sheet 1 (see also drawing H-2-73182, Rev. 5). The interface point with the risers is either a flange located inside the pit or as otherwise defined in the applicable pit drawings. The WRS may interface with existing tank risers that are off vertical up to 5 degrees. The tank risers may be out-of-round.	**This requirement is met at a preliminary level.** The proposed riser and pit interfaces for the new WRS are shown on the P&ID (drawing 4412.091.PDWG.006, sheet 1). The RFD mixing system interfaces with the three existing tank manholes are also shown on the P&ID. Additional details for the fluidic system interfaces are shown in sketches in Section 2 of the PER.
3.2.2.2.2	**Tank 241-SY-102.** The 241-S-102 WRS shall interface with the existing risers and pump pits in tank 241-SY-102 shown in Drawing H-14-010531, Sheet 2, Rev. 6.	**This requirement is met at a preliminary level.** The 241-S-102 WRS interfaces with the 241-SY-102 pit and risers are shown on the P&ID (drawing 4412.091.PDWG.006, sheet 2).
3.2.1.1	**Control 241-S-102 Structure and Waste Temperature.** The 241-S-102 WRS shall control the temperature of the tank 241-S-102 structure and the waste to prevent structural damage to the SST and maintain waste temperature limits established by accident analysis. Control includes monitoring structure and waste temperatures, comparing monitored values to set limits, and maintaining the structure and waste temperature within the set limits. Structure temperature is controlled via control of the waste temperature.	**This requirement is met at a preliminary level.** Estimated waste stream temperature ranges are shown on the Process Flow Diagram (drawing 4412.091.PDWG.004). The waste stream temperatures are within the proper range to protect against structural damage to the SST and maintain the waste temperature limits established by accident analysis. Waste (and structure) temperatures will be controlled as shown on the P&ID (drawing 4412.091.PDWG.006) and the Monitor and Control Block Diagram (drawing 4412.091.IDWG.001).

F&R Section	Requirement or Objective	Comments
3.2.1.1.a	**Tank Design Temperature Limits.** The 241-S-102 WRS shall control structure and waste temperatures in tank 241-S-102 within the following specified design limits to prevent tank structural failure: Temperatures: • Maximum 149 °C (300 °F) for waste • Maximum 121 °C (250 °F) for dome • Maximum change of 11 °C (20 °F) per day for bulk waste temperature in the tank. (Note: Operational limitations on in-tank temperatures will be established as part of pre-conceptual and conceptual design activities).	**This requirement is met at a preliminary level.** See response to 3.2.1.1. The estimated water and waste stream temperatures support these limits. The proposed control system monitors them.
3.2.1.2	**Control 241-S-102 Waste Level.** The 241-S-102 WRS shall control the waste level in tank 241-S-102 to prevent waste overflow and limit the hydrostatic head-induced stresses in the tank and provide for leak detection monitoring. Control includes monitoring waste levels, comparing monitored values to set limits, and providing signals for transfer pump shutdown at the waste level set limits.	**This requirement is met at a preliminary level.** Tank level will be continuously monitored during retrieval operations using the level instrument installed in 241-S-102 Riser 2. A level sensor interlock in the new control system will ensure that established tank level limits are not exceeded. In addition, water quantities added to S-102 to support retrieval and mixing will be measured and reported to the MCS. Tank level can also be visually monitored using the in-tank CCTV camera. See the P&ID (drawing 4412.091.PDWG.002) and Monitor and Control Block Diagram (drawing 4412/091.IDWG.001).
3.2.1.2.a	**Waste Level Limits.** The 241-S-102 WRS shall prevent the waste level in tank 241-S-102 from exceeding 7.11 m (275 in.).	**This requirement is met at a preliminary level.** See response to 3.2.1.2.
3.2.1.2.b	**Tank Structural Limits.** The 241-S-102 WRS shall limit the hydrostatic forces on the tank 241-S-102 such that the hydrostatic forces do not exceed the force equivalent to 275 in. of waste with a specific gravity (SpG) of 2.0.	**This requirement is met at a preliminary level.** This parameter is controlled by means of the tank level instrumentation and control system interlock as discussed in the response to 3.2.1.2.

F&R Section	Requirement or Objective	Comments
3.2.1.2c	**Free-Standing Liquids**. The 241-S-102 WRS shall minimize, to the extent practical, the amount of free-standing liquids in tank 241-S-102 during retrieval.	**This requirement is met at a preliminary level.** The proposed process strategy is to add maximum 20,000-gallon batch quantities of water, which will dissolve salt or be mixed with sludge and transferred from 241-S-102 prior to introduction of the next batch of water.
3.2.1.3	**Control 241-S-102 Vapor Space Pressure.** The 241-S-102 WRS shall control the vapor space pressure in tank 241-S-102 to prevent structural damage to the tank and maintain vapor space pressure limits established by accident analysis. Control includes monitoring vapor space pressure, comparing monitored values to set limits, and maintaining the vapor space pressure to within set limits.	**This requirement is met at a preliminary level.** Tank vapor space pressure will be monitored during WRS operations using the weight factor transmitter (WFT) short dip tube, as shown on the P&ID (drawing 4412.094.PDWG.006, sheet 1). The pressure indicator will be interlocked with WRS operation by means of the new MCS software to control tank vapor space pressure within the set limits.
3.2.1.3.a	**Pressure Limits.** The 241-S-102 WRS shall control the vapor space pressure in tank 241-S-102 within the following specified design limits to prevent tank structural failure: If the waste level is ≥ 38.1 cm (15 in.) divided by the waste SpG, -38.1 cm (15 in.) w.g. ≤ vapor pressure ≤ 1.5 m (60 in.) w.g. If the waste level is < 38.1 cm (15 in.) divided by the waste SpG, - (waste level) * (SpG of waste) ≤ vapor pressure ≤ 1.5 m (60 in.) w.g.	**This requirement is met at a preliminary level.** Tank vapor space pressure will be monitored and controlled during WRS operation as discussed in the response to 3.2.1.3.
3.2.1.4	**Control 241-S-102 Gaseous Discharges.** The 241-S-102 WRS shall control the vapor space pressure in tank 241-S-102 and filter the air exhaust to restrict emissions to the environment. Control includes monitoring gaseous discharges to the environment, comparing monitored values to set limits, and filtering radioactive particulates and hazardous or toxic gases.	**This requirement is partially met at a preliminary level.** Tank vapor space pressure will be monitored and controlled during WRS operation as discussed in the response to 3.2.1.3. A passive ventilation system, equipped with HEPA filters, will filter radioactive particulates from the tank emissions to the environment. There is no emission monitoring capability or hazardous/toxic gas filtration provisions included in the design of the WRS.

F&R Section	Requirement or Objective	Comments
3.2.1.4.a	**Gaseous Discharge Limits.** Limits on gaseous discharges to the environments are specified in Sections 3.3.6.3.3, 3.3.6.3.4, and 3.3.6.3.6.	**This requirement is partially met at a preliminary level.** HEPA filters will be used to control radioactive airborne emissions as required. There is no capability included in the design for controlling non-radioactive airborne emissions. Controls associated with WRS equipment used in a potential flammable gas environment are discussed in the response to 3.3.6.3.6.
3.2.1.5	**Remove Waste from Tank 241-S-102 During Phase 1 WFD.** The 241-S-102 WRS shall remove waste from 241-S-102 for the purposes of removing mobile, long lived radioisotopes and non-radiological hazardous constituents and demonstrating the fluidic mixer retrieval technology. Waste removal includes retrieving the waste from 241-S-102 and transferring the retrieved waste to 241-SY-102.	**This requirement is met at a preliminary level.** The preliminary design and proposed operational strategy presented in this PER are intended to meet this requirement. See the Process Flow Diagram (drawing 4412.091.PDWG.004) for a schematic illustration of the proposed retrieval system.
3.2.1.5.a	**Waste Removal Quantities**. The 241-S-102 WRS shall be capable of removing as much of the tank 241-S-102 waste inventory (see Tank Characterization Report for SST 241-S-102 (CHG 2000a)) as possible within 69 days of operation over a 168 day duration, while satisfying the DST volume limitation specified in Section 3.1.2.1.5 (TBR).	**This requirement is met at a preliminary level.** The process and operational strategy used with this design are expected to meet the TPA goals of 99% volume and 490 curies of long-lived isotopes removal within these durations; however, the anticipated 241-SY-102 space restrictions will require one cross-site transfer from the receiver DST to accommodate the 241-S-102 waste (see Calculation 4412.091.PCAL.001).
3.2.1.5.b	**Waste Output.** The 241-S-102 WRS shall place the appropriate controls on transferred waste temperature and chemistry to preclude transfer-line plugging during normal and upset conditions.	**This requirement is met at a preliminary level.** The design uses heat trace on the OGT line (see Electrical One Line Diagram, drawing 4412.091.EDWG.001) and post-transfer line flushing to control plugging.

F&R Section	Requirement or Objective	Comments
3.2.1.5.c	**Retrieved Waste Properties.** The 241-S-102 WRS shall retrieve waste from tank 241-S-102 such that the commingled waste in receiver tank 241-SY-102 satisfies the following waste properties: Liquid Density: 1.21 to1.46 kg/L Liquid Viscosity: 0.01 to 0.1 g/cm-s (1 to 10 cP) Solids Density: 2.5 to 3.0 kg/L Solids Mean Diameter: 40 to 400 μm Solids Volume Percent: 10 to 30%	**Compliance with this requirement is TBD, pending completion of appropriate waste compatibility assessment studies.**
3.2.1.5.d	**Entrained Gas.** The WRS shall not inject more than 2.83 m^3 per minute (100 ft^3/min.) of air at standard conditions into the waste transfer line terminating at tank 241-SY-102.	**This requirement is met at a preliminary level.** Flow and pressure measurements in the transfer line (see P&ID drawing 4412.091.PDWG.006) will be used to control this parameter.
3.2.1.5.e	**Existing in-Tank Hardware.** The 241-S-102 WRS shall be required to operate in and around the existing 241-S-102 "in-tank-hardware" (e.g., installed equipment, wires, 50- to 100-ft steel tapes, and other debris) (see CHG 2000b).	**This requirement is met at a preliminary level.** The preliminary design of the WRS has been developed to operate in and around the existing 241-S-102 in-tank-hardware.
3.2.1.6	**Control and Monitor the 241-S-102 Waste Removal Process.** The 241-S-102 WRS shall monitor and control the process for retrieving waste from tank 241-S-102. Waste removal process parameters (e.g., waste transfer line pressures, flow rates, waste densities), environmental safety parameters (e.g., leak detection), and equipment parameters (e.g., transfer pump speed and motor amperage) shall be monitored and controlled for safe and effective operation of the 241-S-102 WRS. Data logging and recording also shall be performed by the 241-S-102 WRS. The control and monitoring of the waste removal process shall be integral to the control of in-the tank and waste parameters discussed in Sections 3.2.1.1 through 3.2.1.4.	**This requirement is met at a preliminary level.** The instrumentation and control systems for this system meet these requirements. The P&ID (drawing 4412.091.PDWG.006) and Monitor and Control Block Diagram (drawing 4412.091.IDWG.001) illustrate components used for monitoring and control of the process.

F&R Section	Requirement or Objective	Comments
3.2.1.6.a	**Signal Output Compatibility.** The 241-S-102 WRS shall provide the required output signals (e.g., temperature and level) to the Master Monitor and Control System in a protocol compatible with that system.	**This requirement is met at a preliminary level.** The system specifications developed during later design stages will ensure that this requirement is met.
3.2.1.6.b	**Remote Operation.** The 241-S-102 WRS shall be operated and monitored from a control station outside the S tank farm fence. Manually operated valves may however, be included in the 241-S-102 WRS design.	**This requirement is met at a preliminary level.** As shown in the Site Plan drawing (4412.091.CDWG.001), the control station of the S-102 WRS is located outside of the tank farm fence.
3.2.1.6.c	**Monitor in-Tank Operations.** The 241-S-102 WRS shall be capable of providing real-time video monitoring of in-tank retrieval operations.	**This requirement is met at a preliminary level.** An in-tank CCTV camera is provided in Riser 5, as shown on the P&ID (drawing 4412.091.PDWG.006, sheet 1).
3.2.1.6.d	**Leak Detection System Shutdown.** The 241-S-102 WRS shall include features to shut down waste retrieval pumps and primary motive power on detection of the failure of the primary containment of any out-of-tank waste handling, transfer, or storage facilities.	**This requirement is met at a preliminary level.** As shown in the Monitor & Control Block Diagram (drawing 4412.091.IDWG.001), the WRS pump is interlocked to the Master Pump Shutdown System to ensure that the pump is stopped upon detection of a leak at any out-of-tank waste handling, transfer, or storage facilities.
3.2.1.6.e	**WRS Emergency Stop Feature.** The 241-S-102 WRS shall have an emergency stop feature that will shut down waste retrieval pumps and primary motive power.	**This requirement is met at a preliminary level.** See P&ID (drawing 4412.091.PDWG.006, sheet 1).
3.2.1.6.f	**241-S-102 WRS Exhauster.** The 241-S-102 WRS shall include features to support shut down of the S tank farm ventilation on detection of unfiltered releases from tank 241-S-102.	**This requirement is not applicable, since there is no active S Tank Farm ventilation system.**

F&R Section	Requirement or Objective	Comments
3.2.1.6.g	**Data Logging/Recording.** The 241-S-102 WRS shall log or record the following parameters (TBR): • DST receiver tank liquid level, pressure, temperature and ventilation system operability • DST receiver tank filter delta P • Transfer loop flow rate • Transfer loop liquid mass flow • Tank 241-S-102 exhaust stack radiation monitor alarm • Tank 241-S-102 exhaust stack flow rate* • Tank 241-S-102 pressure. * Active ventilation option only	**This requirement is partially met at a preliminary level.** The P&ID (drawing 4412.091.PDWG.006, sheets 1 & 2) shows that the specified I/O signals are available for logging and recording by the MCS, with the exception of DST vapor space pressure, DST ventilation system operability, DST filter delta P, and S-102 exhaust stack radiation monitoring alarm (also the Tank S-102 exhaust stack flow rate, since there is no plan for active ventilation of this tank).
3.2.1.6.1	**Detect 241-S-102 Leaks During Waste Removal.** The 241-S-102 WRS shall be capable of detecting liquid waste releases from tank 241-S-102 during all waste removal operations. a. **Detection Reliability.** The 241-S-102 WRS shall have a probability of leak detection of 95% and a probability of false alarm less than or equal to 5%. (Note: Leak detection is defined by the detection performance requirement [DPR], which is to be determined for tank 241-S-102 based on the tank 241-S-102 RPE)	**This requirement is partially met at a preliminary level.** The proposed leak detection methodology for 241-S-102 retrieval can provide reliable leak detection within the specified probability range. However, the RPE for 241-S-102 has not been completed and therefore the specific DPR for this SST has not been defined. Preliminary RPE data indicates that a very restrictive DPR may be established. This may result in a detection requirement that cannot be accomplished due to the limits of available detection technology.
3.2.1.6.2	**Monitor 241-S-102 Leaks During Waste Removal.** The 241-S-102 WRS shall quantify liquid waste release volumes from tank 241-S-102 if a release is detected during waste retrieval operations. A leak volume estimate must be accurately predicted to quantify the environmental impact resulting from a leak. ▪ **Leak Monitoring Accuracy**. The 241-S-102 WRS shall be capable estimating a leak volume to within TBD gallons.	**This requirement is not applicable to the WRS design effort.** The responsibility for quantifying liquid waste release volumes from tank 241-S-102 (if a release is detected) falls within the scope of the Hanford vadose zone monitoring program.

F&R Section	Requirement or Objective	Comments
3.2.1.6.3	**3.2.1.6.3 Control and Monitor 241-S-102 Waste Retrieval.** Waste removal process parameters (e.g., waste transfer line pressures, flow rates, waste densities), environmental safety parameters (e.g., leak detection), and equipment parameters (e.g., transfer pump speed and motor amperage) shall be monitored and controlled for safe and effective operation of the 241-S-102 WRS.	**This requirement is met at a preliminary level.** The P&ID (drawing 4412.091.PDWG.006, sheet 1) identifies the required waste transfer line pressure and flow rate measurement devices, as well as the transfer pump speed indicating controller (SIC) used to monitor and control pump speed and motor amperage. Waste density will be determined indirectly using the SST's WFT dip tubes, also shown on the P&ID. Leak detection parameters will be monitored indirectly during WRS operations using mass balance techniques, with secondary monitoring provided using dry wells.
3.2.1.7	**Measure Residual Waste in Tank 241-S-102.** The 241-S-102 WRS shall measure the residual waste in tank 241-S-102 to evaluate the tank 241-S-102 WRS effectiveness. Waste on the walls of the tank; on and under the stiffening rings attached to the walls of the tank; on the exterior surfaces of in-tank debris, hardware, and components; and on the bottom of the tank shall be measured, as necessary.	**This requirement is met at a preliminary level.** The P&ID (drawing 4412.091.PDWG.006, sheet 1) identifies several methods to be used in indirectly assessing effectiveness of the S-102 WRS. These include the in-tank CCTV camera and Tank Monitoring System (TMS) installed in Riser 6, as well as the tank level indicator in Riser 2.
3.2.1.7.a	**Measurement Sensitivity.** The 241-S-102 WRS shall be capable of measuring and integrating at least TBD m^3 (TBD ft^3) of residual waste on these tank surfaces.	**Compliance with this requirement will be assessed following quantification of the "TBDs".**
3.2.1.8	**Transfer Supernatant Liquid from Tank 241-SY-102 to Tank 241-S-102 Waste Retrieval Equipment.** The 241-S-102 WRS may transfer supernatant liquids from tank 241-SY-102 to tank 241-S-102 to facilitate waste retrieval. Required supernatant liquid volume, properties, and flow rate are design-solution dependent and will be specified at the conclusion of the pre-conceptual design phase.	**This requirement is not applicable.** Transfer of supernatant from tank 241-SY-102 to 241-S-102 is not required to facilitate waste retrieval. The selected design will instead introduce relatively small quantities of water to the SST to dissolve the salt and mobilize the remaining insoluble waste.
3.2.1.9	**3.2.1.9 Mitigate 241-S-102 Leaks During Waste Removal.** The 241-S-102 WRS shall mitigate leaks as the primary means of minimizing environmental impact caused by releases during retrieval of SST waste. If a leak occurs, the RPE shall be evaluated and the appropriate actions implemented (e.g., continue retrieval).	**This requirement is met at a preliminary level.** The proposed operating strategy includes minimizing the quantity of liquid in the SST during retrieval operations in order to mitigate the potential for waste leakage to the environment. As discussed in Section 2.1.7 of the PER, in the event of a leak from the tank, the applicable RPE will be evaluated and appropriate actions shall be implemented.

F&R Section	Requirement or Objective	Comments
3.2.2.a	**Axial Loads, 4-in. Risers.** The 241-S-102 WRS may impose axial loads on 4 in. risers not to exceed 227 kg (500 lb), or impose moments not to exceed 339 N.m (250 ft-lb) (TBR, see Appendix A remarks).	**This requirement is met at a preliminary level.** Structural calculations will be prepared during later design development (e.g., Conceptual Design) to verify that axial loads placed on the 4 in. risers do not exceed allowable limits.
3.2.2.b	**Axial Loads, 12-in. and Larger Risers.** The 241-S-102 WRS may impose axial loads on 12 in. or larger risers of no more than 1362 kg (3,000 lb) or impose a moment of no more than 2034 N.m (1,500 ft-lbs) (TBR, see Appendix A remarks).	**This requirement is met at a preliminary level.** Structural calculations will be prepared during later design development (e.g., Conceptual Design) to verify that axial loads placed on the 12 in. risers do not exceed allowable limits.
3.2.2.c	**Allowable Load on Tank 241-S-102 Bottom.** The bottom surface of tank 241-S-102 may be used to support in-tank equipment. The maximum load imparted by the 241-S-102 WRS shall not exceed the value given by the formula W = 2,190 x (load area diameter [cm.] + 10.8) (N) (W = 1,250 x (load area diameter [in.] + 4.25) (lbf.)) (TBR, see Appendix A Remarks)	**This requirement is met at a preliminary level.** The preliminary design described in the PER does not use the 241-S-102 tank bottom to support any in-tank equipment.
3.2.2.d	**Dome Loading.** The 241-S-102 WRS shall not exceed the maximum dome loading on existing SSTs and DSTs specified in HNF-IP-1266, Rev. 2a.	**This requirement is met at a preliminary level.** Preliminary calculations (4412.091.SCAL.001) have determined that the induced dome loading due to the WRS is within allowable limits.
3.2.2.e	**Dome Deflection.** The 241-S-102 WRS shall not cause dome deflections greater than or equal to 0.61 cm (0.02 ft).	**This requirement is met at a preliminary level.** Preliminary calculations (4412.091.SCAL.001) have determined that the dome deflection due to the WRS is within allowable limit.
3.2.3.1	**Component Selection**. 241-S-102 WRS components shall be reliable and component selection shall consider the intended life of the component and its documented performance history in similar environments.	**This requirement is met at a preliminary level.** The pre-conceptual design of the 241-S-102 WRS is based on equipment designs with an appropriate degree of reliability to support its proposed use. A more detailed reliability assessment will be performed during later design development stage(s).
3.2.3.2	**Overall Reliability/Availability**. The 241-S-102 WRS shall have the reliability and availability to meet the operational schedule documented in RPP-7087, Rev. 0, Table 6-1.	**This requirement is met at a preliminary level.** The operational schedule is based on 75% availability of the equipment, which is typical for such a system. The fluidic system test program will confirm reliability and availability.

F&R Section	Requirement or Objective	Comments
3.2.3.3	**Operational Life.** The 241-S-102 WRS shall be operational (i.e., available) for 1 year prior to operations to perform acceptance testing and operational readiness verification, followed by a 168 day retrieval campaign to demonstrate retrieval of mobile, long lived radioisotopes and nonradiological hazardous constituents from tank 241-S-102.	**This requirement is met at a preliminary level.** The schedule provided in Appendix A shows the system will be available for integrated testing, training, and startup for more than one year prior to the system readiness review.
3.2.3.5	**In-tank/In-pit Component Design Life.** In-tank, in-pit, and critical components that cannot be repaired or replaced remotely shall achieve a minimum of 2 years between failures with no maintenance during the 2-year period.	**This requirement is met at a preliminary level.** All components that come into contact with the waste are designed to be remotely maintained and/or readily replaced. There are no moving components associated with the in-tank portion of the S-102 WRS, which greatly enhances the system's reliability. Critical components (e.g., transfer pump, valves, etc.) will be selected based on their ability to meet the project's design life requirement.
3.2.3.6	**Design Life.** The 241-S-102 WRS above-grade components shall have a minimum design life of 5 years with or without preventive maintenance, regardless of operation.	**This requirement is met at a preliminary level.** All above-grade components, except for the Over-Ground Transfer (OGT) line, have a minimum 5-year design life. The OGT line has only an estimated 3-year design life, based on an evaluation of the hose-in-hose transfer line's service life for Hanford's Interim Stabilization Program (RPP-6711, Rev. 1).
3.2.4	**Maintainability.** The 241-S-102 WRS shall be designed for ease of maintenance. To the extent practical, system components shall be of modular design for removal, repair, or replacement.	**This requirement is met at a preliminary level.** All WRS components are of a modular design, to the greatest extent practicable.
3.2.5.1.a	**Natural Environments.** The 241-S-102 WRS shall be designed for the natural environmental conditions specified in HNF-SD-GN-ER-501, Rev. 1. Guidance on the application of requirements found in HNF-SD-GN-ER-501 to the 241-S-102 WRS will be provided to the architect and engineer (A&E) under a separate cover.	**This requirement is met at a preliminary level.** The design will be reviewed against these requirements during conceptual design.
3.2.5.1.b	**Natural Phenomena Hazards.** The 241-S-102 WRS shall be designed to withstand the natural phenomena hazards specified in RPP-PRO-097, Rev. 0. Guidance on the application of the requirements found in RPP-PRO-097 to the 241-S-102 WRS will be provided to the A&E under a separate cover.	**This requirement is met at a preliminary level.** The design will be reviewed against these requirements during conceptual design.

F&R Section	Requirement or Objective	Comments
3.2.5.2.1	**Chemistry.** 241-S-102 WRS equipment in contact with the tank waste shall be designed to perform its intended function in the chemical environment in the tanks. This environment and its context are described in HNF-SD-WM-SP-012, Rev. 2, Appendix B.	**This requirement is met at a preliminary level.** All WRS materials/components that come into contact with the waste are designed to function in the chemical environment described in the referenced document.
3.2.5.2.2.a	**In-Tank Radiation Dose Rate:** • The penetrating dose at the waste surface is estimated to be 388 rad/h. • The nonpenetrating dose at the waste surface is estimated to be 1084 rad/h. • Dose rates to equipment submerged in the waste material would be roughly double the surface numbers.	**This requirement is met at a preliminary level.** Materials and components selected for use in the tank will perform their intended function within the dose rates specified.
3.2.5.2.2.b	**In-Tank Humidity Range.** 10% to 100%.	**This requirement is met at a preliminary level.** Materials and components selected for use in the tank will perform their intended function within the specified humidity range.
3.2.5.2.2.c	**Liquid Waste pH Range:** 8 to 13.65. (before dilution)	**This requirement is met at a preliminary level.** Materials and components selected for use in the tank will perform their intended function within the specified pH range.
3.2.5.2.2.d	**Temperature Range**. see Section 3.2.1.1.a	**This requirement is met at a preliminary level.** Materials and components selected for use in the tank will perform their intended function within the specified temperature range.
3.2.5.2.2.e	**Vapor Space Pressure.** see Section 3.2.1.3 (Note that operation will not continue at positive tank pressures, but the system may be subjected to them).	**This requirement is met at a preliminary level.** Materials and components selected for use in the tank will perform their intended function within the vapor space pressures specified in 3.2.1.a.

F&R Section	Requirement or Objective	Comments
3.2.5.2.2.f	**Flammable Gas.** Detectable levels of ammonia, hydrogen, nitrogen oxide, non-methane organic compounds, and others (see CHG 2000). Ammonia (200 ppmv) was the only analyte with a value greater than the notification level (see 1999 Industrial Hygiene Survey). Total organic compounds (TOC) maximum readings were 35 ppmv (see Section 3.3.6.3.6 for WRS flammable gas design requirements).	**This requirement is met at a preliminary level.** Materials and components selected for use in the tank will perform their intended function within the specified flammable gas concentrations. Appropriate ignition controls have been specified for the equipment in potentially flammable atmospheres.
3.2.5.2.3	**Aerosol Generation in Tank 241-S-102.** The system shall be designed to prevent degradation of components or operation caused by aerosol generation during operation of the 241-S-102 WRS.	**This requirement is met at a preliminary level.** Materials and components selected for use in the tank will are intended to perform their intended function without significant degradation due to aerosol generation during operation of the WRS.
3.2.6	**Transportability** Upon delivery, the 241-S-102 WRS shall be designed to be transportable to and around the Hanford Site using existing Hanford rigging and transport equipment.	**This requirement is met at a preliminary level.** This requirement will be included in the system performance specification.
3.2.7	**Flexibility and Expansion.** The 241-S-102 WRS design shall incorporate features that allow for the operational flexibility to transfer tank 241-S-102 contents to any SY farm tank.	**This requirement is met at a preliminary level.** The destination double-shell tank for the 241-S-102 waste can be readily changed through the use of an alternate jumper configuration in the 241-SY-02A pump pit.
3.2.8	**Portability** The 241-S-102 WRS fluidic mixing subsystem shall be designed to be capable of being moved to another Hanford SST for waste retrieval operations with existing Hanford Site rigging and transport equipment.	**This requirement is met at a preliminary level.** With the exception of the in-tank components, the 241-S-102 WRS is mainly comprised of skid-mounted equipment that can be readily relocated to another Hanford tank or tank farm using existing Hanford Site rigging and transport equipment. The in-tank portions of the WRS could also be moved to another tank, but ALARA and cost considerations would probably preclude doing so.
3.3.1.1	**Materials Restrictions.** The 241-S-102 WRS shall not add any material that will prohibit waste transfer from tank 241-S-102 to tank 241-SY-102 in accordance with HNF-IP-1266, Rev. 2a; HNF-SD-WM-DQO-001, Rev. 3; HNF-SD-WM-OCD-015, Rev. 3; and HNF-1802, Rev. 1.	**This requirement is met at a preliminary level.** There are no required material additions to the 241-S-102 waste with the exception of inhibited water (or possibly raw water). All equipment placed into the tank shall be constructed of stainless steel.

F&R Section	Requirement or Objective	Comments
3.3.1.2	**Process Piping.** Process piping for the 241-S-102 WRS shall meet the following criteria: a. 241-S-102 WRS process piping shall be designed to preclude radioactive waste from being siphoned from tank 241-SY-102 to 241-S-102. b. 241-S-102 WRS process piping shall conform to the requirements of ASME B31.3, "Chemical Plant Petroleum Refinery Piping," normal service fluid. If used, flexible piping shall be shown to be equivalent to ASME B31.3 process piping via the quality assurance provisions to be specified in the flexible piping procurement specification (e.g., see HNF-4407, Rev. 2, Section 4). c. The 241-S-102 WRS flexible process piping, if used, shall be designed to perform the safety functions and satisfy the requirements described in HNF-SD-WM-SAR-067, Section 4.4.1.	**This requirement is met at a preliminary level.** (a) An air gap between the 241-SY-102 drop leg (see P&ID drawing 4412.091.PDWG.002, sheet 2) and the tank's contents will prevent any potential for waste siphoning back out of the DST. (b) The WRS process piping is designed in accordance with the requirements of ASME B31.3 (normal service fluid). The OGT line (hose-in-hose) used between process pits has been demonstrated during previous SST waste retrieval projects to be equivalent to ASME B31.3 process piping based on the quality assurance provisions specified in the applicable procurement specification. (c) The flexible OGT line has been analyzed in support of previous retrieval activities to verify that it meets the prescribed safety functions and other requirements described in HNF-SD-WM-SAR-067, Section 4.4.1.
3.3.1.3	**241-S-102 Raw Water.** The 241-S-102 WRS shall have features that prevent contaminating the raw water system with tank contents.	**This requirement is met at a preliminary level.** The 241-S-102 WRS includes double isolation valves on the raw water supply upstream of any potential contamination source (see P&ID drawing 4412.091.PDWG.006). In addition, the existing S-Farm temporary raw water line is protected by backflow prevention devices to eliminate any possible contamination of the main raw water system from the SSTs.
3.3.1.4.a	**Toxic Products and Formulations.** Lead shall not be used in the 241-S-102 WRS unless fully encapsulated and identified with a permanent tag.	**This requirement is met at a preliminary level.** There is no planned or anticipated use of lead in conjunction with the 241-S-102 WRS.
3.3.1.4.b	**Toxic Products and Formulations.** Materials regulated by 40 CFR Subchapter R shall not be used in the design of the 241-S-102 WRS.	**This requirement is met at a preliminary level.** There is no planned or anticipated use of materials regulated by 40 CFR Subchapter R in the 241-S-102 WRS.

F&R Section	Requirement or Objective	Comments
3.3.1.4.c	**Toxic Products and Formulations.** Hydraulic fluid used in in-tank equipment shall be approved by the Tank Farm Contractor.	**This requirement is met at a preliminary level.** Any equipment requiring the use of hydraulic fluid will be identified and approved for use by the Tank Farm Contractor.
3.3.1.4.d	**Toxic Products and Formulations.** The maximum credible loss of fluid in an accident scenario shall be less than 284 L (75 gal).	**This requirement is met at a preliminary level.** There is no planned or anticipated use of toxic products or formulations in conjunction with the WRS.
3.3.1.5	**Air and Gas Treatment System Design.** The 241-S-102 WRS and its subsystems shall be designed in accordance with the performance and design requirements of ASME N509 and ANSI/ASME AG-1.	**This requirement is met at a preliminary level.** The 241-S-102 passive ventilation system and the compressed air off-gas treatment skid are intended to comply with the requirements of ASME N509 and ANSI/ASME AG-1.
3.3.16	**Electrical Equipment.** All electrical equipment used in the 241-S-102 WRS design shall be listed, or labeled, by a nationally recognized testing laboratory such as Underwriters' Laboratory. Equipment without a listing mark by a nationally recognized testing laboratory is not approved for use in the design unless a nationally recognized testing laboratory category for that type of equipment does not exist. If a category for that equipment does not exist, the equipment may be approved for use only if accepted by one of the designated National Electrical Code inspectors appointed by the Hanford Electrical Codes Board.	**This requirement is met at a preliminary level.** The 241-S-102 WRS equipment is intended to be listed/labeled by a nationally recognized testing laboratory such as UL. Where UL listed or labeled equipment cannot be used, the equipment will be approved for use only if accepted by one of the designated NEC inspectors appointed by the Hanford Electrical Codes Board.
3.3.2	**Electromagnetic Radiation.** The 241-S-102 WRS shall comply with electromagnetic radiation emission requirements set forth in HNF-2962, Rev. 0.	**This requirement is met at a preliminary level.** The 241-S-102 WRS equipment design, as proposed in the PER, complies with the electromagnetic radiation emission requirements set forth in the referenced procedure.
3.3.3	**Nameplates and Product Marking.** The 241-S-102 WRS shall label new equipment and/or modifications to existing equipment in a standardized format in accordance with the tank farm labeling program as specified in HNF-IP-0842, Volume II, Section 6.1.	**This requirement is met at a preliminary level.** The 241-S-102 WRS equipment will be labeled in accordance with the tank farm labeling program as specified in the referenced procedure.
3.3.4	**Workmanship.** Not applicable. The requirements for workmanship are to be addressed in lower level design documentation (drawings, procurement specifications, etc.) created by the project.	**N/A**

F&R Section	Requirement or Objective	Comments
3.3.5	**Equipment Standardization.** The 241-S-102 WRS design shall incorporate standardization of like-function components and selection shall consider documented performance history in similar environments.	**This requirement is met at a preliminary level.** The design of the 241-S-102 WRS equipment will incorporate standardization of like-function components. The selection of components will consider documented performance history in similar environments.
3.3.6.1	**Personnel Safety.** Personnel shall be protected from work place hazards in accordance with the requirements of this section.	**This requirement is met at a preliminary level.** See below.
3.3.6.1.1	**Occupational Radiological Protection**. The 241-S-102 WRS shall be designed to protect workers from occupational radiation exposures in accordance with the requirements contained in HNF-5183, Rev. 0, and shall be designed to keep personnel exposures as low as reasonably achievable (ALARA).	**This requirement is met at a preliminary level.** The WRS as currently designed is intended to protect workers from occupational radiation exposures in accordance with ALARA practices and the requirements of HNF-5183, Rev. 0.
3.3.6.1.2	**Occupational Safety and Health**. The 241-S-102 WRS shall incorporate design features that comply with the requirements of 29 CFR 1910, Subparts D, E, G, J, L, M, O, and S.	**This requirement is met at a preliminary level.** The WRS as currently designed is intended to comply with occupational safety and health requirements 29 CFR 1910, Subparts D, E, G, J, L, M, O, and S.
3.3.6.2	**Equipment Protection.** The 241-S-102 WRS shall be designed to prevent damage to other components.	**This requirement is met at a preliminary level.** The WRS as currently designed is intended to prevent damage to equipment. A detailed evaluation of the final detailed design will be performed
3.3.6.2.1	**Vibration**. 241-S-102 WRS transfer pumps shall meet the applicable design, fabrication, and testing requirements contained in API 610. The highest degree of dynamic balancing shall be specified. Additionally, the resonant frequencies particular to the pump installation shall be analyzed and design features added to preclude damage to the tank structure from resonant frequencies and to eliminate the harmonics in the pump's normal operating range.	**This requirement is met at a preliminary level.** An evaluation of the design to verify compliance with this requirement will be performed as part of the final detailed design.
3.3.6.2.2	**241-S-102 WRS Design**. The 241-S-102 WRS shall be designed to ensure proper structural strength, compatibility with waste and protection against corrosion in accordance with 40 CFR 265.192, WAC 173-303-640(3) and DOE Order 5820.2A, Chapter 1, Section 3.B(2)(g).	**This requirement is met at a preliminary level.** The WRS as currently designed is intended to meet this requirement. A detailed evaluation of the final design will be performed to verify compliance.

F&R Section	Requirement or Objective	Comments
3.3.6.2.3	**Fire Protection.** The 241-S-102 WRS shall meet fire protection design requirements as defined in HNF-IP-0842, Volume IX, Section 5.2, Rev. 0, and DOE-STD-1066-99.	**This requirement is met at a preliminary level.** The WRS as currently designed is intended to meet this requirement. A detailed evaluation of the final design will be performed to verify compliance with the referenced fire protection standards.
3.3.6.2.4	**DST Design Limits.** The 241-S-102 WRS shall not adversely affect the function of the DST System nor exceed the DST design limits specified in HNF-SD-WM-TRD-007, Rev. 0. The design and operation of the 241-S-102 WRS shall also consider the operational limits of tank 241-SY-102 specified in OSD-T-151-00007.	**This requirement is met at a preliminary level.** The design of the 241-S-102 WRS will not impact the DST design limits or 241-SY-102 operational limits as specified in the referenced documents.
3.3.6.3.1	**Secondary Containment and Leak Detection.** The 241-S-102 WRS shall incorporate secondary containment and leak-detection design features in accordance with 40 CFR 265.193, WAC 173-303-640 (4) and DOE Order 5820.2A, Chapter 1, Section 3b(2), and (3).	**This requirement is met at a preliminary level.** Secondary containment is provided from the SST pump pit (S-02A) to the receiver DST (241-SY-102). The pit structures and the hose-in-hose (OGT) transfer line (see P&ID drawing 4412.091.PDWG.006) will ensure secondary containment of wastes during transfer operations. Active leak detection systems in each of the process pits will provide continuous monitoring of the system for leaks.
3.3.6.3.2	**Spill Prevention and Controls.** The new and modified portions of the 241-S-102 WRS shall incorporate spill prevention and control design features in accordance with 40 CFR 264.193, and WAC 173-303-640 (5). In the event of a conflict, the most stringent requirement shall take precedence.	**This requirement is met at a preliminary level.** These design features will be detailed in conceptual design.

F&R Section	Requirement or Objective	Comments
3.3.6.3.3	**Nonradioactive Airborne Emissions.** The 241-S-102 WRS shall be designed to comply with the nonradioactive airborne emissions requirements contained in WAC-173-400 and WAC-173-460. Also, nonradioactive airborne emissions from the 241-S Tank Farm, other tank farms and other Hanford Site major facilities shall be considered when designing the system to be compliant with WAC-173-400 and WAC-173-460.	**This requirement is met at a preliminary level.** The 241-S-102 WRS design includes the use of a passive filtering system for radioactive particulates, however, there is no emissions monitoring capability or hazardous/toxic gas filtration capability included in the design of the WRS. Monitoring and surveillance of the nonradioactive airborne emissions will use currently accepted methods during operation, and are not assumed part of the design. There is insufficient information at this time regarding nonradioactive airborne emissions to establish preliminary design criteria. A study will be needed to quantify those needs, and will be addressed in conceptual design.
3.3.6.3.4	**Radioactive Airborne Emissions.** The 241-S-102 WRS shall be designed to comply with the radioactive airborne emissions requirements contained in HNF-IP-0842, Vol. VI, Section 1.7, Rev. 0. Also, radioactive airborne emissions from the 241-S Tank Farm, other tank farms and other Hanford Site major facilities shall be considered when designing the system to be compliant with HNF-IP-0842, Vol. VI, Section 1.7.	**This requirement is met at a preliminary level.** As shown in the P&ID (drawing 4412.091.PDWG.006), HEPA filtration is provided for each of the potential emission sources associated with the 241-S-102 WRS to limit the release of radioactive airborne contaminants in accordance with the referenced document. A passive ventilation system will be used to limit the release of radioactive particulates from 241-S-102 to the environment. The DST receiver, 241-SY-102, is equipped with an active ventilation system that filters radioactive particulates from the tank's exhaust air stream. A new compressed air off-gas treatment skid will provide HEPA filtration of the compressed air system off-gases to ensure that airborne emissions to prevent radioactive releases from this emission source.
3.3.6.3.5	**Radiation Protection of the Public And Environment.** The system shall be designed in accordance with the radiation release limits specified in 10 CFR 20, 40 CFR 191, and WAC 246-247.	**This requirement is met at a preliminary level.** See response to 3.3.6.3.4.

F&R Section	Requirement or Objective	Comments
3.3.6.3.6	**Flammable Gas Design Requirements.** The design of the 241-S-102 WRS shall comply with HNF-SD-WM-TSR-006, Rev. 1-I, and HNF-IP-1266, Rev. 2a, Administrative Control 5.10, or shall demonstrate safety precautions equivalent to those set forth in these requirements through evaluation by the Flammable Gas Equipment Advisory Board (FGEAB). Interpretation of applicability to the ignition set controls No. 1 and 2 shall be determined by the FGEAB.	**This requirement is met at a preliminary level.** All WRS equipment installed in a potentially flammable atmosphere is intended to be designed in accordance with ignition controls set No. 1 or 2 requirements, as applicable. FGEAB review of the detailed design, prior to operation, will confirm that appropriate controls are included in the WRS design.
3.3.7	**Human Performance/Human Engineering.** The 241-S-102 WRS shall be designed for ease of operation. The 241-S-102 WRS design shall comply with DOE Order 6430.1A, Section 1300-12, "Human Factors Engineering."	**This requirement is met at a preliminary level.** The WRS controlled through an automated control system from a remote control station. All equipment, including the control station, will be designed for ease of operation in accordance with the referenced order.
3.3.8	**Decontamination and Decommissioning.** The new and modified portions of the 241-S-102 WRS shall be designed for ease of decontamination during operation and for decommissioning at the end of system life in accordance with DOE Order 6430.1A, Sections 0110-99.0.1, 0205-2, and 1300-11.	**This requirement is met at a preliminary level.** The in-tank portions of the WRS are planned to be left in place inside the SST following retrieval of the 241-S-102 waste (but could be removed if required). All portions of the system outside of the SST are designed to be easily decontaminated, as applicable, and readily removed for decommissioning or reuse.
3.3.8.1	**Waste Pipe Gravity Drain.** The 241-S-102 WRS process-piping systems should gravity drain for the purposes of minimizing free standing liquids in the process piping.	**This requirement is met at a preliminary level.** All WRS process piping, including the temporary OGT line installed between the S-02B distributor pit and the SY-02A pump pit, is sloped to provide gravity drainage of liquids to an appropriate collection point. See the Site Plan drawing 4412.091.CDWG.001.
3.3.8.2	**WRS In-Tank Equipment Decontamination Fluid.** The in-tank 241-S-102 WRS equipment shall use inhibited water as the decontamination fluid.	**This requirement is not applicable.** There are no provisions in the WRS design for the use of inhibited water for decontamination because in-tank retrieval equipment is assumed to remain in place and no decontamination will be necessary.
3.3.8.3	**Retrieval of Failed In-Tank Equipment.** The 241-S-102 WRS shall be retrievable from the tank in the event of failure.	**This requirement is met at a preliminary level.** All in-tank WRS equipment can be removed from 241-S-102 if required.
3.4.8.4	**Removability.** The 241-S-102 WRS in-tank equipment shall be removable after waste retrieval operations are complete.	**This requirement is met at a preliminary level.** All in-tank WRS equipment can be removed from 241-S-102 if required.

F&R Section	Requirement or Objective	Comments
3.3.9	**Nuclear Safety.** The risks from abnormal events and postulated accidents that can result in the uncontrolled release of radioactive or hazardous material during retrieval of waste from tank 241-S-102 are related to the retrieval concept and resultant design. The nuclear safety requirements are determined by the hazardous conditions associated with deployment and operation of the241-S-102 WRS. As a starting point, the following authorization basis (AB) requirements are established as requirements for the pre-conceptual design activities found in the LCOs and Administrative Controls (AC) of HNF-SD-WM-TSR-006, Rev. 2-B: • LCO 3.3.2, "DST and AWF Tank Waste Temperature Controls" • LCO 3.1.2, "Service Water Pressure Detection Systems" (see Section 3.3.1.3) • AC 5.10, "Ignition Controls" (see Section 3.3.6.3.7) • AC 5.16, "Dome Loading Controls" (see Section 3.2.2 d). Other controls may apply, however, they will be established during the conceptual design. Some equipment, such as leak detectors and continuous air monitors, may be relied on to prevent or mitigate accidents. This equipment, referred to as either safety class or safety significant, will be subject to additional design requirements. These additional requirements will be identified during conceptual and detailed design.	**This requirement is met at a preliminary level.** The 241-S-102 WRS, at the pre-conceptual design stage, is in accordance with the AB controls identified in this requirement.
3.3.9.1	**Criticality Safety.** The 241-S-102 WRS shall store, transfer, and prepare radionuclides in a manner that prevents criticality in accordance with HNF-IP-1266, Rev. 2a, Section 5.7.	**This requirement is met at a preliminary level.** The 241-S-102 WRS will transfer dilute SST waste using equipment geometries and configurations designed to preclude the creation of potential criticality conditions.

F&R Section	Requirement or Objective	Comments
3.3.9.2	**Nuclear Safety Classification.** The 241-S-102 WRS and its components shall be designed in accordance with the safety classification for each. The safety classification shall be determined using the process described in RPP-PRO-700, Rev. 0; RPP-PRO-702, Rev. 0; RPP-PRO-703, Rev. 0; and RPP-PRO-704, Rev. 1; based on the guidelines in HNF-SD-WM-SAR-067, Section 3.0.	**This requirement is met at a preliminary level.** An formal assessment of the 241-S-102 WRS to determine safety classifications for structures, systems, and components (SSCs) will be performed during the Conceptual Design stage of development. Assumptions made during the pre-Conceptual Design stage with regard to safety classification of SSCs are based on existing SSC designations and engineering judgment, and a preliminary Safety Equipment List (SEL) is provided in Appendix G of the PER document.
3.4.1	**Engineering Documents** Records, documents, and drawings pertinent to design functions shall be controlled in accordance with HNF-PRO-222. Engineering documents shall be developed in accordance with HNF-IP-0842, Vol. IV, Section 1.2, Rev. 0.	**This requirement is met at a preliminary level.** The pre-Conceptual Design documentation (i.e., PER) has been prepared and controlled in accordance with approved procedures, consistent with the referenced documents.
3.4.2	**Master Equipment List.** All structures, systems, and components (SSC) shall be incorporated into the master equipment list in accordance with RPP-MP-606, Rev. 3a.	**This requirement is met at a preliminary level.** A preliminary Master Equipment List (MEL) is provided in Appendix G of the PER document.
3.5.1	**Maintenance and Operation.** Remote, limited, or contact maintenance requirements shall be implemented with current regulatory requirements, policies, and procedures. Operation should be remote to minimize exposure and contamination. Corrective and preventive maintenance shall be performed by Hanford Site Crafts personnel, unless special circumstances require specific vendor maintenance support. A vendor service agreement shall be used under these circumstances.	**This requirement is met at a preliminary level.** The 241-S-102 WRS is designed, at the pre-Conceptual Design stage, for remote operation and maintenance, with limited contact maintenance requirements, in accordance with current regulatory requirements, policies, and procedures. A determination with regard to the use of off-site vendor personnel vs. Hanford Site Crafts personnel to support operation and maintenance of the WRS equipment will be made during the Conceptual Design phase.
3.5.1.1	**Calibration.** The 241-S-102 WRS shall be designed to allow periodic calibration. Calibration cycles, methods, and equipment shall be established based on manufacturer's instruction, component and system reliability, environmental conditions, and site-specific historical data. 241-S-102 WRS equipment located inside the SST, DST, or transfer-associated structure shall not require calibration after installation.	**This requirement is met at a preliminary level.** The 241-S-102 WRS is designed, to allow periodic calibration of equipment. WRS equipment located inside the SST, DST, and transfer-associated structures (pits) will not require calibration after installation.

F&R Section	Requirement or Objective	Comments
3.5.2	**Spares.** A minimum numbers of spares for like components shall be determined during design of the 241-S-102 WRS. The minimum number of spares will be determined based on the mean time between failures, vendor recommendations, procurement lead times, operational strategy, safety classification, and the number of like components installed.	**This requirement is met at a preliminary level.** A determination of the required spare parts for the 241-S-102 WRS will be made during the Detailed Design phase of project development.
3.5.3	**Installation of 241-S-102 WRS.** In-tank hardware preventing or interfering with the installation and operation of the 241-S-102 WRS shall be removed before retrieval operations begin.	**This requirement is met at a preliminary level.** The 241-S-102 WRS is intended to be installed and operated in the SST without in-tank equipment removal. Modifications to support installation of the equipment through three construction manholes located in the tank dome will be necessary.
3.5.4	**Solid Waste.** The 241-S-102 WRS shall comply with the requirements of HNF-IP-0842, Vol. XVIII, Section 2.4, Rev. 0, for solid waste generated as a result of system operations and maintenance.	**This requirement is met at a preliminary level.** Solid waste generated during the WRS installation and operation phases will be controlled per the referenced procedure.
3.6	**Personnel and Training**. Not applicable.	**This requirement is met at a preliminary level.** Personnel training and procedure preparation will be completed prior to start-up and turnover.
3.7.1	**241-S-102 Fluidic Mixer.** To be provided at the end of the concept development activity.	**Compliance with this requirement is TBD.**
3.7.2	**241-S-102 Waste Transfer Subsystem.** To be provided at the end of the concept development activity.	**Compliance with this requirement is TBD.**
3.7.3	**S Tank Farm Ventilation System.** To be provided at the end of the concept development activity.	**Compliance with this requirement is TBD.**
3.7.4	**241-S-102 WRS Monitor and Control Subsystem.** To be provided at the end of the concept development activity.	**Compliance with this requirement is TBD.**
3.7.5	**DST Supernatant Liquid and Transfer Pump Subsystem.** To be provided at the end of the concept development activity.	**Compliance with this requirement is TBD.**

F&R Section	Requirement or Objective	Comments
3.7.6	**DST Transfer Piping Subsystem.** The characteristics of the DST Transfer Piping Subsystem are fully defined in HNF-4161, Rev. 0.	**This requirement is met at a preliminary level.** The WRS transfer-related SSCs are compatible with the documented characteristics of the DST Transfer Piping Subsystem.
3.7.7	**DST Transfer Valving Subsystem.** The characteristics of the DST Transfer Valving Subsystem are fully defined in HNF-4160, Rev. 0.	**This requirement is met at a preliminary level.** The WRS transfer valving components are compatible with the documented characteristics of the DST Transfer Valving Subsystem.
3.9	**Security**. The 241-S-102 WRS shall be designed such that access controls to radiation and high-radiation areas meet the requirements of HNF-5183, Rev. 0 (local implementation of 10 CFR 835).	**This requirement is met at a preliminary level.** The 241-S-102 WRS is designed to be operated remotely from outside the tank farm boundary, with minimal access required to potential radiation and high-radiation areas. Access to these areas will be strictly controlled in accordance with the referenced requirements.
3.10	**Computer Resource Reserve Capacity.** Not applicable.	**N/A**

APPENDIX F:

TANK S-102, PRELIMINARY WASTE RETRIEVAL

OUTLINE

CONSTRUCTION SPECIFICATION

prepared for

CH2MHILL HANFORD GROUP

Prepared by

Holmes and Narver/DMJM

OUTLINE SPECIFICATION INDEX

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OUTLINE SPECIFICATION

DIVISION 2 – SITEWORK

Section 02050 Demolition

General

Table CS-2-1 identifies equipment/components to be installed, removed/disposed of as part of the work scope. Specific details of demolition (by tank farm) are identified below.

Table CS-2-1. TANK EQUIPMENT REMOVAL/INSTALLATION

TANK	RISER	SIZE (IN.)	EXISTING EQUIPMENT TO BE REMOVED	EQUIPMENT TO BE INSTALLED
S FARM	1	4	NONE	Breather Filter
S FARM	2	4	NONE	Level Indicator (ENRAF)
S FARM	3	4	NONE	Temperature Probe
S FARM	5	12	NONE	LOW
S FARM	6	12	NONE	Camera/TMS Assembly
S FARM	13	42	Saltwell Screen and Pump	Fluidic Pump, Dip Tubes, Accumulator drain and vent, Water Introduction Lines
S FARM	Manhole	42		Manhole – Fluidic Mixer
S FARM	Manhole	42		Manhole – Fluidic Mixer
S FARM	Manhole	42		Manhole – Fluidic Mixer

Section 02200 Earthwork

S Farm

1. Excavation for Over-ground Transfer Line

2. Excavation for underground piping and utility trenches.

3. Grading for Fluidic Mixer Pump foundation pads

4. Structural backfill, compacted: WSDOT M41-10, Section 2-03.3(14)C.

5. Controlled density fill (CDF): ASTM C 94 and WSDOT M41-10 Section 6-02.3, compressive strength between 50 and 100 psi @ 28 days for underground pipe.

6. Plastic sheet marker for buried pipe/conduit: non-detectable for metallic pipe, detectable for all other pipe/conduit.

7. Contaminated soil: Most soil displaced during excavation activities will be used as backfill in the general vicinity of the original excavation. ALARA concerns

require the contaminated soil to be managed as any other waste generated on the Hanford Site.

8. Stabilization of disturbed areas: WSDOT M41-10, Section 9-09(3), top course.

SY Farm

1. Excavation for Over-ground Transfer Lines

2. Excavation for underground piping and utility trenches.

3. Structural backfill, compacted: WSDOT M41-10, Section 2-03.3(14)C.

4. Controlled density fill (CDF): ASTM C 94 and WSDOT M41-10 Section 6-02.3, compressive strength between 50 and 100 psi @ 28 days for underground pipe.

5. Plastic sheet marker for buried pipe/conduit: non-detectable for metallic pipe, detectable for all other pipe/conduit.

6. Contaminated soil: Most soil displaced during excavation activities will be used as backfill in the general vicinity of the original excavation. ALARA concerns require the contaminated soil to be managed as any other waste generated on the Hanford Site.

7. Stabilization of disturbed areas: WSDOT M41-10, Section 9-09(3), top course.

Section 02650 Pipe Utilities

S Farm

1. Buried raw water piping: ASTM A106, Grade B, Schedule 40.

2. Fittings: 1-1/2 inch and smaller – ASTM A47, Class 150, malleable iron, threaded.

3. 2 inch and larger – ASTM A234, Grade WPB, Buttweld.

4. Valves: 3 – piece carbon steel ball valves.

5. Protective coating: fusion bonded epoxy, Scotchkote 206N.

6. Flush and leak test piping per ASME B31.9.

DIVISION 3 – CONCRETE

Section 03300 Cast-in-Place Concrete

S Farm

1. Concrete minimum strength: 4000 psi at 28 days.

2. Sampling and testing in accordance with ACI 301, Section 16.
3. Reinforcing steel: ASTM A 615, Grade 60, deformed.
4. Formwork: In accordance with ACI 301, Section 4.
5. Grout: non-shrink, non-metallic, ASTM C1107.

DIVISION 5 – METALS

Section 05120 Structural Steel

S Farm

1. Rolled steel shapes and plates: ASTM A 36.
2. Steel tubing: ASTM A 500, Grade B.
3. Bolts
   a. General application: ASTM A 307, Grade A or B
   b. Structural connections: ASTM A 325
4. Nuts: ASTM A563, heavy hex.
5. Washers: ASTM F844, circular.
6. Welding electrode: E70XX
7. Expansion anchors: Hilti Kwik-Bolt II.
8. General Fastening: AISC S326 and M011.

SY Farm

1. Rolled steel shapes and plates: ASTM A 36.
2. Steel tubing: ASTM A 500, Grade B.
3. Bolts
   a. General application: ASTM A 307, Grade A or B
   b. Structural connections: ASTM A 325
4. Nuts: ASTM A563, heavy hex.
5. Washers: ASTM F844, circular.
6. Welding electrode: E70XX

7. Expansion anchors: Hilti Kwik-Bolt II.

8. General Fastening: AISC S326 and M011.

Section 05500 Metal Fabrications

S Farm

1. Rolled steel shapes, plates, and bars: ASTM A 36.

2. Steel pipe: ASTM A106, Grade B, Schedule 40.

3. Supports: Channels, nuts and bolts: Unistrut.

4. Weld studs: Nelson Type H4L.

5. Expansion Anchors: Hilti Fastening Systems Kwik-Bolt II.

SY Farm

1. Rolled steel shapes, plates, and bars: ASTM A 36.

2. Steel pipe: ASTM A106, Grade B, Schedule 40.

3. Supports: Channels, nuts and bolts: Unistrut.

4. Weld studs: Nelson Type H4L.

5. Expansion Anchors: Hilti Fastening Systems Kwik-Bolt II.

DIVISION 9 – FINISHES

Section 09900 Painting

S Farm

1. Exterior metal surfaces

   a. Surface preparation: Power tools (SSPC SP 2) or commercial blast (SSPC SP 3).

   b. Application PDCA Architectural Specification Manual and manufacturer's instructions.

   c. Primer: Rust-inhibitive ferrous metal primer.

   d. Base and finish coats: Alkyd semi-gloss enamel

SY Farm

1. Exterior metal surfaces

a. Surface preparation: Power tools (SSPC SP 2) or commercial blast (SSPC SP 3).

b. Application PDCA Architectural Specification Manual and manufacturer's instructions.

c. Primer: Rust-inhibitive ferrous metal primer.

d. Base and finish coats: Alkyd semi-gloss enamel

Section 13440 Instrumentation

S Farm

SY Farm

DIVISION 15 – MECHANICAL

Section 15493 Chemical Process Piping Systems

S Farm

1. Materials

a. Piping, tubing, and fittings

b. Piping in contact with earth or concrete and not cathodically protected shall have a protective coating.

c. Hose-in-hose transfer line: Materials compatible with tank waste. Primary hose maximum working pressure 375 psig. Secondary hose maximum working pressure 60 psig. Burst pressure greater than four times the maximum working. Primary pipe shall have continuous heat trace pressure.

d. Jumper assemblies: Stainless steel, Hanford Standard HS-BS-0084 modified.

e. Insulation: Over-ground Transfer Line, Flexible closed cell elastomeric thermal insulation with low-transmittance vapor barrier for a –40 to +220°F temperature range. Weather-resistant protective finish for outdoor applications. Armstrong "Armaflex II."

2. Equipment

a. Pumps

b. Solenoid valves

c. Miscellaneous equipment

SY Farm

1. Materials

   a. Piping, tubing, and fittings

      i. Piping in contact with earth or concrete and not cathodically protected shall have a protective coating.

      ii. Jumper assemblies: Stainless steel, Hanford Standard HS-BS-0084 modified.

      iii. Piping systems, Over-ground Transfer Lines: Fabricated and installed in accordance with ASME B31.3, Normal Service. In addition to the requirements of ASME B31.3, all secondary, confinement piping welds will be examined by either the Liquid Penetrant Test or the Magnetic Particle Test. Longitudinal welds are the exception, which are required to be Ultrasonic Test examined. The Liquid Penetrant Test, Magnetic Particle Test, and Ultrasonic Test examinations will be performed in accordance with the requirements of ASME Section V. The acceptance criteria for these examinations will be in accordance with the requirements of ASME Section III, ND-5300.

      iv. Insulation: Over-ground Transfer Line, Flexible closed cell elastomeric thermal insulation with low-transmittance vapor barrier for a –40 to +220°F temperature range. Weather-resistant protective finish for outdoor applications. Armstrong "Armaflex II."

2. Equipment

   a. Pumps

   b. Solenoid valves

   c. Miscellaneous equipment

   d. Pipe Codes

Section 15499 Building Services Piping Systems

S Farm

1. Materials

   a. Piping, tubing, and fittings

      i. Piping in contact with earth or concrete and not cathodically protected shall have a protective coating.

ii. Raw Water (RW) piping: Carbon steel, Pipe Code M-5.

iii. Piping systems fabricated and installed in accordance with ASME B31.9.

iv. Insulation: Above Grade, Flexible closed cell elastomeric thermal insulation with low-transmittance vapor barrier for -40 to +220°F temperature range. Weather resistant protective finish for outdoor applications. Armstrong "Armaflex II."

v. Insulation: Below Grade loose fill Vermiculit enclosed in ¾-inch plywood box (3 sides).

b. Equipment

i. Manual Valves

i) Ball valves: 3-piece brass body, stainless steel, Teflon seats and body seal, threaded ends (Worcester).

c. Pipe Codes

PIPE CODE M-5			
Service	Design Pressure Psig	Test Pressure psig	Design Temp °F
Filtered Water (FW)	200	300	200
Sizes	1-1/2 inch and smaller	2 – inch and larger	
Pipe	ASTM A 106, Grade B.		
Wall Thickness	Schedule 40		
Fittings (1)	ASTM A47, Grade 32510 or 35018, or ASTM A197, Class 150, threaded in accordance with ASME B16.3.	ASTM A234, Grade WPB, wrought steel, butt welding in accordance with ASME B16.9. Wall thickness to match pipe.	

Section 15500 Heating, Ventilation, and Air Conditioning

S Farm

1. Materials

a. Duct: Stainless steel sheet: ASTM A 240, Type 304 or 304L.

b. Duct reinforcement: Stainless steel sheet: ASTM A 240, Type 304 or 304L.

i. Stainless steel shapes: ASTM A 276, Type 304 or 304L.

c. Duct supports and hangers

i. Channels and clamps: unistrut.

ii. Carbon steel shapes: ASTM A 36.

iii. Stainless steel shapes: ASTM A 276, Type 304 or 304L.

iv. Carbon steel rods: ASTM A 108 with ASTM A 563 nuts and plain washers.

v. Fasteners: ASTM A 307, Grade A or B bolts, with ASTM A 563, heavy hex nuts, UNC threads. Finish to be cadmium plating.

d. Duct insulation: UL listed in the building materials directory, and carry UL Logo.

i. Insulation and adhesive shall have UL fire hazard classifications of 25 maximum for flame spread and 50 maximum for smoke developed.

ii. Insulation for duct: 11/2" – inch thick glass fiberboard, 3 lb/ft^3 minimum density board type.

e. Insulation Jacket: Stainless steel jacket 0.010" thick.

2. Equipment

DIVISION 16 – ELECTRICAL

Section 16400 Service and Distribution

General

1. Installation of electrical components shall be per NFPA 70, National Electrical Code.

2. Heat Trace

a. Chromalox Self-regulating heating cable, Type SRL, 5 Watt per foot, 120 VAC, 150°F (65 °C) maximum maintenance temperature.

b. Chromalox Self-regulating heating cable, Type SRL, 10 Watt per foot, 120 VAC, 150°F (65 °C) maximum maintenance temperature.

c. Local control for Heating Cable, Chromalox Type RTAS-1 22 AMP SPDT, 120 Vac

d. Chromalox Splice and tee Kit, Catalog # RTST-1

e. Chromalox End Seal Kit, Catalog # RTES-1

S Farm

1. Materials

a. Conduit: PVC coated rigid, galvanized steel, PVC rigid.

b. Conductors: Stranded copper with Type THWN/THHN or XHHW insulation.

c. Control/Signal Cable: Type TC, 600V, 90 °C copper, #14 minimum, number of conductors as required.

d. Handhole: 4' x 4' x 4' concrete vaults.

2. Equipment

a. Equipment enclosures: NEMA ICS 6 Type 1 inside building and Type 4 outside building.

b. Feeder circuit breakers: Molded case circuit breakers, 3 phase, trip free, rated for use at 600 V AC. Interrupting rating for the feeder circuit breakers shall be 50,000 A.I.C. symmetrical at 480 V AC. Ampere frame and trip rating for the individual molded case circuit breakers to be as indicated on the one-line diagrams.

c. Combination Motor Starter: The combination motor starter shall consist of an instantaneous trip, magnetic only motor circuit protector, 480-120V control transformer with primary and secondary fused motor controller with overloads to be installed in an existing Cutler-Hammer MCC or mounted in NEMA 4 enclosures for units mounted on equipment.

d. Mini-power zone: shall include a 15 kVA 480-208Y/120 V, 3 phase transformer and 208Y/120 V, panelboard in one enclosure, and shall be UL listed, surface mounted, suitable for use as service equipment, NEMA 3R enclosure, operating at maximum full load temperature rise of 115 °C, with primary and secondary main breakers size and rating shown on one-line diagrams.

e. Safety switches: Non-fused heavy duty Type HD, 600 V AC, horsepower rated as noted on the Drawings.

3. Piping requiring cathodic protection will be tied into the existing cathodic protection system.

SY Farm

1. Materials

a. Conduit: PVC coated rigid, galvanized steel.

b. Conductors: Stranded copper with Type THWN/THHN or XHHW 90oC insulation.

c. Control/Signal Cable: Type TC, 600V, 90 °C copper, #14 minimum, number of conductors as required.

2. Equipment

a. Equipment enclosures: NEMA ICS 6 Type 1 inside building and Type 4 outside building.

Appendix G

Preliminary Master/Safety Equipment List

COMPONENT NUMBER (EIN)	COMPONENT NAME	COMP SFTY CLASS	COMP LOC BLDRM
S02-WT-SKID-001	Air Compressor Skid	GS	
S02-WT-SKID-002	Valve Skid	GS	241-S-102
S02-WT-SKID-003	Prescon Control System	GS	241-S-102
S02-WT-MIXER-001	RFD Mixer 1	GS	241-S-102
S02-WT-MIXER-002	RFD Mixer 2	GS	241-S-102
S02-WT-MIXER-003	RFD Mixer 3	GS	241-S-102
S02-WT-PUMP-001	Diode Master Pump	GS	241-S-102
S02-WT-SKID-004	Compressed Air Off-Gas Treatment	GS	241-S-102
S02-WT-SKID-005	Generator	GS	
S02-WT-PIT-001	Pressure Indicating Transmitter Air Supply	GS	241-S-102
S02-WT-PIT-002	Pressure Indicating Transmitter Water Supply	GS	241-S-102
S02-WT-PIT-003	Pressure Indicating Transmitter RFD Mixer 1	GS	241-S-102
S02-WT-PIT-004	Pressure Indicating Transmitter RFD Mixer 2	GS	241-S-102
S02-WT-PIT-005	Pressure Indicating Transmitter RFD Mixer 3	GS	241-S-102
S02-WT-PIT-006	Pressure Indicating Transmitter Diode Pump Charge Vessel 1	GS	241-S-102
S02-WT-PIT-007	Pressure Indicating Transmitter Diode Pump Charge Vessel 2	GS	241-S-102
S02-WT-PIT-008	Pressure Indicating Transmitter Waste Transfer	GS	241-S-102
S02-WT-UIT-001	Flow Indicating Transmitter S Farm Water	GS	241-S-102
S02-WT-UIT-002	Flow Indicating Transmitter Waste Transfer	SS	241-S-102
S02-WT-UE-001	Flow Element S Farm Water	GS	241-S-102
S02-WT-UE-002	Flow Element Waste Transfer	SS	241-S-102
S02-WT-BF-001	Breather Filter	GS	241-S-102
S02-WT-LIT-001	Level Indicating Transmitter	GS	241-S-102
S02-WT-PRV-001	Pressure Reducing Valve	GS	241-S-102
S02-WT-TE-001	Temperature Element	GS	241-S-102
S02-WT-TMS-001	TMS\Camera	GS	241-S-102
S02-WT-WFT-001	Weight Factor Transducer	GS	241-S-102
S02-WT-PLC-001	PLC I/O	GS	241-S-102
S02-WT-V-001	Manual Valve	GS	241-S-102
S02-WT-V-002	Manual Valve	GS	241-S-102
S02-WT-TK-001	Accumulator Tank	GS	241-S-102
S02-WT-P-002	Booster Pump	GS	241-S-102
S02-WT-LDK-001	Leak Detector	SS	241-S-102
SY02-WT-LDK-001	Leak Detector	SS	241-SY-102
SY02-WT-UE-001	Flow Element Receiver Tank	SS	241-SY-102

SY02-WT-UIT-001	Flow Indicating Transmitter	SS	241-SY-102
SY02-WT-PT-001	Pressure Transducer Flush Water Isolation	SS	241-SY-102
SY02-WT-PIT-001	Pressure Indicating Transmitter Flush Water Isolation	SS	241-SY-102
SY02-WT-SV-001	Solenoid Operated Valve	GS	241-SY-102
SY02-WT-SV-002	Solenoid Operated Valve	GS	241-SY-102
SY02-WT-SV-003	Solenoid Operated Valve	GS	241-SY-102
SY02-WT-TE-001	Temperature Element	GS	241-SY-102
SY02-WT-LT-001	Level Transducer	GS	241-SY-102
SYA-WT-UIT-001	Flow Indicating Transmitter SY Water	SS	241-SY-A
SYA-WT-LDK-001	Leak Detector	SS	241-SY-A
SYA-WT-UE-001	Flow Element SY Water	SS	241-SY-A
SYA-WT-V-001	Manual Valve	GS	241-SY-A
SYA-WT-V-002	Manual Valve	GS	241-SY-A

COMPONENT NUMBER (EIN)	COMPONENT NAME	COMP SFTY CLASS	COMP LOC BLDRM
S02-WT-LDK-001	Leak Detector	SS	241-S-102
S02-WT-UIT-002	Flow Indicating Transmitter Waste Transfer	SS	241-S-102
S02-WT-UE-002	Flow Element Waste Transfer	SS	241-S-102
SY02-WT-LDK-001	Leak Detector	SS	241-SY-102
SY02-WT-PIT-001	Pressure Indicating Transmitter Flush Water Isolation	SS	241-SY-102
SY02-WT-PT-001	Pressure Transducer Flush Water Isolation	SS	241-SY-102
SY02-WT-UE-001	Flow Element Receiver Tank	SS	241-SY-102
SY02-WT-UIT-001	Flow Indicating Transmitter	SS	241-SY-102
SYA-WT-UE-001	Flow Element SY Water	SS	241-SY-A
SYA-WT-UIT-001	Flow Indicating Transmitter SY Water	SS	241-SY-A
SYA-WT-LDK-001	Leak Detector	SS	241-SY-A

Appendix H

Alternative Analysis

241-S-102 Alternative Analysis

Prepared for
CH2M Hill Hanford Group
Single-Shell Tank Project

Prepared by

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241-S-102 ALTERNATIVE ANALYSIS

1.0 Analysis

Various alternative processes and configurations have been developed and evaluated to determine an optimal [preliminary] system design and operational strategy. Assumptions made during the analysis are discussed in subsequent sections.

A number of options have been examined for fluidic systems suitable for deployment to mobilize and retrieve waste in 241-S-102. Three principal types of individual fluidic system were identified as most applicable.

- Pulse jet mixer
- RFD Pump modified to incorporate a high level nozzle/jet
- Diode Pump

1.1 Assumptions

Various assumptions were made during the development of the preliminary alternative system, which are discussed in this section.

1.1.1 System Deployment

The inlet to the charge vessel will be deployed as near to the tank floor as possible at the onset of operations. The initial water introductions will be dispersed into the waste requiring that retrieval be performed in a bottoms-up fashion to minimize the liquid inventory and potential leak risk.

1.1.2 System Operations

If the waste is not completely saturated with liquid at the onset of operations, then each of the deployed systems will function independently. The waste between the deployed charge vessels will prevent communication of the liquid between the "wells" formed around the charge vessel deployment location in the solid waste. Water introduced into the well will require removal from the same well until such time as the wells become connected. This will require that each unit deployed combines the pumping and mixing function.

The combined mixing and pumping system will initially utilize the top nozzle to mine waste in a controlled fashion making the hole in which the system is deployed stable. The Reverse Flow Diverter (RFD) in the base will remove the saturated salt solution away from the well.

The water used as a solvent will become saturated near instantaneously as it contacts the waste because of the highly soluble nature of the saltcake components (e.g., NaNO3, NaOH, etc.).

The water introduced into the well will migrate very slowly into the salt matrix at a rate that is negligible when compared to the mixing and pumping cycle duration.

Operating three RFD pumps 120 degrees out of phase, or two two-diode pumps 180 degrees out of phase will produce continuous flow. The rate of continuous flow production will be a function of the charge vessel size(s) and backpressure.

The insoluble waste constituents (sludge) can easily be mobilized by mixing and recovered using the same system that recovers the solutes.

1.2 Transfer Piping System

One of the functions the 241-S-102 Waste Retrieval System must perform in addition to the mobilization of the tank constituents is to recover and transfer the waste to the double-shell tank (DST) system. Several alternatives have been evaluated for transfer the waste from 241-S-102 to 241-SY-102.

1.2.1 New Transfer Line

A new above grade temporary transfer line system could be installed to mitigate the concerns associated with utilization of the existing lines. Temporary hose-in-hose piping systems have been utilized successfully in 241-SY, 241-S, and 241-SX Farms. A similar hose-in-pipe assembly was utilized successfully in 241-U Farm and hose-in-hose lines are being installed in 241-BY Farm, although they have not yet been utilized.

The recent history of utilizing temporary piping systems has demonstrated their relative effectiveness and affordability. They reduce the pipe run distance and associated line holdup, eliminate sharp bends and waste settling or trapping points, ensure functional heat tracing, and reduce the pressure losses.

Fluidic pumps are not 100% efficient and do have leakage back into the tank. The amount of leakage, or efficiency, is dependent upon the backpressure in the transfer line. Reducing the backpressure by installing a new transfer line will reduce this leakage back to the tank, improving pumping rate and increasing tank recovery rate significantly.

A new temporary pipe line, with reduced flow resistance, will also allow for the utilization of two two-diode pumps to produce continuous flow without the aid of a booster pump. Diode pumps cannot provide flow when any appreciable backpressure is present.

Two possible routes have been evaluated for installation of temporary transfer lines. One option is the direct route approach (4412.091.CDWG.002). This option will require filling of a depression between the tanks to allow for line drainage. The second option is to follow the contour around the depression an then cut over to 241-SY-102 (4412.091.CDWG.001). The costs, advantages, and disadvantages of these two rates are discussed in further detail in the following sections.

1.2.1.1 Straight Run Over Ground Transfer With Backfill

A straight run of over ground transfer (OGT) from 241-S-102 to 241-SY-102 crosses a low area that is estimated to be 50-ft long and average 5-ft deep. Since particulate settling in the OGT line is a concern, especially in low areas, a 14 -ft wide bed would be backfilled with new material to level out the OGT run. A unit cost of $490/ft to run an OGT, including hand excavation to 1-ft, heat trace, insulation, and shield plate, was used in this estimate. The unit cost was derived from previous estimates used for interim stabilization. An overall length of 275-ft is needed for a straight run between tanks.

Additional costs were included for backfill material and mass excavation work using heavy equipment. Clean bedding material would be trucked to a staging area and relocated by a front-end loader to the excavation site. A unit cost of $390/yd^3 was used for mass excavation, derived from previous estimates provided in the Project W-521 Conceptual Design Report. Approximately 130 yd^3 was estimated assuming a backfill of 50 x 14 x 5 ft is needed. Engineering costs were included, assuming four new drawing sheets, one engineering change notice, and one USQ screening. Hardware costs of approximately $170,000 were included for OGT pit termination and tie-in. Installation costs of approximately $100,000 were included for pit entries and OGT tie-in work based on costs derived from interim stabilization efforts.

1.2.1.2 Contour Run Over Ground Transfer

An alternate OGT route was proposed between 241-S-102 to 241-SY-102 that would follow terrain contour and avoid low areas. This would eliminate the need for placement of backfill material. A unit cost of $490/ft to run an OGT, including hand excavation to 1-ft, heat trace, insulation, and shield plate, was used in this estimate. The unit cost was derived from previous estimates used for interim stabilization. An overall length of 340-ft is needed to avoid low areas between tanks. Engineering, pit termination and tie-in hardware procurement, and installation costs are identical to costs used in Option 1 for the straight run of OGT.

1.2.2 Existing Transfer Route

A hydraulic calculation performed on the existing transfer route from 241-S-02B to 241-SY-02A shows that the critical flow velocity of 6-ft per second cannot be achieved utilizing the existing transfer routing (4412.091.MCAL.001). The calculations assume that the transfer lines will sustain 200 psi of internal pressure. The line from 241-S-02B and from 241-S-A to 241-SY-A (SL-140 and SN-275, SL-177 respectively) have only been pressure tested to 100 psi (Work package numbers WS-98-176 and WS-98-177). The minimum transfer velocity, however, occurs only in the 3-in section of the transfer route and velocities much higher are realized in the 2-in sections of the line. To avoid over pressurizing SL-140, a booster pump could be installed in the 241-S-A Valve Pit. This would allow transfer of the necessary fluid volume at a lower pressure to the slurry pump located in the 241-S-A valve pit. The primary factors contributing to the line losses using the existing route are:

- Varying pipe sizes, going from 2-in to 3-in and back to 2-in,
- The number of PUREX connectors utilized in the transfer route,
- The amount of corrugate steel flex hoses utilized, and
- The excessive "pipe" length of the transfer route.

Realizing that the primary technical consideration for transferring the waste is maintaining sufficient velocity (Reynolds numbers in the turbulent range) to keep the transported solids in suspension. Cooling of the waste during the transport allows solids to come out of solution and contribute to line plugging potential. The cooling of the in-route waste stream is not considered for any of the alternatives evaluated, as it has been assumed sufficient heat tracing is present or could be added to prevent this occurrence. This will, however require further analysis in subsequent design activities to determine the appropriate heat trace requirements and associated electrical power consumption.

1.3 Mixing System

Two options for mixing systems were evaluated. Options 1, is to combine the mixing and transfer system together into a single units for installation in the existing 12-inch risers. Options 2, is to separate the two functions into separate units and place the mixing system in existing manholes.

The limited availability of risers on the tank will require the integration of the mixing and pump functions into singular units if placement in the existing risers is the chosen options. While this is very effective at maximizing the available space, significant degradation of mixing performance is expected. The pressure drop through the RFD significantly reduces the effective cleaning range of the submerged nozzle. A solution to

this problem is to introduce above waste mixing nozzles to allow for the projection of solution to ranges otherwise unachievable. The effective range and energy imparted by these mixing nozzles is not anticipated being significant. As a result these nozzles may not successfully mobilize the insoluble solid constituents located a distance from the deployment location. The existing available risers that are large enough for the assemblies (R6 and R7) are near centrally located creating a significant distance that the mixers must operate effectively.

Risers R6 and R7 are 12-in diameter, non-pit risers and will require installation of temporary, above grade pits. Costs to design, build, and install temporary, above grade pits were obtained from Hanford Site personnel familiar with other temporary pit installations. The cost to design and build two temporary, above grade pits is estimated to be $180,000. The unit installation cost is estimated to be $50,000.

The preferred approach would be to separate the mixing and pumping functions into separate units and relocate the mixers further from the tank center. Dedicated mixers could be placed in near ideal locations by placement in the manholes and devoted to the performance of mixing. The placement of the mixers in the manholes also allows for the charge vessel size to be significantly increased. Placement of the mixers in the manholes resolves both the issue of charge vessel size and installation location.

If the insoluble waste constituents are not easily mobilized, then mixers deployed in the available risers will not likely achieve the retrieval goal of 99% recovery by volume (TPA M-45-05A). It may however, achieve the recovery of the 490 curies of long-lived radionuclides, as these constituents are predominantly highly soluble.

Based on the increased mixing performance observed in other applications using fluidic pulse-jet mixers, the larger charge vessels installed in the manholes is expected to increase the recovery performance from between 200 and 400%.

Installation of three, new, 42-in risers will necessitate hand excavation to the manhole covers, installation of risers, backfill, and installation of new temporary, above grade pits. The cost basis used for installation of a new riser was obtained from the 241-C-104 Preliminary Engineering Report. Installation of the first riser is expected to cost $1,035,000, and a second and third riser is expected to cost $850,000 each. The cost to design and build two temporary, above grade pits is estimated to be $180,000. The cost to build a third temporary pit was estimated to be $40,000, based on comparison of this item with other tank hardware of similar complexity and the assumption that no additional design would be required. The unit installation cost is estimated to be $50,000.

1.4 Pumping System

Three options are considered for recovering the solution from 241-S-102: Option 1) a RFD pump, Option 2) a diode pump, and Options 3) a conventional mechanical pump

Diode pumps are preferred over RFD pumps because two charge vessels can produce continuous flow verses three or more for the RFD. The disadvantage is that diode pumps produce significantly less head than RFD pumps, requiring the installation of a booster pump, a new transfer line, or both.

Conventional submersible type pumps can be designed to perform in a range of applications. While many of the technical uncertainties can be mitigated by the incorporation of a conventional pump, system reliability may be significantly degraded. Pumps deployed in these types of applications have a limited life expectancy and are difficult and costly to replace.

The location for the pump installation has also been evaluated to maximize the retrieval volume. Because the tank floor is dished, the pump should be mounted in the center of the tank, as near to the bottom as possible. This will require removal of an existing salt well screen to accommodate use of Riser 13. The cost to remove a salt well screen was estimated to be $1.4 million. This cost is based on previous estimates performed for long length removal and disposal of a salt well transfer pumping system. The cost to remove a salt well pump was estimated to be on the order of $500,000 for pump removal. Based on uncertainties associated with removal of a salt well screen, high contamination and dose levels, and the greater potential for the salt well screen to be stuck in the salt-cake, a factor of 1.5 was applied to the normal cost for long length removal and disposal of a salt well pump. A cost of $250,000 for a support frame that would be used to suspend the salt well screen as it was removed and cut into segments was included. The cost for a support frame was derived from a previous W-521 cost estimate for design and fabrication of a steel support frame for a flexible receiver. Other costs were included for engineering, waste disposal planning, waste disposal, As Low As Reasonably Achievable planning, and overall job control system work package preparation.

1.5 Waste Transfer Operations

A Fluidic pump (either RFD or diode) does not produce continuous flow as an inherent function of the design. Multiple pumps could be operated out of phase to produce continuous flow, however there are technical issues that must be overcome to implement this approach.

The alternatives for transferring waste evaluated within this section include the development of a system(s) producing continuous flow and system(s) producing intermittent flow. The advantages and disadvantages to the methods proposed are discussed in this section.

1.5.1 Recirculation Loop

This waste transfer option is to incorporate a supernatant recirculation loop running between 241-S-102 and 241-SY-102. Supernatant recovered from the receiver tank, 241-SY-102, and would be used as the recirculation medium. Solution recovered from 241-S-102 would be injected into the return side of the loop as it is recovered. This system would accommodate a wide range of recovery rates and not depend on the fluidic system to provide the motive pressure to reach the receiver tank.

There are several disadvantages that must be considered before applying this approach. The primary problem is the cost associated with implementing this alternative. Two lines are required to connect the recovery and receiver tank as well as a submersible pump in receiver tank (241-SY-102). Depending upon the submersible pump selection, a booster pump may be required as well. Careful consideration of the placement of the pump suction inlet is important to prevent the possibility of exposing the intake or recovering solids.

The complexity of operating a recirculation system over the entire retrieval duration will also introduce maintenance and reliability issues that could otherwise be avoided. The two pumps, additional transfer line, associated instrumentation, and interlocks will all contribute to a decreased system reliability and availability.

The decreased risk of line plugging associated with implementing this option are not considered sufficient to outweigh the added cost and system complexity. While the risk of line plugging could effectively be eliminated, the deployment and operations are anticipated to result in additional technical and performance issues.

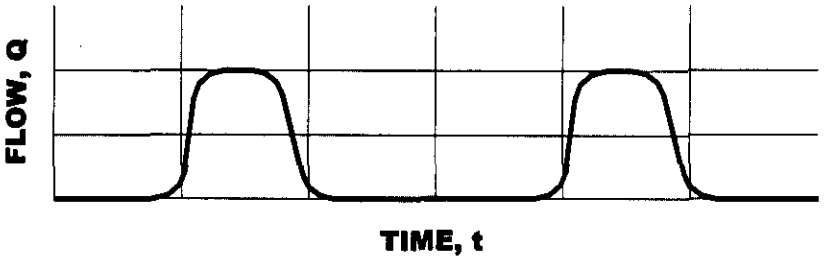
1.5.2 One-Way Transfer

Past retrieval using the baseline retrieval technology, sluicing, generally relied on the recycling of supernatant from the receiver tank to function as the mobilizing media. For the 241-S-102 Waste Retrieval System, raw water will be utilized exclusively to recovery the predominantly soluble waste from the tank. The water can be introduced through a transfer system or directly into the tank. The issue of water introduction is not, however, considered an area of significant concern. A single transfer line can be effectively utilized to support the project requirements. Two alternative methods of transferring the recovered solution through a single pass transfer system are addressed in this section. Both systems have been developed under the premise that the dissolution and mixing system will perform adequately to mobilize the waste for retrieval.

1.5.2.1 Intermittent Waste Transfers

Based upon the availability of risers and access to the tank, a possible system configuration would include one or two pumps. In this configuration, intermittent flow will be produced to the receiving tank (241-SY-102) as illustrated in Figure 1. Solids recovery, particle size, and flushing requirements will be considered in evaluating the potential for line plugging with this option.

Figure 1 Intermittent Pumping



1.5.2.2 Continuous Waste Transfers

Based upon the availability of risers and access to the tank, it may be possible to achieve continuous flow from 241-S-102. This will require the use of multiple RFD pumps or a 4-diode pump (a.k.a. two 2-diode pumps operated in concert). As an example, the operation of three RFD pumps running 120 degrees out-of-phase is illustrated in Figure 2. The result is near continuous flow when combined into a single output inline with an accumulator (and possibly a booster pump), illustrated in Figure 3.

Figure 2 Continuous Pumping, RFD Pumps

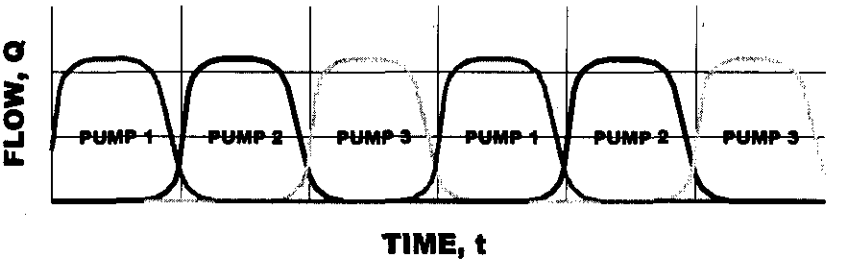
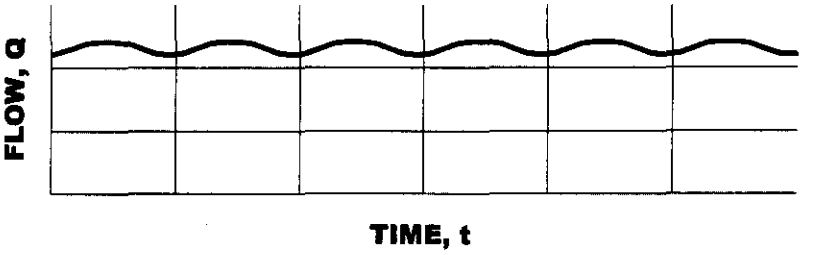


Figure 3 Continuous Pumping Flow Composite



1.6 Line Plugging

Regardless of the method of pumping or piping system configuration selected, measures must be included to prevent transfer line plugging. The primary plugging mechanisms have been considered and mitigation options proposed. The primary (and historical) causes of transfer line blocking are:

- High solids loading in transfer solution,
- Low flow velocity in conjunction with solids transport,
- Cooling of saturated solution resulting in solids precipitation,
- Inclusion of debris in transfer stream.

The transport of solution with excessively high solids loading is not considered a significant risk. The percentage of insoluble constituents in 241-S-102 is relatively low. The distribution of the insolubles, however may increase the potential likelihood that a "slug" of solids could be introduced to the transfer system. The recovery of solids can be mitigated by the introduction of a settling period between the mixing and pumping cycles. The duration of the settling time would not be required to be significant.

The required flow velocity to maintain solids suspension is a function of the size, density, distribution, and concentration of the subject solids. The concentration of the solids is not considered a significant concern, as discussed previously. Particle size and density are factors that cannot be manipulated. Lacking precise solid property data, the velocity is the one factor that can easily be used to mitigate the potential of line plugging by solid settling. The velocity should be maintained conservatively high until such time as the particle properties can be assessed with certainty.

Calculations performed on the existing transfer route from 241-S-102 to 241-SY-102 show that significant pressure losses will be realized by using the available route (4412.091.MCAL.001). The increase and reduction of the transfer line size from 2-in to 3-inch and back to 2-inch along the route may make it impossible to achieve the critical flow velocity without exceeding the allowable transfer line pressure.

Cooling of the transfer lines and the often-ensuing solid solidification has been responsible for several line blockages while saltwell pumping. While increased transfer velocity may have prevented some, if not all, of these occurrences, line/solution cooling has been identified as the primary mechanism of most for line plugs in recent history. This problem can be mitigated or eliminated by ensuring adequate heat tracing of the transfer lines is provided.

The primary area of concern for line plugging with is the fluidic system is the intake of debris into the transfer system. The inclusion of provisions for preventing the intake of debris in the transfer lines requires careful consideration. Fortunately there are numerous methods for precluding or removing debris from the transfer system.
Methods for the preventing the intake of debris include:

- Use of inlet screens, or
- Reduction of inlet flow velocity.

Methods for the removal of debris from the transfer system include:

- Use of strainers or filters with provisions included for back flushing,
- Inclusion of cyclone-type separator, or
- Inclusion of a settling tank.

Any combinations of the methods identified could be incorporated, however each method introduces other concerns. Inlet screen will degrade the charge vessel efficiency resulting in an increased retrieval duration and decreased retrieval performance. Strainers, filters, separators, and settling tanks/chambers increase the system complexity and will require frequent hands-on maintenance.

Special pumps or debris ingesters could also be included, but are not considered ideal because the debris will still be transferred through the pipeline and end up in the DST system.

1.7 Ventilation

An evaluation of the system performance and propensity for aerosol generation will need to be performed as it relates to the existing tank's passive filtration system. Based on this evaluation, the ventilation requirements will be assessed and means of satisfying these requirements will be developed. It is currently assumed that active ventilation is not required to support safe operations.

1.8 Fluidics System Configuration

Alternative arrangements of fluidics systems have been evaluated at a pre-conceptual level of detail to support the preliminary design analysis. Initially, two basic system configurations were developed. The first system emphasizes the minimization of the over all system complexity and cost, with performance as a secondary consideration. The second system, places the emphasis on the optimization of the overall system performance, where complexity and cost are secondary considerations.

The optimal performing system will be of the same basic configuration as the minimal impact, low cost system proposed. Additional features are present in the optimal system that enhances the anticipated system performance in regards to retrieval efficiency. These additional features were each examined individually to determine the increased performance expectation and added ROM cost estimate of adding the feature to the minimal impact system. A rudimentary cost-benefit analysis was performed in the Value Engineering (VE) Session, which allowed the development of a system, which is both affordable and yet meets the minimum system performance requirements.

1.8.1 Minimal Impact System

The first retrieval system developed and analyzed minimizes the impacts to the existing tank (241-S-102) and in tank hardware and maximizes the system performance only as a secondary consideration. Specifically, the following assumptions were used to develop the system:

- Existing risers will be used exclusively.
- Removal from the tank of long length equipment in contact with the waste is not required.
- The existing waste transfer system piping from 241-S-102 would be used. No new transfer lines will be installed.

A retrieval system was developed, which satisfied the initial set of development criteria established. This system does not however, satisfy the minimum criteria set of requirements for the retrieval. In particular, the system does not produce continuous waste transfer flow or reach the minimum waste transfer velocity to prevent solids settling (4412.091.MCAL.001). The system mixing capability is also severely limited by the placement of the charge vessels and combination of mixing and pumping functions. A process flow diagram (PFD) and estimated material balance are provided in (4412.091.PDWG.003)

1.8.1.1 Equipment Selection and Placement Rationale

Three 12-in risers (R6, R7, R8) are available for use in 241-S-102 that will not require the removal of long-length contaminated equipment. Several 4-in risers are also available, but are insufficient in size to have any utility for the deployment of mixing or pumping devices. The near-center location of the 12-in risers will inhibit the ability of the system to adequately dissolve and/or mobilize the waste near the tank walls. For this reason, above waste nozzles were selected for incorporation that will have greater range projection capability than would a conventional pulse-jet mixing system. This also allows for the pumping and mixing functions to be combined into a single unit utilizing a common charge vessel.

The three charge vessels deployed through the 12-in risers will have a nominal operating capacity of approximately 80 gallons. The volume is limited by the overall size of the charge vessel that can fit through the riser and the maximum height the solution can be lifted (based on specific gravity estimates and vapor pressure). Operating at 60 to 70 psi these three RFD pumps can produce near continuous flow when operated 120 degrees out of phase. An accumulator and booster pump are required to be installed downstream of the pumps to overcome the line losses and increase the flow velocity. Utilizing the existing lines, it is not recommended that the pressure be increased to a level required to achieve the minimum flow velocity.

To prevent line plugging with solids at the reduced transfer velocity, a cyclone-type separator has been included in the transfer system. This separator removes solids and debris from the system that would otherwise be transferred to the DST system. This minimizes the potential for line plugging with solids by their exclusion.

1.8.2 Optimal Performance System

An optimal performing Fluidic WRS requires risers larger than those currently available. Ideal placement of the system components also requires riser locations, which currently do not exist. Because 241-S-102 has a dished heel, the ideal location for the transfer pumping system is in the central riser, R13. To maximize the waste mobilization, the mixers pumps should be located such to minimize the required effective cleaning radius. That is, the mixers should be separated from each other sufficiently to minimize the mixer-to-tank wall distance and areas of minimal coverage. The development of the optimal performance system did not consider the removal of equipment or utilization of existing risers as a primary consideration.

1.8.2.1 Equipment Selection and Placement Rationale

1.8.2.1.1 Transfer Pump Design and Placement

Due to the size and central location, Riser 13 was selected to contain the waste transfer pump. Because the system will be required to retrieve a significant portion of the solids, to achieve the 99% recovery goal, continuous flow in excess of the critical solids settling

velocity was considered a significant or primary requirement. Hydraulic calculations performed on the existing waste transfer route (4412.091.MCAL.001) show that the critical flow velocity of 6-ft per second cannot be achieved regardless of the pumping method chosen without creating excessive pressures. For this reason, an OGT, similar to that already utilized by Interim Stabilization, has been proposed. The estimated head (hydraulic pressure and line) losses through an OGT are significantly lower than that of the existing transfer route(s) (see 4412.091.MCAL.002). This allowed for the consideration of a 4-diode pump to achieve the continuous flow. Diode pumps are more suitable for providing continuous flow than RFD pumps, however they produce significant less head pressure. The large, 42-in, size of this riser is also necessary to accommodate the two charge vessels incorporated into the two 2-diode pumps (a.k.a. a 4-diode pump). Installation of the pump in this riser will require the removal and disposal of the existing saltwell pumping system and screen.

Two types of pumps were considered in the development of this system. As a general rule, RFD pumps can produce much greater head (pressure) than diode pumps. RFD pumps also have a much smaller charge vessel evacuation time to fill time ratio. This means that more RFD pumps are required to produce continuous flow than diode pumps. Utilizing RFD pumps that would install into 12-in risers and overcome the required head would require five separate pumps (based on input from AEA Technologies). For diode pumps, the fill cycle time and evacuation cycle time can be adjusted to be nearly equal. This allows for two 2-diode pumps to operate out of phase to produce near continuous flow.

1.8.2.1.2 Mixer Pump Design and Placement

During the construction of 241-S-102, man-way accesses were provided in the tank dome to allow for the removal of the concrete forms. After the dome construction was completed (and the forms removed from the tank interior), the man-ways were plugged with concrete sealed with mortar and an asphalt membrane (H-2-1814). Three man-ways, or manholes, are located in the dome of 241-S-102. They are 120 degrees apart and almost perfectly located for the placement of mixers. Reopening of the manholes will not affect the structural integrity of the tanks dome because the manhole covers are void of structural reinforcement.

With the exception of the central, 42-in riser, all of the remaining riser penetrations on 241-S-102 are 12-in or smaller. The size and location of the existing risers will restrict the performance capability of the system to dissolve and mobilize the tank waste. For these reasons, the manholes were selected as the ideal location for the installation of the mixing units.

The larger size of the manholes (in comparison to the 12-in risers) will allow for the installation of sufficiently sized charge vessels to mobilize the tank waste. Based on the performance fluidic mixing system utilized in other mixing applications, the larger, more appropriately located charge vessels are anticipated to increase mixing efficiency between 200 and 400%.

1.8.3 Hybrid System

One of the primary obstacles in the design and deployment of a fluidics system in 241-S-102 is resolution of limited riser size and availability. Fluidic mixing and pumping systems require the deployment of relatively large charge vessels to function efficiently. Combination of the transfer pumping and mixing function into a single unit may resolve this issue, however the degraded mixing performance may also produce less than desirable results. An option to mitigate this performance uncertainty is to separate the mixing and transfer pumping functions and perform one or the other using more conventional methods.

Fluidic mixing systems were deployed at Oak Ridge National Laboratory where the waste transfer function was performed using conventional pumps. The performance characteristics of the conventional pumps (centrifugal or positive displacement) are well understood and can easily be incorporated into the system design. This would replace the fluidic pumps and free space for the installation of larger mixing dedicated systems.

Production of a "hybrid" fluidic and conventional system is not developed in this preliminary engineering report. The fluidic system recommended for deployment is anticipated to satisfy the project requirements for the retrieval. Conventional mixing systems would require significant inventories of liquid in the tank, which is contrary to the proposed Leak Detection, Monitoring, and Mitigation strategy. Conventional pumps, however, may have utility when used in conjunction with the fluidic mixers. While conventional pumps are not being considered at this time, there has not been any reason identified which would preclude their incorporation into the system if fluidic pumping is found unsuitable for whatever reason.

1.8.4 Proposed System Evaluation

A preliminary evaluation was performed by developing and evaluating the features present on the optimal performing system, which are not provided on the minimal impact system. The optimal performing system features generally increased the system performance, but at an associated cost. The minimal impact system reduced system complexity and overall cost but at the sacrifice of performance. The ROM costs associated with the features and the anticipated performance enhancement(s) is provided at a summary level in Table 1.

The intent of developing two systems was to selectively add those features to the minimal impact system required to meet the minimum set of requirements for the project. The decision was made to select the optimal performing system as the preferred system at this stage of project development in a VE workshop with representatives from CH2M Hill Hanford Group, Inc. and Holmes and Narver/DMJM. The basis for the decision was to take the most conservative approach in the preliminary engineering stage and realize cost efficiencies in latter project phases after the TFA sponsored testing has been completed.

Table 1 Features Under Consideration

Feature	Relative Cost	Performance Enhancement	Other Considerations and Comments
Transfer System			
Existing Transfer Route	~$0	Baseline	Uncertainty of internal pipe condition
Existing Route w/S-A Booster Pump	$221k	Increased transfer velocity	Eliminates route from use by others (i.e. 241-S-112)
New OGT Straight	$557k	Reduces head loss, plugging potential, and line failure potential	Requires significant backfill be brought into farm
New OGT Contour	$536k	Reduces head loss, plugging potential, and line failure potential	
Mixing System			
Existing Riser Utilization	$280k	None	
Manhole Access	$3107k	200 to 400% mixing enhancement	
Pumping System			
RFD Pump	~$0Δ	High pressure, can combine mix and pump function	Minimum 3 RFDs required for continuous flow
Diode Pump	~$0Δ	2 units will produce continuous flow	Cannot effectively combine mix and pump functions
Conventional Pump	~$0Δ	Low technical uncertainty	High maintenance liability
Central Pump Installation	$1394k	Maximize waste removal (heel)	Requires removal/disposal of existing saltwell screen
Transfer Operations			
Existing Transfer Route	~$0Δ	Large head losses	Low implementation cost
Recirculating	$825kΔ	Low plugging potential, High system flexibility	High costs for two transfer line installtions, decreased system reliability
Intermittent	~$0Δ	Low equipment costs	High plugging potential
Continuous	~$250Δ	Higher equipment costs	Moderate plugging potential, moderate higher equipment costs

Appendix I

VE Session Minutes/Output

S-102 Workshop
Meeting Minutes
05/23/01

Attendees:

Jim Frederickson, HND	Dennis Crass, NHC
Mike Leonard, CHG	Eric Clements, AEAT
Toni Lauricella, CHG	Martin Williams, AEAT
Mike Deffenbaugh, CHG	Tom May, CHG
John Harris, CHG	Jeff Doeler, CHG
Brett Simpson, CHG	Paul Kison, CHG
John Bores, CHG	Milton Schultz, CHG
John Elsen, HND	Jerry Cammann, CHG
Safik Rifaey, CHG	Mike Boger, NHC
Kevin Kjarmo, CHG	Greg Bogen, HND

Summary

The purpose of this meeting was to reach concurrence/consensus on the selection of a baseline concept and the associated assumption to use the Power Fluidic technology for the S-102 retrieval. The meeting was an informal workshop with a presentation given by Greg Bogen summarizing Power Fluidics and the 30% Draft Preliminary Engineering Report (PER) options. Mr. Bogen presented a discussion of the options and CHG (Safik Rifaey and Dennis Crass) elected to rank/score each of the alternative system configurations to make the final selection. Scoring of options was based on criteria provided by Safik Rifaey. The following agreements were reached:

- 99% volumetric retrieval and 490 curies of long-lived radioisotopes from S-102 is a fundamental requirement at this project stage (reflected in the TPA milestones). Regulators will expect the retrieval concept to be designed to meet these requirements.
- Waste transfers between S-102 and SY-102 will be made through an above ground line, which follows ground contours. The goal will be a self-draining transfer line, eliminating waste holdup.
- The salt well screen and pump in the center riser (13) in S-102 will be removed and retrieval will be performed from that location. Because of the dish shaped tank floor, central location of the pump is paramount to minimize the residual volume.
- Mixing will be performed through the three manhole covers on S-102 requiring excavation and riser installation at those locations. Existing riser locations and sizes will not support complete tank retrieval.

Minutes

Introduction and Purpose

Dennis Crass began by stating that the purpose of this meeting was to reach consensus on the selection of a baseline concept using Power Fluidic technology for the S-102

retrieval. The basic assumption was made that Fluidics is going to work for the 241-S-102 Waste Retrieval. Testing performed this summer (sponsored by TFA) by AEAT may shed further light on this issue.

Overview of Power Fluidics

A Power Point presentation was given by Greg Bogen, HND, and is included for reference as Attachment 1.

Mr. Bogen led off with an overview of power fluidics. He presented the general system components common to all fluidics systems, which include:

- A compressed air supply (normal operations at 70 psig),
- A valve skid for directing the air flow,
- A jet tower for prevention of siphoning,
- A pipe bridge to connect the jet tower/valve skid to the charge vessel,
- Charge vessel(s), and
- A ventilation skid.

Mr. Bogen went on to explain that the "jet tower" component would not be included in the baseline design. If a "tower" is going to be included, it will be incorporated into the valve skid and not be the conventional 35 feet tall (above grade level). The height of the tower is set to prevent siphoning from the recovery tank and contamination of the upstream components. Siphoning will not occur in S-102 with the level of the waste being far below grade and the equipment installation at grade. The conventional "pipe bridge" would be incorporated but only as flexible hoses connecting the charge vessel to the valve skid.

Mr. Bogen also established that the ventilation skid used by the Power Fluidic system could also function as the S-102 tank exhauster if required. He stated that the concepts developed in the PER had not assumed an exhauster would be required.

A discussion of the Power Fluidic mixing options was then presented. From the two different options, "pulse-tube" and "pulse-jet", the pulse jet method was presented as the only rationale option for application to S-102 retrieval. Martin Williams stated that the pulse-jet mixer would require liquid a minimum depth of one inch above the nozzle.

A discussion of Power Fluidic pumping options was then presented. Reverse flow diverters (RFD) were explained to operate at higher pressures, have shorter evacuation to fill times than do diode pumps. The net result is that more RFD pumps are required to be operated simultaneously and out of phase to produce continuous flow than diode pumps. The fill and evacuation times on a diode pump are approximately equal. A four-diode pump was agreed upon as the best option for pumping waste from S-102. It was discussed and understood that an accumulator (less than 100 gallons in size) would be required to produce even flow and allow for the addition of a booster pump if needed.

The final option for both pumping and mixing discussed by Mr. Bogen was to utilize a combined pump/mixer. A conventional pump would be used with the intake replaced by

a nozzle and an above waste discharge provided for re-injecting the process stream to mobilize the waste.

Engineering Approach

Following the introduction to Power Fluidics, Mr. Bogen explained the process used in the Preliminary Engineering Report to develop the retrieval alternatives. Two systems were developed; one system optimized performance without regard for cost or complexity, while the other system minimized the system cost with performance as a secondary consideration.

- Minimal Impact System
  - Cost is primary
  - Performance secondary
  - No new risers
  - Existing piping is used- Existing line starts 2", to 3" line, back to 2" line.
  - Water addition can be via a tank or truck.
  - Pumping and mixing functions are combined into singular units due to limited riser availability
  - Will not produce continuous flow while pumping – it will be intermittent. Proposed in the PER that the lines will be flushed through the tank, then a back flush to clear the lines.
  - Off center pump installation will leave greater residual volume than 1% goal
  - Central location of mixers will not likely be effective at recovering the insoluble constituents
  - Have not addressed continuous pumping when near the sludge level, only mobilizing the sludge during mixing/pumping. Sludge recovery can be addressed towards the end.

- Optimal Performance System
  - Performance is primary
  - Cost is secondary
  - Pumping function is separate from mixing function
  - Will produce continuous flow during pumping cycle- may or may not require a booster pump
  - New transfer line installed
  - Above waste nozzle on mixers is adjustable and can point at different angles in the tank.
  - Central location of pump will maximize the recovery efficiency
  - Distributed location of mixing vessels will maximize the mobilization and recovery of waste

Features present on the optimal performing system were then broken out and an increased performance expectation or reduced risk reduction factor assigned/qualified (insufficient data were generally available for quantification) for each of the features. Based on the cost of each of the features, a rudimentary cost benefit analysis could be performed to

determine which features to incorporate into the minimal impact system to arrive at a "compromising system". The intent, and ultimate goal of the VE Session, is to arrive at a system meeting the minimum set of performance requirements while maintaining a reasonable cost. Mr. Bogen clarified that the ultimate decision was to be made at the discretion of CHG and the representatives present.

General Discussion on Two Options Presented in PER

- Cannot recover or transfer solids without continuous pumping because lines will plug. Solids need to keep moving all the time in order to achieve 99%.
- The LDMM strategy of minimizing the leak potential is to minimize the inventory of liquid in the tank.
- Relatively small batches of water will be added and then pumped at a rate to maintain solids suspension. This introduces many pumping and water introduction cycles, after which a line flush would be required.
- Automated flushing between pump cycles is an operational approach never attempted before. Paul Kison did not like the approach of using the line flush from SY to S-102 as the means of adding water to S-102. The number of times this was required and potential for misroute were his primary concern.
- With the interlock flush system, can't tell what the impact is without accident analysis.
- If flushing can't be done more than once a day, tank will need to be flooded which is not desirable from an LDMM standpoint.
- Back flush would be approximately 2 line volumes. This equals approximately 300 gallons, which would take about 2 minutes at 140 gpm if automated, but hours if done manually.
- Each batch of water additions would need to be sufficient to provide a working volume for the mixers and pump. Some or all of the water additions could be made through the line flushing system.

- Transfer System Options
  - SL140 is an encased line currently being used by Interim Stabilization for saltwell pumping of S-102 (which is not running). It was pressure tested to 100 psig. The line may be good for 200psi, but has not been tested at that pressure.
  - SN-275 was never used until recently and is active. This line was pressure tested by Interim Stabilization to 100 psi. Will be non-compliant in September 2005.
  - SN-276 for S-B to SY-B has never been used as far as is known
  - Have looked at installing new transfer line of the hose-in-hose design (1. following contours and 2. a straight run with backfill). Both options would be self draining.
    - New transfer line following contours – crosses the berm running between S and SY and follows around the berm.
    - New transfer line with backfill – runs straight between tank and will require a lot of backfill.

- Unknown risk associated with a baseline using the existing transfer lines. Best option (lowest programmatic risk) is to use a new transfer line.
- From a schedule standpoint – no difference between the two "new transfer line" options.
- New transfer line can be 1 ¼" or 1 ½" instead of 2" or 4" lines and sized to the system.
- Duration: 1 year in the ground (how long it will be used), and less than ½ year for retrieval.
- Alternative hose in hose – shelf life 7 years; design life has been reduced to 3 years
- Equipment cost is negligible.
- Conclusion: The best transfer option is above ground following contours.

- Mixing and retrieval options
  - Possibility of installing system that can be moved and directed inside the tank – not favorable.
  - In order to achieve 99%, will need mixer installation locations not currently available.
  - The location and size of the 12" risers will not provide a high confidence in recovering 99% of the tank (stated by Mr. Bogen and confirmed by AEAT's Mr. Williams)
  - The most practical alternative access locations are the 42" manholes
  - The manholes would allow larger mixers and near ideal location
  - Even using the manholes we may still not achieve the 99%
  - More likely to meet TPA goal of 490 curies
  - Ecology wants 99%, but if we can demonstrate less with no risk and high cost for removing remainder, they may change their number.
  - No technical basis today for 99%, but we have to design at 99% because it is stated in the TPA
  - Need to guarantee exclusion of debris in the line
  - Manholes are out near the edge of the tank. Can get best coverage, but pumping needs to be done from the middle – not the edge.
  - Soil contamination will be an issue when digging up the manholes
    - Remove and dispose of soil
    - Hand excavate required
    - Structure required to support the mixer
  - Not sure if using 12" riser is effective in terms of ability to achieve mobilization
  - Need to guarantee exclusion of debris in the line
  - Total amount of liquid required for mixing is dependent on what size vessel you use.
  - Amount of liquid is determined by what is needed.
  - As salt is dissolved, the amount of water can be increased to fill the cavern.
  - When sludge is reached, the amount of water decreases.

- The Power Fluidic mixers require a minimum 1 inch of liquid covering the nozzle to operate. A four inch nozzle, one inch off the tank floor would then require a minimum of 6 inches to operate
- If a minimum of 1" is required to cover valve, there is not a system to control the level of fluid cover
- A combined mixer and pump will not pump the tank down far enough to reach the 99% goal

- Mixing Option
  - C-106 Lessons Learned
    1. To achieve 99%, pump needs to be as close to the bottom center (riser) of the tank as possible.
    2. 99% will not be achieved, no matter how mobilized unless the pump is centrally located in the heel.
  - Efficiency will change if 2-3 RFDs are put around R13.
  - If trying to mobilized, best to move out from center of the tank to minimize the distance the mixers are from the waste.
  - If soil is removed, disposal cost may be $10M+ going to manholes rather than using risers.
  - Install pulse jets for first 80%?
  - Minimal impact system has pump that won't work for retrieval (to reach 99%).
    1. Won't reach and will need an additional pumping mechanism.
    2. Saltwell screen should come out.
  - Suggest adding water down saltwell screen and let it dissolve a cavern for pump installation.
  - Pumping system without the mixing function will have better chance of achieving 99%
  - Optimal Performance System
    - Costly going into manhole – no basis today.
    - Technical risk outweighs cost
    - Operational cycle periods using a larger system (than would fit in a 12" riser) would end up with shorter retrieval duration and lower operational costs.

- Retrieval duration
  - 12" risers in center will be just as fast for first 80% as going into manholes. This due to dissolution as the primary mechanism of mobilization.
  - Prefer Diode pump over RFD pump for retrieval because less would be required to produce continuous flow.
  - More pumps make for a more complicated and costly system
  - To achieve continuous flow with RFD pumps will require 5 RFDs. Will lose efficiency because charge vessels will have to be smaller than the 2 charge vessels required for a 4-diode pump.

- With 42" diameter, it's possible to install 5 RFD pumps with above waste nozzles but will not likely reach outside wall with any force or meaningful volume

Conclusions from discussion:

- Meeting 99% technical requirement is more important than cost at this stage of the project.
- Mixing using 10" pumps through existing risers has very low chance of meeting retrieval requirements
- The saltwell pump in the center riser should be removed to allow tank access for the installation of a central pump. This is the only way to even have a chance of reaching 99% retrieval.

Alternative Selection:

At the direction of Dennis Crass and Shafik Rifaey, alternative system configurations were established and ranked against a requirement set developed by Mr. Rifaey. This was not a formal VE session, however, a ranking method was used to select a preferred option. The evaluation criteria were modified as necessary during the session to the set listed in the attached matrix. Six options were examined, all with retrieval via the center riser (in agreement with previous conclusion):

1. The minimum option used 2 existing risers and 10" pumps for mixing.
2. Three 10" pumps requiring removal of saltwell screen riser 5.
3. Three manhole locations and three 24" pumps.
4. Two manhole locations and two 24" pumps.
5. One manhole location and one 24" pump.
6. Two manhole locations and one existing riser location (requiring removal of saltwell screen riser 5) with corresponding 24" and 10" pumps.

The evaluation criteria, weight factors, relative scoring, and results are provided in Attachment 2. Option 3, using the three manhole location with three 24" pumps was selected as the preferred alternative. This decision was primarily influenced by the high weight given to performance and meeting technical requirements at this stage of the project. Waste Minimization is shown because it was initially considered a factor that would differentiate options. However, discussions concluded flush water quantities would be approximately the same for each option.

It was agreed that the optimal performing system as described in the 30% Preliminary Engineering Report would be used as the preferred system configuration. Efficiencies such as reducing the number of mixers could be evaluated in later project phases once test data is obtained from TFA sponsored testing. The optimal performing system was decided to be the most technically conservative baseline and the most appropriate for the preliminary stage of the project.

HND

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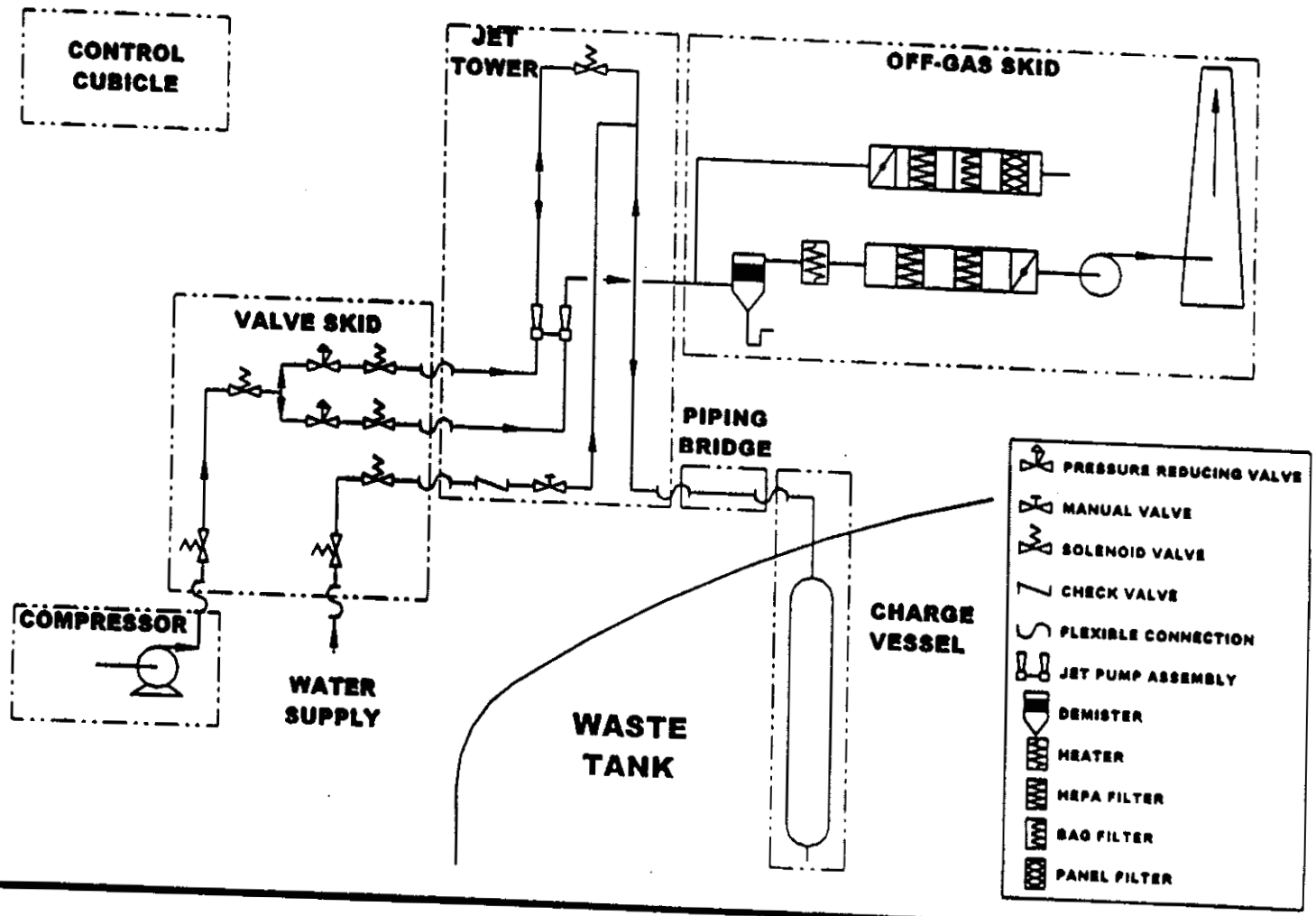
S-102 Workshop

HND Team

Power Fluidics

- System Description
- Mixing Alternatives
- Pumping Alternatives

Power Fluidic System Description



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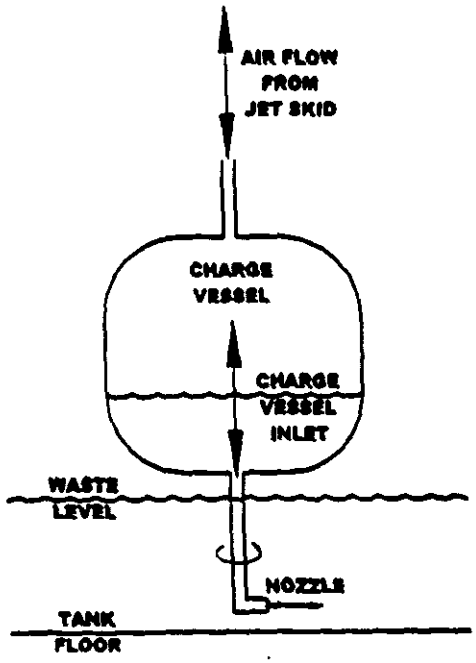
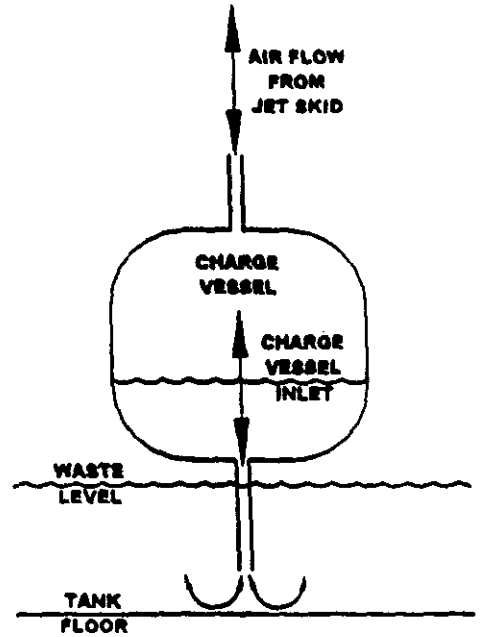
Power Fluidic Mixing

Pulse-Jet Mixer

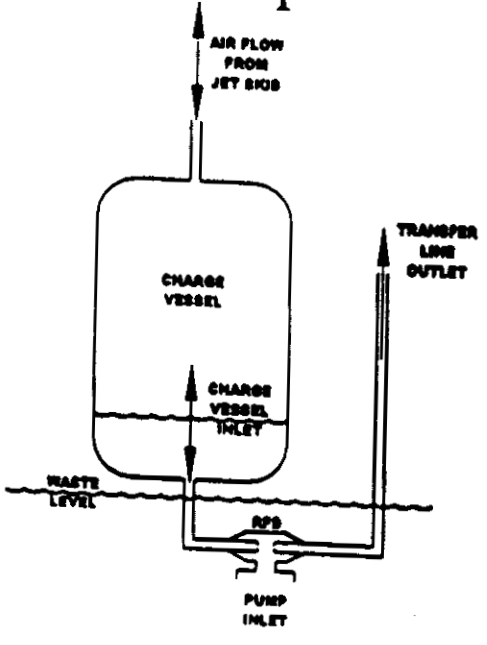


Pulse-Tube Mixer

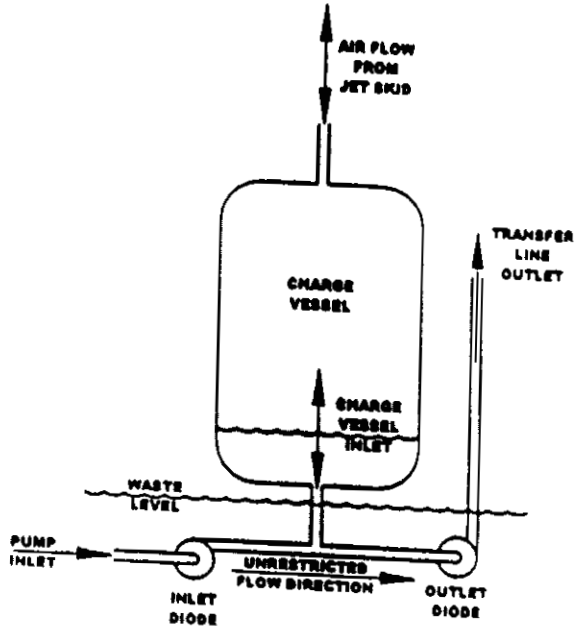


Power Fluidic Pumping

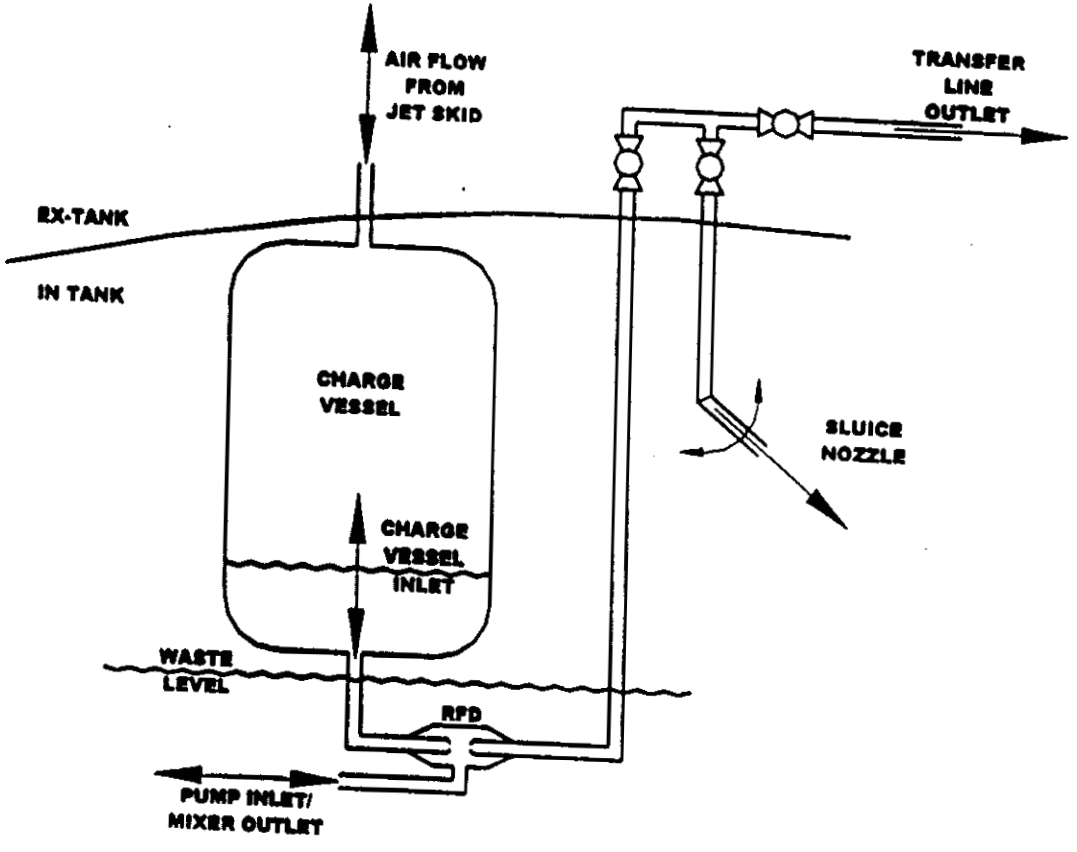
RFD Pump



Diode Pump



Combined Mixer and Pump



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Engineering Approach

Develop a Power Fluidic mixing and transfer pumping system for the initial waste retrieval of Tank S-102. The system will utilize relatively small quantities of solvent (water) to dissolve and mix the waste within the SST.

Two alternative system designs and arrangements were initially developed; a minimal impact system and optimal performing system.

Engineering Approach (continued)

Minimal Impact System

- Cost and system simplicity were primary consideration
- Performance was a secondary consideration
- No long length contaminated equipment removal
- No new riser installation
- Existing transfer piping is used

Engineering Approach (continued)

Optimal Performance System

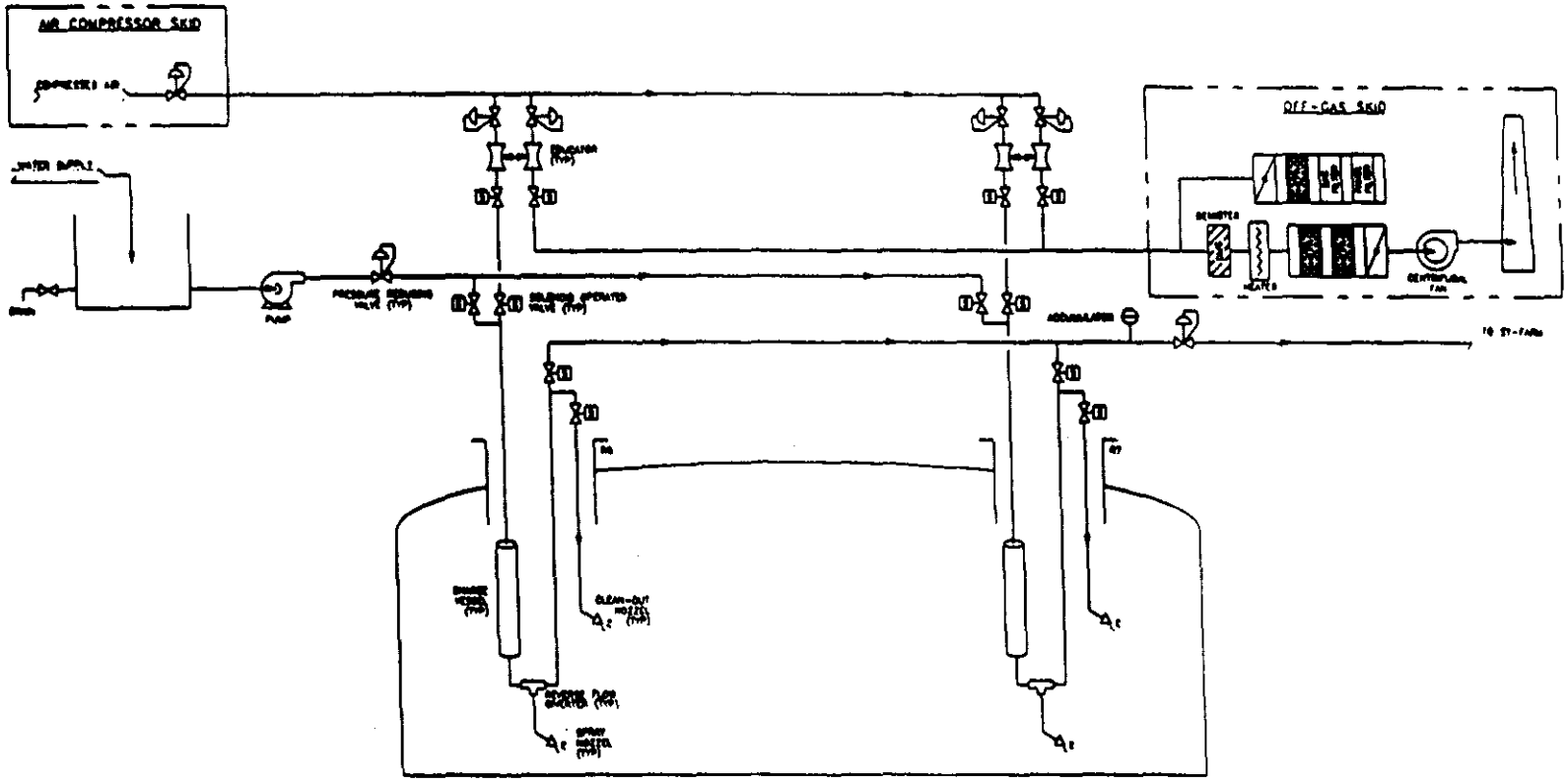
- Performance was the primary consideration
- Cost and system simplicity were a secondary consideration

Engineering Approach (continued)

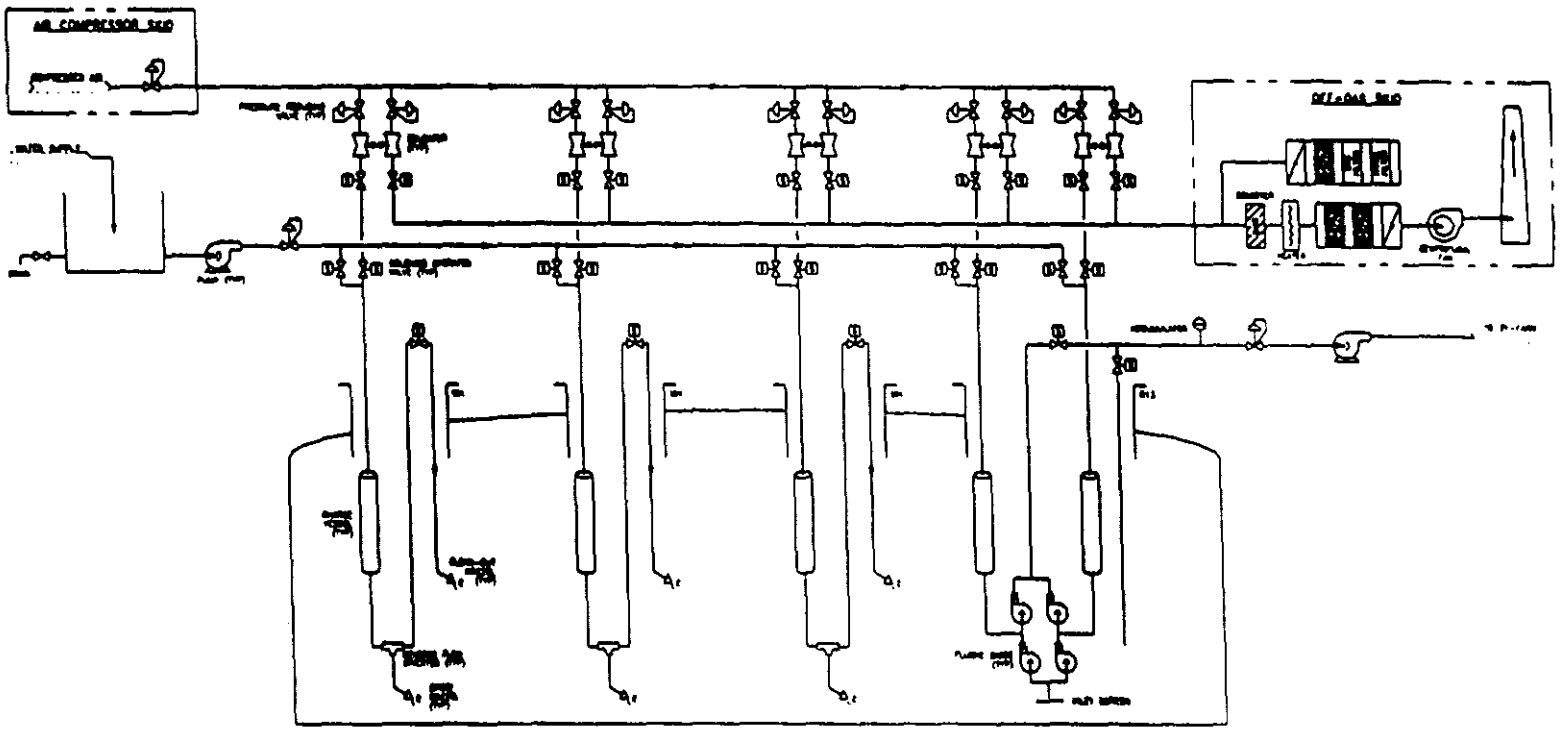
Hybrid Systems

The use of conventional pumping and mixing technologies were not considered for the in-tank portions of the retrieval system. Conventional methods would have potential utility if Power Fluidics is determined incapable of satisfying the project requirements and objectives.

Minimal Impact System Configuration



Optimal Performance System Configuration



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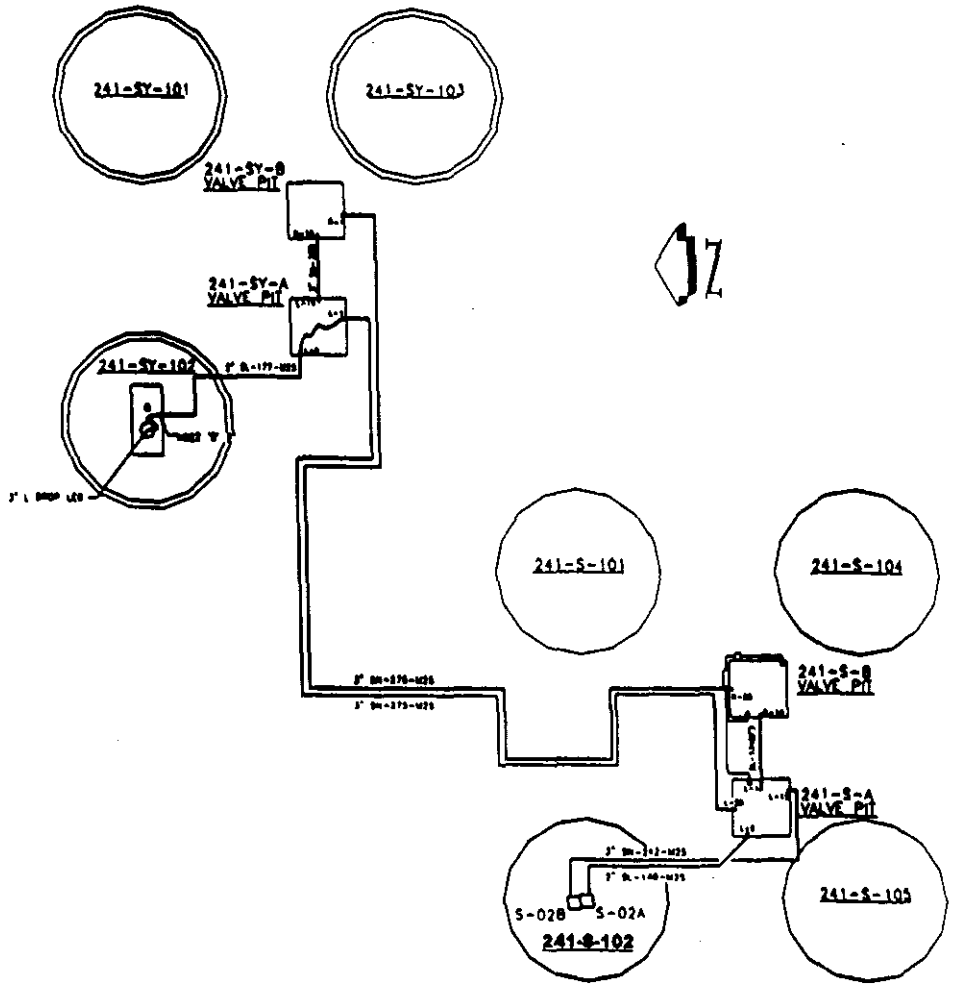
Transfer System Options

- Existing Transfer Route
- Existing Transfer Route with Booster in S-A
- New Transfer Line Following Contours
- New Transfer Line with Backfill

Existing Transfer Route



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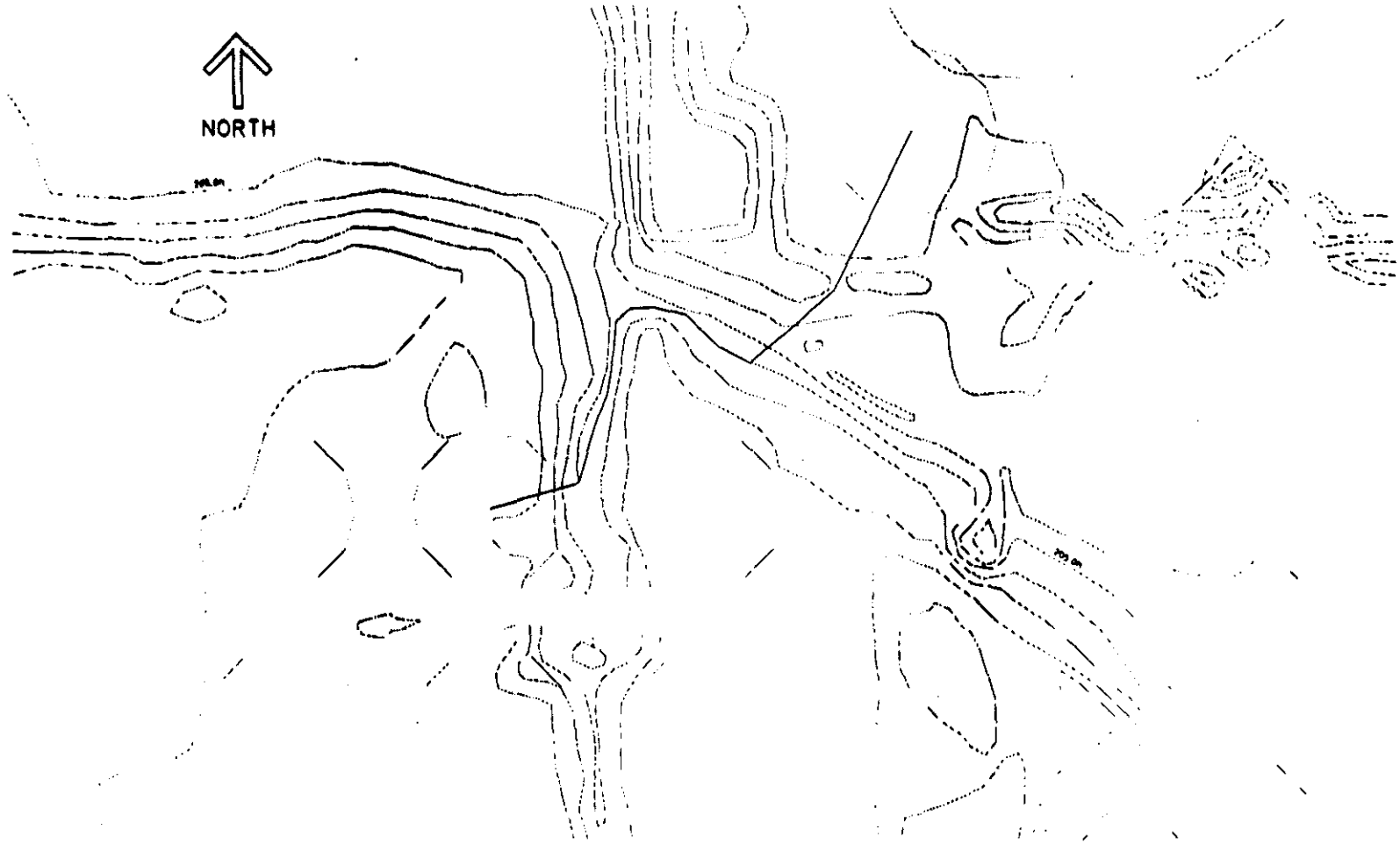
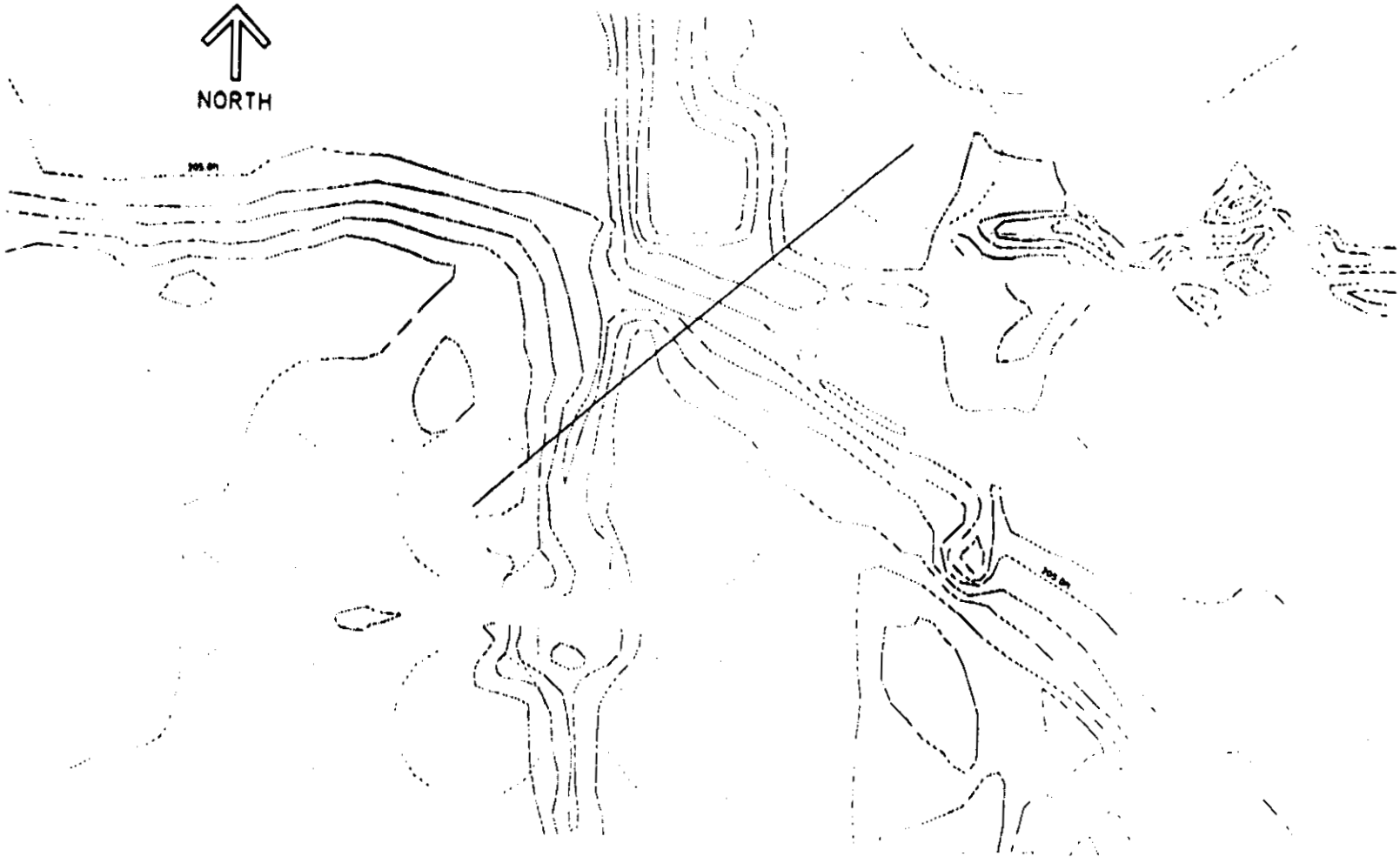
New Transfer Line Following Contours



New Transfer Line with Backfill



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	ATTRIBUTES	WEIGHT FACTOR		2x10"	3X10"	3X24"	2X24"	1x24"	2x24" & 1x10"
Cost & Schedule	Capital Cost	3	0.03797	5	1	1	5	10	1
	Schedule	7	0.08861	10	5	1	1	5	1
	Difficulty of Installation & Removal of existing equip.	2	0.02532	10	5	1	3	5	3
	Duration of Operation	10	0.12658	1	3	10	7	3	7
99% Removal	Salt Cake	10	0.12658	1	5	10	6	3	7
	Sludge/Solids	10	0.12658	1	3	10	5	1	7
Waste Minimization	Dissolving Salt Cake	5	0.06329	10	10	10	10	10	10
	Flush	5	0.06329	5	5	5	5	5	5
	Sludge	5	0.06329	5	5	5	5	5	5
Operation/ Maintenance	Complexity of Operation	5	0.06329	5	1	1	5	10	1
	Ease of Maintenance	3	0.03797	5	1	1	5	10	1
RAD CON/ ALARA	Operations Risk	7	0.08861	10	10	10	10	10	10
	Construction Risk	7	0.08861	10	5	1	2	5	2
				6.3	4.7	6.3	5.5	5.4	5.3

Appendix J

LDMM Design Concepts Evaluation Report for Fluidic Mixing and Pumping-Based Retrieval Technologies

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Acronyms

ASTM	American Society for Testing and Materials
BBI	Best Basis Inventory
CBAT	current best available technology
CERCLA	*Comprehensive Environmental Response, Compensation, and Liability Act of 1981*
CFR	Code of Federal Regulations
CVR	compensated volume rate
DOE	U.S. Department of Energy
DST	double-shell tanks
D_T	detection threshold
Ecology	State of Washington Department of Ecology
EPA	U.S. Environmental Protection Agency
ERT	electrical resistance tomography
ENRAF	Enraf-Nonius Series 84 level detection device
FRD	Functions and Requirements Document
gph	gallons per hour
gpm	gallons per minute
HDW	Hanford Defined Waste
Hp	horsepower
HVAC	heating, ventilation, and air conditioning
HVC	height-to-volume conversion
ILCR	incremental lifetime cancer risk
ILL	Interstitial-Liquid Level
LDMM	Leak Detection, Monitoring and Mitigation
LCO	Limiting Condition of Operation
LOW	liquid observation well
LR	leak rate
P_D	probability of detection
P_{FA}	probability of false alarm
PITT	partitioning inter-well tracer test
RCRA	Resource Conservation and Recovery Act
RPE	Retrieval Performance Evaluation
RPP	River Protection Project
RRC	Retrieval Release Criterion
SIR	statistical inventory reconciliation
SPL	system performance limit
SST	single-shell tank
TLDR	Target Leak Detection Rate
TPA	Tri-Party Agreement (See *Hanford Federal Facility Agreement and Consent Order*)
UST	underground storage tank
VR	volume rate

1.0 INTRODUCTION

Numerous technologies have been identified for retrieving the various single-shell tank (SST) waste types. The current baseline technology for the retrieval of SST waste is "past practice sluicing." This technique has been used successfully at the Hanford Site to retrieve sludge wastes from SSTs, including the recently completed retrieval of waste from 241-C-106. Tank S-102 predominantly contains salt-cake waste in which a dissolution technology (fluidic mixing) will be employed. In addition to evaluating SST retrieval technologies for their recovery capability and feasibility, the associated waste retrieval strategies and equipment must also integrate the means to detect, monitor, and mitigate any resultant leaks that could potentially occur during the waste retrieval process. Fluidic mixing retrieval introduces additional liquids into the tank that could potentially increase the risk of leakage to the environment. Consequently, dissolution may not be an appropriate retrieval technology for some SSTs that have or are suspected to have leaked in the past. Nevertheless, fluidic mixing is considered one of the primary tools available to support the River Protection Project's (RPP) waste retrieval objectives.

This report focuses on identification and evaluation of LDMM concepts suitable for use with fluidic-based SST waste retrieval systems. More specifically, the report addresses LDMM concepts appropriate for integration with the fluidic-based retrieval systems proposed for the recovery of salt cake and sludge waste from 241-S-102.

The environmental and programmatic risks posed by different retrieval technologies, tanks, and tank constituents vary significantly. To develop and implement a consistent and reasonable LDMM design concept, a risk-based approach to the development of the quantitative requirements has been employed. This risk-based approach utilizes the information in the Retrieval Performance Evaluation (RPE) for selection of tank criteria, and evaluates the employment of current best available technology (CBAT) economically achievable versus waiting for alternative ideas/technology to be developed and implemented. The risk associated with "doing nothing" has to be weighed against the use of the CBAT, even if that technology cannot meet the risk curves in the RPE.

1.1 Background

The 241-S-102 retrieval release protection strategy is based on the "*Proposed Strategy for Leak Detection, Monitoring, and Mitigation During Hanford Single-Shell Tank Waste Retrieval,*" first presented in 1996 (WHC 1996a) and updated in 1999 and 2000. This strategy includes two strategic concepts for retrieval-related LDMM activities. The first strategic concept is that design and development of LDMM provisions should be completely integrated into the design and development of the SST waste retrieval technologies. The second strategic concept is that the RPE methodology, which includes consideration of environmental risk resulting from potential tank leakage during retrieval operations, should be used to develop tank-by-tank SST closure source terms. This information, in turn, could be used as a basis for developing a minimum LDMM system performance requirement and for development of retrieval release response actions. This LDMM strategy was presented to the State of Washington Department of

Ecology in 1999, and was subsequently incorporated into the legally binding requirements of the Tri-Party Agreement (TPA) (Ecology 1999).

1.2 Scope

This report documents the process used to develop and implement a LDMM design concept for fluidic-based retrieval systems, and more specifically, for the retrieval of salt-cake waste from 241-S-102. The evaluation of LDMM methods and particular applications presented in this report are specific to the strategy to be employed on 241-S-102. The process used, however, has been developed adequately for application to any Hanford SST retrieval. The outputs resulting from the process include a preliminary operational strategy; preliminary leak detection, leak monitoring, and leak mitigation strategies; and preliminary equipment and ancillary components required for implementation. Key issues and uncertainties requiring resolution or further consideration during latter project phases are also identified.

This report includes an analysis of the applicable regulatory requirements associated with LDMM for SST retrieval. These regulations drive the functions and requirements for LDMM and how they relate to development of the risk-based retrieval release protection strategy and the RPE process.

LDMM will play a key role in determining the operational strategy for retrieving tank waste, particularly using fluidic-based technologies. The overall LDMM strategy will consist of three elements: (1) minimizing the tank liquid inventory and total campaign duration during retrieval operations, (2) monitoring liquid inventories and testing for the possibility of a large sudden (catastrophic) release while waste is actively being retrieved, and (3) testing the tank for the presence of a leak that may have environmental consequences, if it were to occur at any time during the retrieval campaign.

1.3 Purpose

The purpose of this report is to develop and implement a process for selecting and developing preferred LDMM alternatives and design concepts that can be used when retrieving waste from any SST using fluidic-based technologies. The process is then utilized to develop the LDMM design concept for 241-S-102 based on the preliminary design proposed for fluidic-based retrieval of 241-S-102. The main emphasis of this work is to link the LDMM system design and strategy development directly to the retrieval technology selection, recovery tank, and tank waste properties.

2.0 LDMM HISTORICAL BASIS

Based on work documented over much of the past decade, it has been determined that while there are many possible methods to detect leaks in underground storage tanks (USTs), the number of methods currently available or that can be readily implemented for the SSTs are limited. In 1998, a review of the previous LDMM investigations and new information regarding LDMM technologies applicable to SST retrieval (LMHC 1998) recommended the use of in-tank volumetric methods and external methods for leak detection.

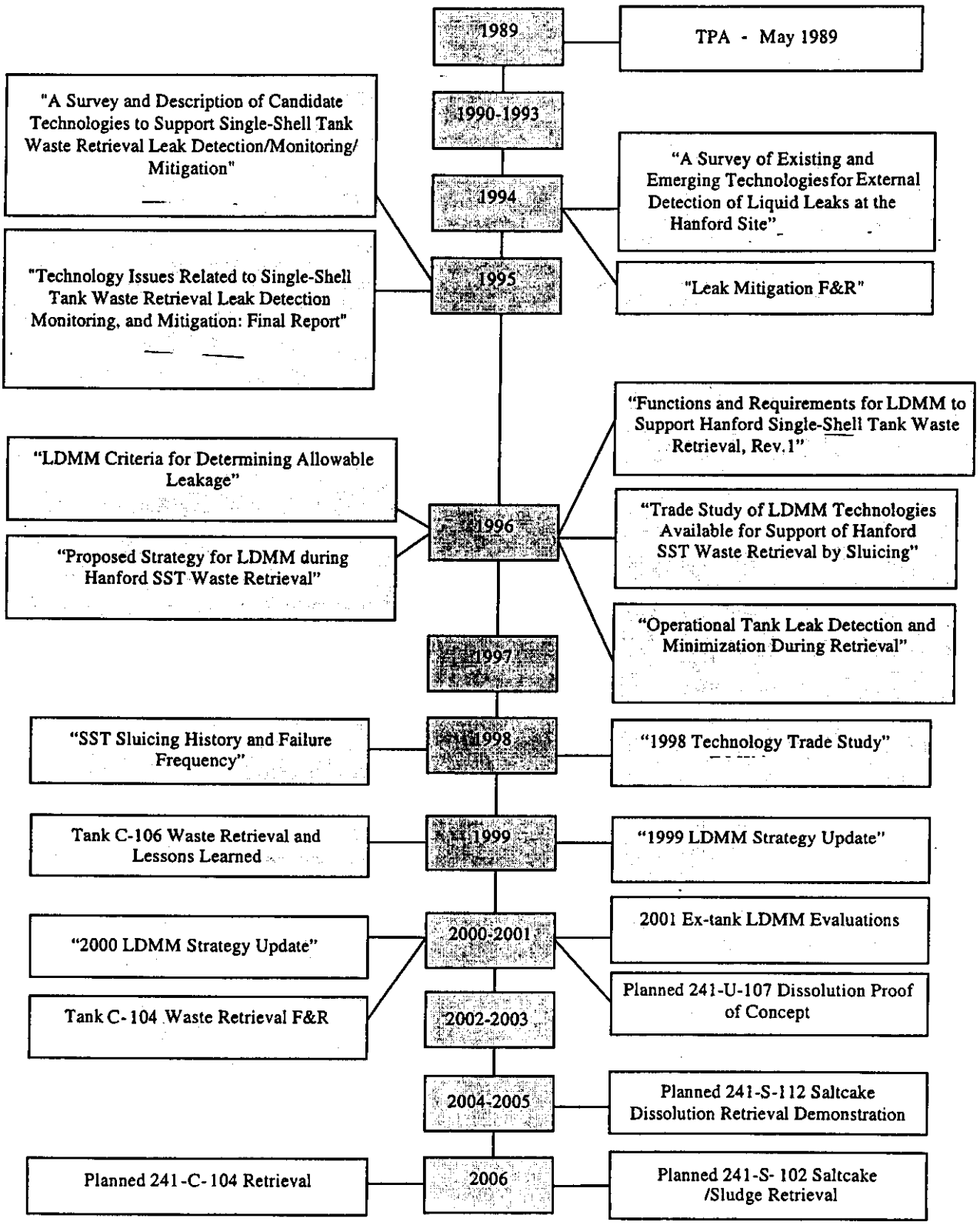
Volumetric technologies, which can include adaptation of elements of the mass-based technology, were recommended for leak detection because of the advantages they have over other technologies. These advantages include deployment readiness, technology maturity, performance, successful application in industry and at other DOE sites, the ability to evaluate the performance of the system, and life-cycle cost.

In 1999 and 2000, an update of the SST retrieval LDMM strategy repeated the recommendations from the 1998 study and incorporated the Retrieval Release Protection Strategy (LMHC 1999). The updated LDMM strategy has provided a path forward for testing and evaluating LDMM methodologies as a basis for conceptual design and integration with retrieval technologies.

During fiscal year 2001, several external tank LDMM technologies (i.e. technologies designed to detect leaks outside the SST) are being evaluated to determine their applicability and appropriateness for use in the SST system. The preliminary results of these evaluations are expected early in fiscal year 2002. The results of that evaluation will be distributed as they become available.

Figure 2-1, "LDMM Timeline," shows a timeline of key documents and major LDMM program events. These documents have been developed over the life of the RPP, formerly the Tank Waste Remediation System, in response to the M-45 series of milestones included in the TPA.

Figure 2-1 LDMM Timeline.



3.0 LDMM FUNCTIONS AND REQUIREMENTS

Functions and requirements (F&R) including and beyond those identified in regulations have been presented for SST waste retrieval in a number of documents, including the Level 2 specification for the *241-S-102 Waste Retrieval System* (RPP-7512), technical reports, and the *Retrieval Release Protection Strategy* (DOE/RL-98-72). In the 1999, *LDMM Strategy Update* (LMHC 1999), a risk-based approach was established for the LDMM strategy deployment. This approach sets risk-based thresholds for release response criteria that determine the LDMM approach and operational response for detected leaks. A clear understanding of the performance, operational requirements, and capabilities of viable technologies to detect, monitor, and mitigate potential leakage during retrieval operations can be used to develop retrieval and closure action plans for each SST. Changes in LDMM functions resulting from programmatic maturation has redefined the system functional definitions. The following sections encompass the current and applicable functions and requirements on which design concepts in this document have been developed.

3.1 LDMM Functions

LDMM functions applicable to all SST retrievals have previously been defined in the 1996 report, *Functions and Requirements for Hanford Single-Shell Tank Leakage Detection and Monitoring* (WHC 1996a). These will not be reiterated here. However, the 241-S-102 retrieval-specific function definitions presented below (RPP-7512) reflect program changes and new information. These were presented in the LDMM annual progress report (RPP-7012):

- Leak Detection: technologies, methods, or systems used to detect a leak.
- Leak Mitigation: technologies, methods, or systems that can reduce a leak, or reduce the environmental impact of a leak.
- Leak Monitoring: technologies, methods, or systems used to quantify liquid waste release volumes from a SST, if a release is detected during waste retrieval operations.

The pre-conceptual LDMM F&Rs are derived from inputs, outputs, interfaces, and constraints associated with each of the SST waste retrieval activities. LDMM-specific functional requirements must support each of the SST waste retrieval system objectives. In the case of the 241-S-102 waste retrieval project, these system objectives include:

- Retrieve a minimum of 99% of the current waste volume to meet the requirement specified in the TPA.
- Retrieve 490 curies of mobile, long-lived isotopes.
- Retrieve as much tank waste as technically possible, with residual tank contents not to exceed 360 cubic feet or to the limits of the retrieval technology capability, whichever is less as a closure goal.

3.2 LDMM Requirements

Using the risk-based graded approach outlined in the Retrieval Release Protection Strategy, the qualitative LDMM functions can be developed into quantitative requirements applicable to the SST waste retrieval effort. Using this risk-based (or graded) approach, the top-level requirement for the retrieval of any tank is as follows.

> **The sum of the risks from various waste volumes, including past leaks, residual waste, and leaks during retrieval shall meet the predetermined Retrieval Performance Evaluation value.**

The RPE is a process that evaluates the impacts of varying the amount of waste that is assumed to leak and the amount of residual waste assumed to remain in the tank. The RPE estimates the short and long-term risks (remediation worker exposure, dose to an intruder at 100 years; and Incremental Lifetime Cancer Risk (ILCR) to a residential farmer or industrial worker over a 10,000 year period.) The goal of the RPE is to identify bounding combinations of leak volume and residual waste volume that fall within the exposure criteria for each scenario. For the intruder, for example, the limit is exposure of 100 mrem/year. For the long-term risk to a residential farmer or industrial worker, the limit is less than 10^{-5} ILCR. The resulting plot of the curve of retrieval release (leakage gallons) vs residual waste (gallons left in the tank) at a constant limiting risk level shows the combinations that would result in meeting the risk criteria. The acceptable combinations can be used to evaluate the effectiveness of LDMM steps. Not shown in the curve is the risk of not retrieving the waste. The risk of not retrieving the waste is much higher than for the retrieval cases.

The risk-based RPE-determined value is a tank-specific function of the waste constituents and tank integrity. Two of the three contributing factors to the RPE-calculated risk values are primarily functions beyond the immediate control of the operator. The first is the past leaks associated with 241-S-Farm. The second is the residual waste volume, which is a function of the retrieval technology, tank configuration, and waste rheological properties. The residual waste volume for salt cake fluidic mixing will be validated with the 241-S-102 retrieval.

The final contributor to risk, leaks during retrieval, is the focus and reason for the development of a LDMM design concept. In the case of 241-S-102, the RPE evaluation has not been completed. The RPE evaluates the potential risks to human health and the environment from waste leakage during retrieval, past leaks, and residual waste remaining in the tanks after retrieval. A comparison of the waste constituents from 241-S-112 and 241-S-102 indicate that the risks will be similar. Therefore, the risk data for 241-S-112 are presented in this document as representative of 241-S-102. As the RPE data for 241-S-102 are evaluated, the data will be incorporated into the LDMM engineering design requirements for the waste retrieval project.

3.2.1 Leak Detection Requirements

From the top-level requirements defined above, the functions and requirements of the leak detection system can be further refined. These leak detection F&Rs are as follows:

1) The system shall be designed to detect and mitigate a total leak loss using the CBAT economically achievable as dictated by the RPE Process and LDMM Strategy.

2) The Leak Detection minimum detection goal will be to detect a loss less than or equal to the retrieval release limit divided by the expected duration of the retrieval campaign. If the release limit is not detectable, Leak Detection equipment will still be used to the best of its ability.

3) The 241-S-102 waste retrieval system shall have a probability of leak detection of greater than 95%.

4) The 241-S-102 waste retrieval system shall have a probability of false alarm less than or equal to 5%.

These last two requirements consider the performance of the leak detection system. These requirements are adapted from U.S. Environmental Protection Agency (EPA) guidance on performance of bulk fuel storage leak detection systems and is intended to reduce the possibilities of false alarms and includes all errors and uncertainties associated with the instruments, means of measurement, and analysis method. (The EPA guidance does not address configurations where there is no free liquid surface.)

3.2.2 Leak Monitoring

Leak monitoring is the quantification of a liquid waste release volume from an SST after detection of a leak during waste retrieval operations. A leak volume estimate must be accurately predicted to quantify the environmental impact resulting from a leak. The leak monitoring F&Rs are as follows:

1) The 241-S-102 waste retrieval system shall quantify liquid waste release volumes from 241-S-102 if a release is detected during waste retrieval operations. The data shall be collected, in the event of a leak, to support a post-retrieval RPE, which will be used to address retrieval of the next S-Farm tank. Data collected will address estimates of the volume and composition of leaked material, as well as the residual waste in the tank.

3.2.3 Leak Mitigation

The primary goal of leak mitigation is to employ a methodology/technology that will minimize the impact of a leak whether it is detected or not. The following requirement identifies an administrative control for implementation of a plan to minimize the risk to the environment and to minimize any potential human health effects.

1) The 241-S-102 waste retrieval system shall mitigate leaks as the primary means of minimizing environmental impact caused by releases during retrieval of SST waste. If a confirmed leak occurs, the release shall be evaluated according to the RPE and the appropriate actions implemented (e.g., immediate pump out or continue retrieval). As the

primary mitigation means, the retrieval pump shall be designed to allow continuous pumping for a sufficient amount of time (to be determined during design) to remove all pumpable liquids from 241-S-102 and the liquid in the tank shall be kept to a minimum at all times.

3.3 Tri-Party Agreement Requirements For LDMM

The TPA is a legally binding document between the EPA, DOE, and Ecology. The TPA was first issued in May 1989 and has been amended to accommodate changes in program direction at the Hanford Site. Among other things, the TPA incorporates the SST retrieval LDMM requirements, identified in Section 5.2, "Retrieval Release Criterion," of this report. LDMM activities are specifically addressed in milestones M-45-08 and M-45-09. The applicable milestones and their target dates (Tri-Party Agreement, 1996 Revision 4) are included in Table 3-1, "Hanford Federal Facility Agreement and Consent Order (Tri-Party Agreement) M-45 Milestones." Revision 4 has been modified and agreed to by the parties involved (Ecology 1999). The proposed changes have moved the LDMM requirements to the M-45-03 Milestones.

Table 3-1 Hanford Federal Facility Agreement and Consent Order (Tri-Party Agreement) M-45 Milestones

Milestone	Description	Required Completion
M-45-00B	Complete "Near Term" SST waste retrieval activities. "Limits of Technology" retrieval demonstrations will seek to improve upon past practice sluicing (PPS) baseline technology including but not limited to retrieval efficiency, leak loss during retrieval, and LDMM.	9/30/2006
M-45-00C	Complete renegotiation of second phase (I.E., 9/30/2006 through 9/30/2015) SST waste retrieval activities. Negotiations shall be designed to establish a sufficient number of agreement milestones and target dates to effectively drive each phase of working including but not limited to: LDMM.	2/28/2004
M-45-03C	Complete full-scale salt-cake waste retrieval technology demonstration at single-shell tank S-112. Waste shall be retrieved to the DST system to the limits of the technology (or technologies) selected. Selected salt-cake retrieval technology (or technologies) must seek to improve upon the past-practice sluicing baseline in the areas of expected retrieval efficiency, leak loss potential, and suitability for use in potentially leaking tanks. This demonstration shall also include the installation and implementation of full-scale LDMM technologies.	9/30/2005
M-45-03-T03	Submit S-112 salt-cake waste retrieval technology demonstration functions and requirements document. This document will establish demonstration system specifications (including LDMM system specifications) and will also include a scooping level retrieval performance evaluation (RPE).	12/30/2001
M-45-03D	Complete S-112 salt-cake waste retrieval technology demonstration design (to include all physical systems including design and operating strategies necessary for LDMM.	5/31/2003
M-45-03E	Complete S-112 salt-cake waste retrieval technology demonstration construction (to include all physical systems including those necessary for LDMM.	9/30/2004
M-45-03F	Complete full-scale sludge/hard heel, confined sluicing and robotic technologies, waste retrieval demonstration at tank C-104. The demonstration shall also include the installation and implementation of full-scale LDMM technologies.	TBE (This milestone shall be established during the parties' M-45-00C negotiations.)
M-45-03-T04	Submit C-104 sludge/hard heel, confined sluicing and robotic technologies, waste retrieval demonstration functions and requirements document. This document will establish demonstration system specifications (including LDMM system specifications) and will also include a scooping level retrieval performance evaluation (RPE).	12/31/2001
M-45-03G	Complete C-104 sludge/hard heel, confined sluicing and robotic technologies, waste retrieval cold demonstration. The full-scale demonstration will be sufficient to support final design and testing of all equipment, including the LDMM approach used in the actual system.	6/30/2004

M-45-03H	Complete C-104 sludge/hard heel, confined sluicing and robotic technologies, waste retrieval demonstration design (to include all physical systems including design and operating strategies necessary for LDMM .	9/30/2004
M-45-03I	Complete C-104 sludge/hard heel, confined sluicing and robotic technologies, waste retrieval demonstration construction (to include all physical systems including those necessary for LDMM.	9/30/2006
M-45-05-T16	Submit S-102 initial waste retrieval functions and requirements document. This document will establish demonstration system specifications (including LDMM system specifications) and will also include a scooping level retrieval performance evaluation (RPE).	10/30/2002
M-45-05B	Complete S-102 initial retrieval project design (to include all physical systems including design and operating strategies necessary for LDMM.	3/31/2004
M-45-05C	Complete S-102 initial retrieval project construction (to include all physical systems including those necessary for LDMM.	11/30/2005
M-45-05-T17	Submit second tank initial waste retrieval functions and requirements document. This document will establish demonstration system specifications (including LDMM system specifications) and will also include a scooping level retrieval performance evaluation (RPE).	4/30/2004
M-45-05E	Complete second tank initial retrieval project design (to include all physical systems including design and operating strategies necessary for LDMM.	6/30/2006
M-45-05F	Complete second initial retrieval project construction (to include all physical systems including those necessary for LDMM.	TBE (Specific tank identification and this milestone date shall be established no later than 12/31/02.)
M-45-08-T02	Establish the criteria through stakeholder participation and Ecology approval for: (1) determining allowable leakage volumes, and (2) acceptable leak monitoring/detection and mitigation measures necessary to permit sluicing operations	4/30/1997 Submitted, but not accepted
M-45-09*E*	Submit annual progress report on the development of waste tank leak monitoring/detection and mitigation activities in support of M-45-08. Reports will provide a description of work accomplished under M-45-08, technologies, applications, cost, schedule, and technical data. Reports will also evaluate demonstrations performed by DOE and private industry for applicability to SST retrieval and provide recommendations for further testing for use in retrieval operations.	9/30/2000 (Complete – "A" through "E" (1996-2000))

4.0 LDMM STRATEGY

In 1996, an LDMM strategy was submitted to Ecology and stakeholders for review (WHC 1996a). The 1996 strategy proposed "allowable" or "potential" leak volumes based on constituents of concern. In effect, these volumes become another set of requirements for the LDMM system to take into consideration based on the performance (risk) of the residuals and leaks as determined by the RPE process.

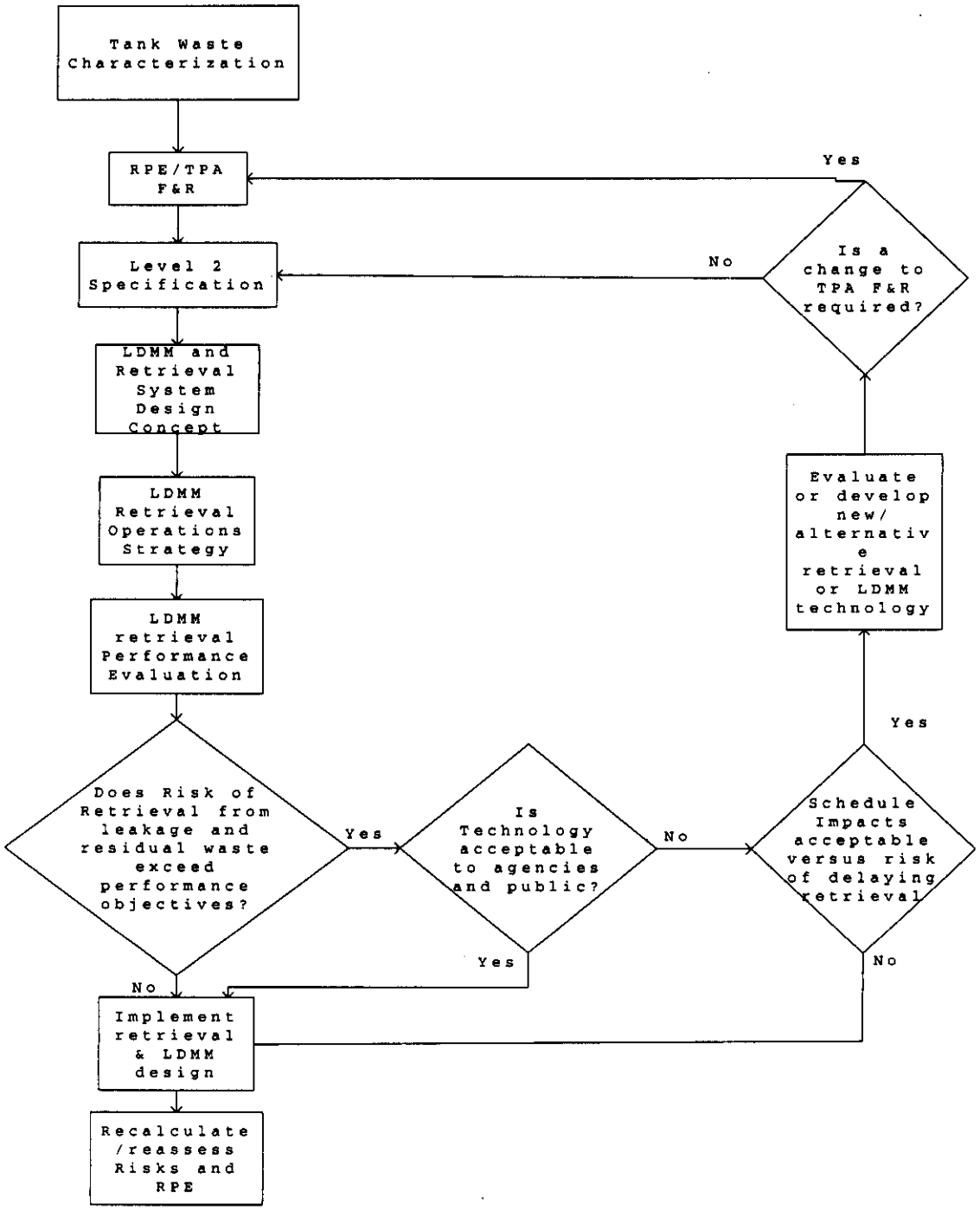
The 241-AX Farm RPE (DOE/RL-98-72) was completed in 1999 following extensive agency, stakeholder and Tribal Nation involvement. Comments received on the draft and final report from agency staff, the Vadose Zone Expert Panel, and Tribal Nations indicated wide acceptance of the methodology as a starting point for establishing tank-by-tank performance criteria for leaks caused by retrieval technologies. It was acknowledged in the report that additional information was required before final criteria could be established for each SST. This additional information included (1) evaluation of tank-specific releases within the context of the entire tank farm and other 200 Area waste sites; (2) establishment of final closure criteria for the tank farms, which would set cleanup standards for past releases and retrieval losses; and (3) additional information on past releases, retrieval technologies, and leak detection capabilities.

Following completion of the 241-AX Farm RPE, the 1999 LDMM Strategy Update (LMHC 1999) was issued. The 1999 LDMM document developed the concept of the Retrieval Release Protection Strategy. The strategy is based on the RPE methodology and used to develop a tank specific risks vs. assumed leakage and residual waste volumes. The volumes are used to develop minimum LDMM system performance goals for each tank.

The minimum LDMM system performance goal is then used to direct the LDMM method selection and operation strategy, and develop release response actions for use during retrieval operations. This Retrieval Release Protection Strategy to LDMM allows for a tank specific LDMM strategy to be developed based the history of each tank and upon the associated release response criterion developed. Tank S-102 release rate criteria as defined on the risk curves, is well below current technology detection range that will be employed by waste retrieval activities. An alternative strategy has been developed that evaluates at the risk of leaving waste in the tank versus removing the waste. Leaving the waste in the tank until better or more advanced technology can be developed, tested, and implemented increases the risk of a leak that may be undetected until a major amount of tank waste (containing CoCs) has been released. This risk will be weighed against the risk of removing the waste using CBAT currently proposed for the waste retrieval activity.

If new technology becomes available during the process of design preparation and review the project will evaluate the impacts to the schedule and determine the risk involved to initiate a change to the current design. The process developed for determining the tank specific LDMM strategy is contained in Figure 4-1. Each of the parameters used in this strategy, as well as the quantification of the values for 241-S-102, are discussed briefly in the following subsections.

Figure 4-1 LDMM Strategy Development by Waste Classification.



4.1 SST Closure Risk

The first step in developing the leak detection strategy is to compute the SST risk for closure using the RPE risk model methodology and to select one or more potential retrieval methods. The residual waste volume, assumed leak volume, and retrieval technology selection are

tank-specific functions of the waste's constituents and rheological properties, respectively. To compute the RPE closure source term, the tank history, waste type, and inventory are gathered through review of the Best Basis Inventory (BBI), historical leak estimates, and other historical information.

The RPE closure source term methodology that will be used to establish tank-by-tank LDMM requirements is composed of three components.

Retrieval Activity Source Term =
Past Leaks Inventory + Residual Waste Inventory + Retrieval Release Inventory

Source terms can be expressed in units of volume, radiation dose, and risk. The resulting risk is typically expressed in units of incremental lifetime cancer risk (ILCR) to a maximally exposed individual under various scenarios. The current RPE calculates ILCR for a peak industrial worker scenario, a residential farmer scenario, and an intruder scenario (intrusion after 100 years) during the next 10,000 years. The Washington State long-term human health risk standard for cancer risk is 1.0×10^{-5} ILCR.

A preliminary analysis has been completed for 241-S-112. A comparison of the waste constituents from 241-S-112 and 241-S-102 indicate that the risks will be similar and that the relationship and magnitude of the residual waste risk and release risk should be similar.

Retrieval releases are leaks caused during retrieval operations. Retrieval releases will be controlled by the LDMM capabilities associated with the specific retrieval technology, tank condition, and retrieval application.

When the S farm RPE is completed a Retrieval Release Risk (RRR), and associated volume, can be calculated for 241-S-102 from the maximum S-Farm closure source term risk. Currently the past leak risk is not included in the scoping RPE.

Retrieval Activity Risk = Past Leaks Risk + Residual Waste Risk + Retrieval Release Risk

The RRR is calculated by performing dividing the state allowable risk limit by the number of tanks that will contribute to the receptor's (e.g. farmer or worker) risk and determining the allotment of risk that this tank in the farm is able to contribute to the total farm closure source term. For S-farm the number of contributing tanks is set at 3 and the allowable retrieval release risk is determined with the following equation.

$$RRR = (1.00 \times 10^{-5} / 3 \text{ tanks}) - (\text{Past leak Risk}) - (\text{Residual Waste Risk})$$

4.2 Retrieval Release Criterion

The RRR is based on the SST Retrieval Demonstration source term as calculated above. The RRR is converted to a volume expressed as the Retrieval Release Criterion (RRC) by performing the following equation.

RRC =(ILCR) ÷ Risk per retrieval release gallon (ILCR/gal)

In the case of 241-S-102, the RPE evaluation has not been completed. However as an example, the 241-S-112 RRC as a function of residual waste for several scenarios is shown in Figure 4-2.

Figure 4-2 presents the relationship between the residual waste and the potential leak volume for three risk scenarios for 241-S-112, resulting in the risk curves illustrated below. A comparison of the waste constituents from 241-S-112 and 241-S-102 indicate that the risk curves will be similar and that the relationship and magnitude of the residual waste and release criterion should be similar. Therefore, the risk curves for 241-S-112 are presented and are representative of the curves for 241-S-102.

Figure 4-2 Risk Curves for Tank S-112 (Representative of Tank S-102).

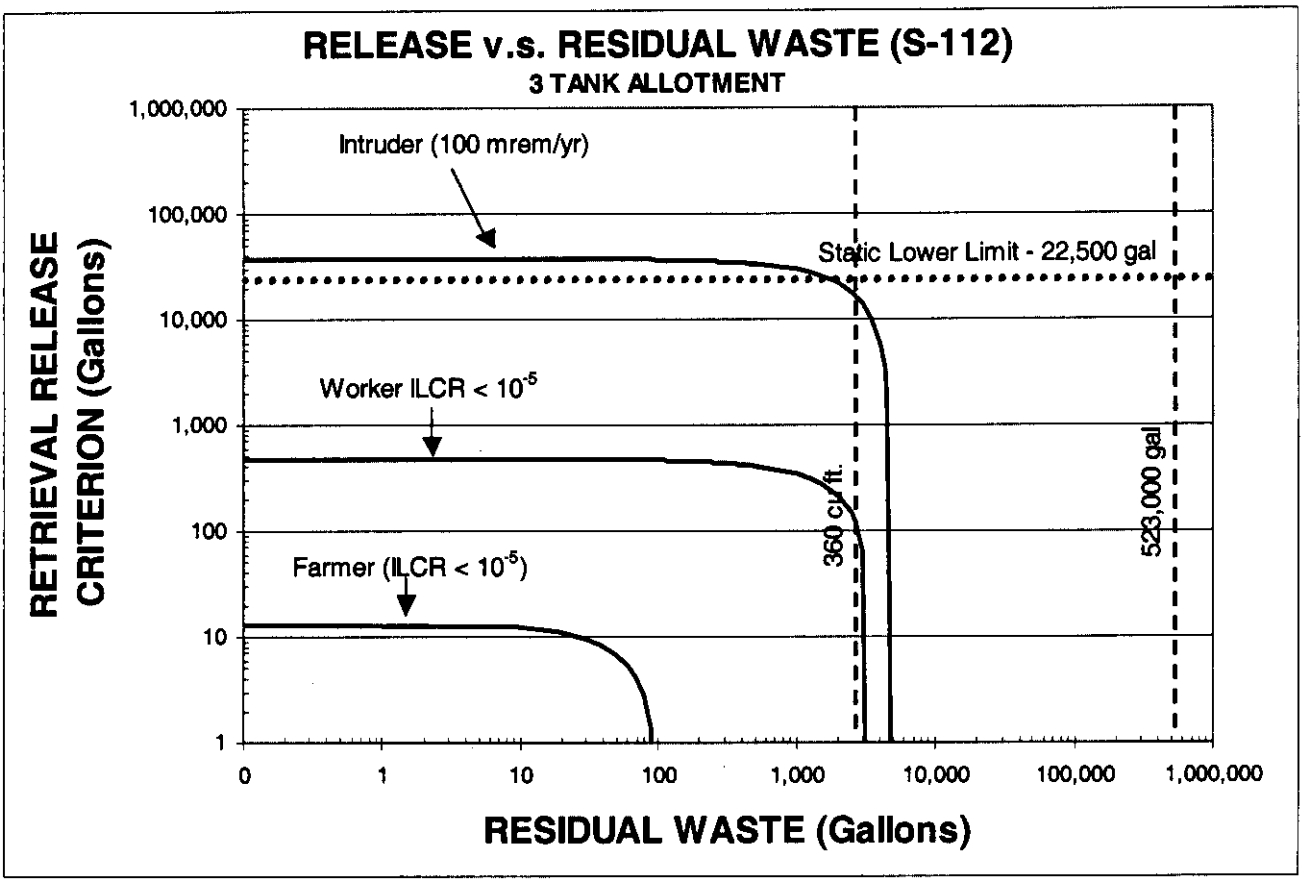
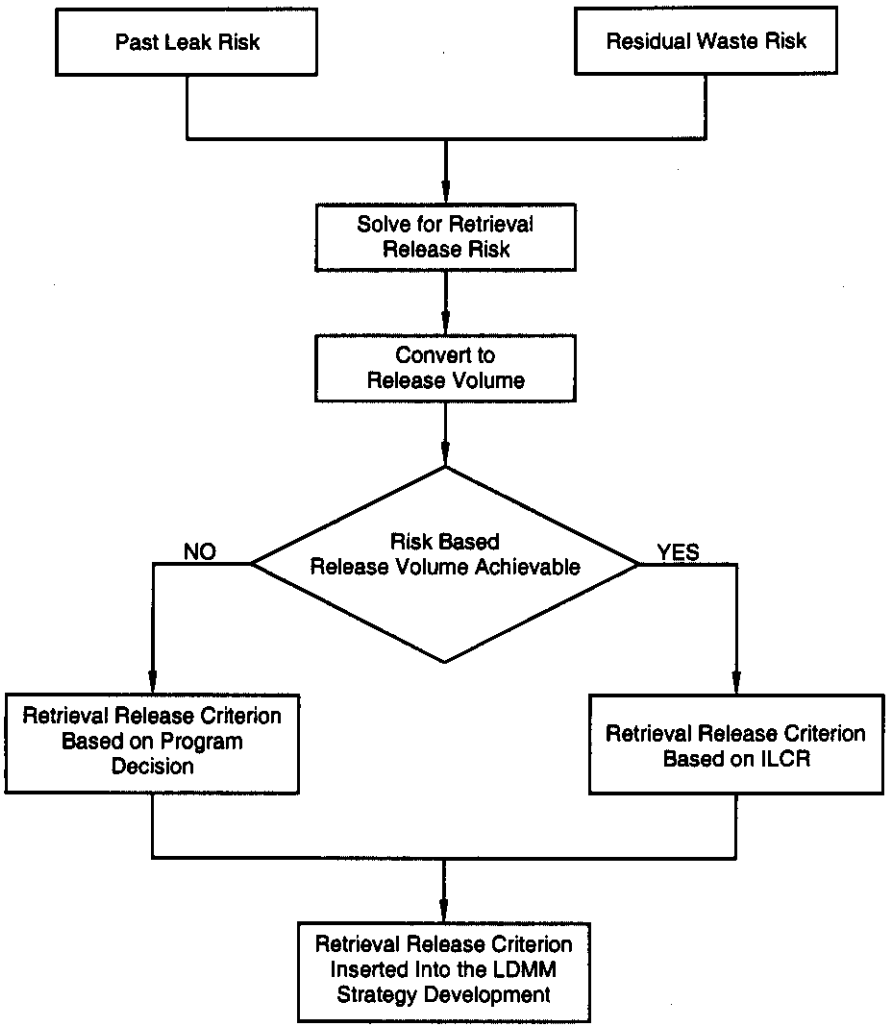


Figure 4-3 RPE Determination of Retrieval Release Criterion.



The RRC (programmatic or risk based) and the anticipated residual waste at the end of the retrieval campaign are then used to develop tank-specific LDMM requirement (i.e., the operational performance) for the leak detection method to be selected for use in the retrieval operations. This process is shown in Figure 4-3. The tank-specific LDMM performance requirement for the selected leak detection method is defined in terms of a minimum performance requirement in gph with a P_D of 95%, and a P_{FA} that is no greater than 5%. The selection of the minimum performance requirement and the P_{FA} is an interactive process, because it is closely tied to the expected total duration of the retrieval campaign, the operational strategy for use of the retrieval method, as well as the programmatic, safety, and environmental risks.

If the most conservative risk scenario is used to establish the release criterion (Farmer risk scenario), the LDMM strategy must mitigate leaks to below 15 gallons with a corresponding retrieval efficiency of 100%. This is unrealistic performance for both the retrieval system and the leak detection system because technology currently used in the field cannot achieve these goals. In light of the risks associated with a leak during retrieval, the risk of doing nothing and leaving the waste in the tank until a future date must be examined. If the risk of the retrieving

the tank is compared to the risk of not receiving the tank, preliminary analysis shows a two orders of magnitude reduction in the incremental lifetime cancer risk. This two orders of magnitude risk reduction provides incentive to retrieve the tank even though the 15 gallon release criterion cannot be assured, especially in light of the age of the SSTs and their design life.

4.3 Release Response Actions

The primary strategy for mitigation is a retrieval technology that limits the liquid volume and accelerates retrieval. The back up strategy for mitigation is to evaluate techniques to reduce contaminant migration.

In the event a release is detected, a total projected release volume will be calculated based on the release rate that is detected. Table 4-1 presents a graded approach to release response actions for any specified SST. Retrieval release responses for a specific tank should be calculated before retrieval begins. Leak detection technologies that provide appropriate resolution (detection accuracy) can be deployed if available. If the LDMM-required resolution cannot be achieved, the use of alternate retrieval technologies must be evaluated.

Table 4-1 Tank S-102 Retrieval Release Criterion Response Actions.

Detected Retrieval Release (gal)	Total Source Term	Increased MEI-ILCR at POC	Example Operational Response
0	<< RPE	Low	Continue Retrieval – No additional actions
<LCO	< RPE	Moderate	Continue Retrieval – Increase monitoring frequency
>LCO	<RPE	Moderate	Suspend Retrieval – Remove free liquids, re-evaluate retrieval strategy
>RRC	> RPE	High	Emergency Shutdown – Remove free liquids, re-evaluate retrieval strategy

ILCR = Incremental Lifetime Cancer Risk
LCO = limiting condition of operation
MEI-ILCR = maximally exposed individual-incremental lifetime cancer risk
POC = point of compliance
RPE = Retrieval Performance Evaluation
RRC = retrieval release risk

The application of operating responses consistent with the LDMM risk-based approach and the Hanford Site safety limit implementation can be used. The Limiting Condition of Operation (LCO) is set at a value equal to, or less then, the RRC. If a leak is detected or suspecting with a potential leak volume approaching the Limiting Condition of Operation, operations are suspended and secured in a "safe shut-down" manner. If the leak or suspected leak is determined to be less than the LCO, operations are continued after re-evaluating the LDMM strategy, method, monitoring frequency and duration. For a detected or suspected leak greater then the LCO, operations are immediately secured in a "safe shut-down" manner. This projected release volume will then be included in the closure source-term calculation, the potential ILCR will be calculated, and an appropriate operations response will be initiated based on the ILCR at the

point of compliance. For tanks where the past leaks and residual waste exceed the established criteria for the ILCR, tank-specific operational responses will have to be negotiated using a similar methodology following a tank-specific closure evaluation.

5.0 LDMM ALTERNATIVES

The alternatives for fulfilling the leak detection, and leak monitoring, and leak mitigation functions are described below with the preferred alternative described in the following section.

5.1 Leak Detection Design Concept

The overall strategy for leak detection is; 1) test the tank frequently for the possibility of a sudden release while waste is actively being retrieved, and 2) test the tank at appropriate intervals during the retrieval campaign for the presence of a leak that might exceed the limits based on LDMM Retrieval Release Protection Strategy. An understanding of the performance of the leak detection method is important because it will determine whether or not the risk-based leak detection requirements are met and how to successfully meet them (e.g., by the type and number of tests to be conducted or the combination of the number of in-tank parameters measured and frequency of measurement/testing).

The most successful and robust leak detection technologies are those that have been developed and demonstrated in tanks at the Hanford Site or other DOE sites, those used in other industries that can be adapted to the Hanford Site SSTs, or those new technologies that are emerging as a direct result of the Hanford Site's unique requirements. The leak detection technologies that were compared and evaluated for applicability to the Hanford Site include internal (or in-tank) methods of leak detection (implemented inside a tank to test that tank), and external (or ex-tank) methods of leak detection (test for the presence of a release outside of the tank).

The leak detection and monitoring technologies considered in this report include both internal and external methods.

In-tank Methods

- Volumetric inventory balance (catastrophic leak detection), and
- Volumetric precision (precision leak detection)

Ex-tank Methods

- Dry well monitoring before, during, and after retrieval
- Experimental technologies under development.

The current drywell leak detection used to identify leaking SSTs will continue to be employed as a secondary leak detection system. The systems are in place and, while monitoring wells are not generally considered a highly accurate leak detection method, they should be included as part of the leak detection program. Radiation detected in a drywell can be difficult to interpret. The

lack of contamination might mean only that a release has not migrated to the well. The presence of contamination could be attributed to migration of existing contamination or contamination from another tank or pipe other than the one being considered. Thus, this methodology should not be the primary method of leak detection. However, even with interpretation difficulties, periodic samples obtained in existing wells before, during, and after retrieval operations are recommended. When used in conjunction with other leak detection systems, they can be very helpful in assessing the existence and extent of a leak.

5.1.1 In-Tank Methods

Volumetric inventory balance techniques (catastrophic leak detection) require that the volume of liquid that flows into the tank must be equal to the volume of liquid that flows out of the tank plus the volume of liquid that is stored in the tank if no leak is present. These techniques require level measurements in the tank and flow meter measurements in the inlet and outlet transfer piping. This simple inventory balance can be improved dramatically by developing and implementing noise compensation algorithms. This improved methodology is known as statistical inventory reconciliation (SIR). The SIR techniques may detect releases approaching those detected by static precision volumetric systems. More recently, SIR techniques have reduced the duration of a test from 30 days to 1 or 2 days without sacrificing performance in petroleum tanks. This technique, however, has not been evaluated for the Hanford Site SSTs.

The main criterion for successful implementation of a volumetric methodology for leak detection is the presence of a measurable liquid level in the tank before and during operation. Leak detection is accomplished by calculating the change of volume over time and comparing the volume rate (VR) to a pre-determined "leak-detection threshold" to determine whether the tank has an inflow or an outflow, or that the tank is not leaking. This method requires the development and implementation of noise compensation algorithms to account for non-leak-related volume changes (e.g., evaporation and condensation, thermal expansion and contraction of the waste, instrumentation, the tank, and its appurtenances).

This method requires testing a measurement of liquid level in the SST that would decrease with the presence of a leak from the tank and increase or decrease with other volume changes in the tank not related to a leak. Unlike inventory-based methods, a high degree of precision when making level measurements is required for accurate test results. The less precise the measurement, the longer the test must be. If a free surface exists in the tank, then implementation of this methodology is straightforward. When the liquid level interface is below the surface of the solid materials in the tank, this methodology becomes more challenging and requires a measurement of the interstitial liquid level.

5.1.2 Ex-Tank Methods

Ex-tank leak detection methods are placed outside the tank to detect a leak. There are single point ex-tank leak detection systems like neutron probes, and there are volumetric sweeping leak detection methods like the partitioning tracer method that sweeps a gas in the strata below the tank and identifies leaks. A sweeping type of ex-tank method is preferred because of its ability to detect a leak in the center of a 75-ft. diameter tank without having to place an instrument

there. Table 5-1 lists ex-tank methods being tested and developed. One of these technologies may be used in addition to the favored in-tank volumetric leak detection methods as an alternative external method to verify the existence of a leak if one is detected, or may serve as the primary method for leak detection if one of the volumetric methods cannot be satisfactorily implemented. The existing monitoring wells should be integrated as part of the overall approach to LDMM.

Table 5-1 Ex-Tank Leak Detection Methods.

Method	Application	Properties Measured/Derived	Resolution	Status
Neutron-Neutron	Moisture content, porosity (saturated), identification of aquitards, lithology	Hydrogen concentration	≤10cm	Provides precise measure of hydrogen concentration. Multiple detector systems are borehole compensated. Epithermal systems are less affected by lithologic variation than thermal systems.
Electrical Resistivity Tomography	Monitor changes in bulk resistivity	DC electrical resistivity	≥ 1m	Continuous monitoring of resistivity in either a plane of a volume. Requires the installation of a series of electrodes in at least two monitoring wells. Now commercially available.
Crosshole Radar	Moisture distribution, lithology, soil disturbances, buried materials	Dielectric permittivity	5-60cm depending on frequency	Depth of penetration may be quite limited (<30cm) if formation is electrically conductive; it can be as high as 9m in nonconductive formations. Measures continuous vertical profile. Interpretation may be difficult in complex situations
Crosshole Electromagnetic Induction	Moisture distribution, identification of shallow contaminant plumes, lithology through steel casing	Electrical conductivity, Dielectric permittivity	1.5 to >4.5m	Measurements can be made rapidly. Depth of investigation is 1-60 m. Sensitive to signal interference from transmission lines. Can measure continuous profiles.
High-Resolution Resistivity	Moisture, lithology, geologic structure, buried materials, identification of shallow contaminant plumes	DC electrical resistivity	>1m	Rapid measurements. Can measure continuous profiles to a depth of –60 m. Sensitive to signal interference from transmission lines. Improved data acquisition and incorporation of topography into volume calculations.
Time Domain Reflectrometry	Monitoring flow and transport, lithology	Dielectric permittivity, Electrical conductivity	≥2cm depending on probe length	Capable of providing continuous measurement. Limited depth of investigation. Traditional probes may not operate effectively in saline waters. Requires direct contact with formation

Method	Application	Properties Measured/Derived	Resolution	Status
Inoculation Tracer	Leaks in single-wall USTs and transfer piping	Chemical constituents or properties of the liquid in the tank (e.g., radioactivity or specific type of emission), or unique chemical or other type of tracer material added to the tank contents (e.g., halogen compounds).	≥10m	Capable of providing continuous measurement. May require establishing steady-state flow stream under the tank.
Partitioning inter-well tracer test method (PITT)	Locate and quantify hazardous substances that were released to the subsurface, potential application to detect and quantify releases of aqueous solutions from tanks	Retardation factor for the partitioning tracer.	≥20m	Capable of providing continuous measurement and can quantify leak volume. May require establishing steady-state flow stream under the tank.

5.2 Leak Monitoring Design Concepts

If a release were to occur during retrieval, the leak monitoring function is for quantification of the volume of a release. Leak monitoring will currently use the leak detection techniques to determine the leak rate and postulate the earliest time that a leak of the detected size occurred based on monitoring frequency and calculate the released volume. As the fiscal year (FY) 2001 ex-tank leak detection testing is completed, the results of that analysis will be included in the leak monitoring concept.

5.3 Leak Mitigation Design Concepts

Leak mitigation is the primary means of minimizing environmental impact caused by releases during retrieval of SST waste. By designing retrieval systems with leak mitigation concepts, such as reducing the amount of free (drainable) liquids and optimizing retrieval system response time, leaks can be minimized.

The two leak mitigation technologies recommended for further consideration in the 1998 technology trade study update (LMHC 1998) are (1) auxiliary pump and (2) inherent liquid minimization. A third leak mitigation strategy was developed for salt cake fluidic mixing — minimization of campaign duration.

All three of these technologies essentially reduce the "free" leakable liquid in an SST during retrieval either via reduction of liquid required for retrieval, or via the time that an undetected leak may escape to the environment.

6.0 PREFERRED ALTERNATIVES FOR TANK 241-S-102

The LDMM strategy for 241-S-102 is intended to be a combined approach, using leak detection, leak monitoring, and leak mitigation to reduce the risk to human health and the environment from retrieval leak loss. However, leak detection and leak monitoring using the currently CBAT require a free liquid surface within the tank to accurately measure liquid volumes. The retrieval technology selected for the 241-S-102 is designed to minimize the liquid volume and may not provide a free surface.

The retrieval and LDMM strategy relies on minimizing the retrieval duration to reduce the overall risk to human health and the environment. In addition to using the best proven and available technology for leak detection and leak monitoring, leak mitigation is strengthened by this reduction in the retrieval duration, which reduces the time available for leakage to occur.

6.1 Preferred Leak Detection Technologies

The preferred in-tank and ex-tank leak detection methodologies are described in the following sections.

6.1.1 In-Tank Methods

Leak detection is easily employed on the existing transfer lines, new transfer lines, and the receiving DST itself. Leak detection in the receiving DST will be performed primarily with the existing annulus leak detection. Unlike an SST, a DST has redundant protection against leakage (secondary encasement), which allows for using direct forms of leak detection, i.e., conductivity probes. The existing transfer lines and receiving DST are encased and the encasement on each leg of the transfer route will terminate inside of a pit. A conductivity probe will be placed beneath each low point pit drain to monitor for overflowing leaks in the primary line.

Preliminary design calls for an over-ground transfer line. This will allow leak detection to be installed during the construction phase. Leak detection will utilize conductivity probes at all low points along the transfer line.

A second alternative for transfer line leak detection is to perform a volumetric/mass balance. Flow meters placed at the inlet and outlet of the lines can be compared continuously for discrepancies greater than the anticipated measurement error.

The LDMM strategy for the SST focuses heavily on mitigation of the potential for and consequences of a leak and use of accepted and available methods of leak detection. These accepted and available methods include monitoring liquid and waste inventories while waste is actively being retrieved (i.e., dynamic testing) and when operations are temporarily suspended (i.e., static testing).

The 241-S-Farm RPE will establish a leak detection goal for 241-S-102. Based on industry experience for large volume tanks and the anticipated retrieval duration, at the most extreme estimate (lowest probability of succeeding), and with the presence of a free liquid surface, static testing has a projected capability to detect a leak as small as 2,400 gallons over the retrieval campaign. However, the fluidic retrieval system deployed in 241-S-102 may not produce a free liquid surface that can be accessed by leak detection instruments as the tank will be retrieved from the bottom up, the available liquid surface may not be beneath a riser often enough, and the salt may collapse on the cone created during retrieval. For the purpose of risk reduction, the liquid inventory will not be increased solely for improved detection capabilities. The increased liquid inventory required to produce a free liquid surface imposes a greater potential leak volume and is contrary to the strategy of mitigating the risks associated with a release event. Static and dynamic leak detection methods are described in the following sub-sections.

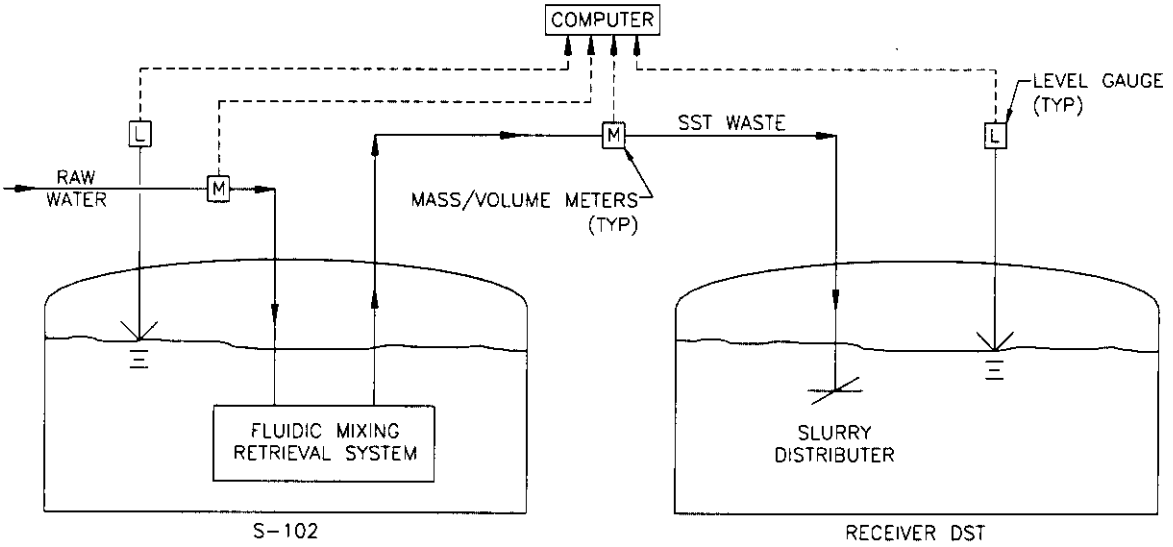
<u>Volumetric Inventory Balance (Dynamic)</u>

The volumetric inventory balance method uses level instruments in the retrieval and receiver tanks along with flow meters to continuously balance the flow in and flow out of the retrieval tank. It is important to note that this technique has not been evaluated for SSTs and that the system evaluation should be completed prior to the completion of definitive design to understand the complexities of waste solubility and evaporation combined with the system scaling issues in a 75-ft-diameter SST. The advantage of this technology is that it provides a continuous online measurement. This technique will be sensitive to a number of environmental and operational interferences, and require compensation for those interferences to achieve acceptable

performance levels. Evaluation of this technique for SST retrieval will be compared to the forthcoming RPE results and the LDMM design concept modified as required.

Dynamic leak detection will be implemented during waste retrieval operations. It will consist of liquid waste level measurements, including measurements required to compensate for short term variations in the measurement signals, in both 241-S-102 and the DST receiver tank. In addition, flow measurements will be made in both the transfer piping and raw water lines going into and out of 241-S-102 and into the DST. This will allow static leak tests to be performed as well as the dynamic estimates based on transferred volumes. A schematic of a dynamic leak detection system is shown if Figure 6-1.

Figure 6-1 Tank S-102 Dynamic Leak Detection
(Based on Mass/Volumetric Flow & Tank Liquid Level)

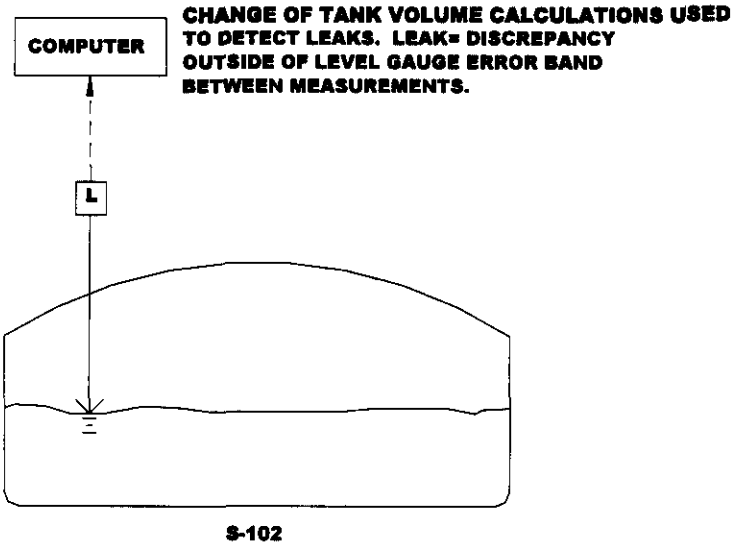


For dynamic leak detection, the retrieval system will be treated like a closed loop system consisting of the recovery tank, 241-S-102, the receiving tank, a DST, and the connecting transfer lines. Solids loading and specific gravity may be measured and used to compensate/reconcile the recovery volume. The discrepancy between the inflow and outflow from 241-S-102 will be compared to the volume in the DST (converted from surface level measurements) and the transfer line. Any discrepancy greater than the uncertainties in the volume calculations and estimates of 241-S-102 liquid inventory, including the error produced by all compensating measurements (thermal expansion, dissolution, solids loading, etc.) will be considered a leak in 241-S-102. This assumes that no leak is detected in the transfer line(s) or the DST. This assumption will be verified during the actual retrieval operations.

Volumetric (Static)

Volumetric methods use direct measurement (e.g., surface level) or indirect measurement (e.g., differential pressure) to establish the liquid volume data from the known tank parameters. Leak detection is accomplished by calculating the rate of volume change over time and comparing this rate to a pre-determined "leak detection threshold" to determine whether the tank has an inflow, an outflow, or that the tank is "tight." Direct level-sensing instrumentation such as the ENRAF™ and FIC™ gauges are currently used in SSTs with a continuous liquid surface and are well suited for the volumetric method in tanks with a measurable air-liquid interface. A schematic of a static leak detection system is shown in Figure 6-2.

Figure 6-2 Tank S-102 Static Leak Detection
(Based on Changes in Tank Liquid Level Only)



A static leak test will require that all retrieval operations be suspended for a period of time to allow the system to reach equilibrium and to conduct the leak detection test. Static leak detection is comprised of liquid waste level measurements in the SST being retrieved, as well as measurement of other liquid collection or dispersion points.

Once retrieval operations have been suspended, a waiting period will be observed to allow the liquids to gravity drain to retrieval system low points. Static testing will be performed once 241-S-102 has reached equilibrium. The frequency and duration of the static test will be determined during the design of the retrieval system. Data will be collected over a period of time (48 hours, for example), and measurements will include tank liquid waste levels and temperatures (to account for thermal expansion.)

6.1.2 Ex-Tank Methods

Ex-tank methods using existing drywells will not be the primary method of leak detection because interpretation of measurements is difficult. Logging of drywells will be employed only as a secondary leak detection system because radiation detected in a drywell may be difficult to interpret for the following reasons:

- Lack of a reading may only mean that a release has not migrated to the well, and
- A positive reading may be the result of existing contamination or waste migration from another tank.

Even with these interpretation drawbacks, periodic scans will be obtained in existing wells before, during and after retrieval operations. When used in conjunction with other leak detection systems, they can be helpful in assessing the existence, extent, and mitigation of a leak.

During FY 2001, DOE ORP is sponsoring testing and demonstrations to examine alternate LDMM technologies that provide indirect leak detection outside of a tank. These technologies may have potential to augment the existing drywell ex-tank leak detection system. These ex-tank LDMM technologies include:

- Neutron-Neutron
- Electrical Resistance Tomography (ERT)
- Crosshole Radar
- Crosshole Electromagnetic Induction
- High-Resolution Resistivity
- Time Domain Reflectrometry
- Partitioning Interwell Tracer Tests (PITT)

If testing during FY 2001 demonstrates that any of these technologies significantly decreases uncertainty associated with static and dynamic leak testing, they will be evaluated for inclusion in the demonstration. The parameters that will be evaluated are:

- Maturity, accuracy, and precision of the technology,
- Amount of additional development required to deploy the technology,
- Degree by which LDMM is enhanced versus the cost to deploy the technology,
- Impacts to the project schedule, and
- Cost impacts to the project baseline.

6.2 Preferred Leak Monitoring Technologies

Leak monitoring is the quantification of a liquid waste release volume from a SST after detection of a leak during waste retrieval operations. A leak volume estimate must be predicted to quantify the environmental impact resulting from a leak. Dynamic, static, and ex-tank methods will be applied to quantify a potential leak volume during retrieval operations. The limitations associated with leak detection, as discussed above, apply to leak monitoring.

6.3 Preferred Leak Mitigation Alternative

Based on above discussions, the primary strategy for mitigation is a retrieval technology that limits the liquid volume and accelerates retrieval. The retrieval duration and relationship to the LDMM mitigation strategy will be developed once the preliminary configuration of the fluidics system is final. Elements to be examined include the relationship of retrieval time and interstitial liquid level to potential leak loss and other factors.

If a leak is indicated during retrieval operations, appropriate process control procedures will be implemented. The first response to an indication of a potential leak will be to verify the instrumentation. If the verification process concludes that no leak is indicated, retrieval

operations would continue under normal operating procedures. However, if a leak is verified, the operating contractor will notify DOE ORP, which will, in turn, notify Ecology. The process control procedures will consider the leak loss limit, leak loss rate, and estimated duration to completion of retrieval operations when determining the appropriate response action. Potential response actions include (1) continuing retrieval activities if the estimated leak volume would remain within the leak loss limit, (2) modifying leak monitoring (e.g., implementing more frequent dynamic monitoring or static testing), (3) modifying operating conditions, (4) discontinuing adding or recycling liquids, (5) implementing emergency retrieval, or (6) stopping all operations. The response actions would then be implemented and, if appropriate, retrieval operations would continue under modified procedures through the completion of the retrieval activities. The requirements for implementation of leak response actions during retrieval operations will be established in the Process Control Plan, which will be developed concurrent with the design of the retrieval and LDMM system.

6.4 Tank S-102 LDMM Equipment

Equipment that will be used to employ a LDMM system is described below.

6.4.1 In-Tank Systems

Dynamic leak detection will be implemented during waste retrieval operations. It will consist of liquid waste level measurements, including measurements required to compensate for short term variations in the measurement signals, in both 241-S-102 and the DST receiver tank. In addition, flow measurements will be made in both the transfer piping and raw water lines going into and out of 241-S-102 and into the DST. This will allow static leak tests to be performed as well as the dynamic estimates based on transferred volumes. A schematic of a dynamic leak detection system is shown in Figure 6-3.

Figure 6-3 Tank S-102 Dynamic Leak Detection
(Based on Mass/Volumetric Flow & Tank Liquid Level)

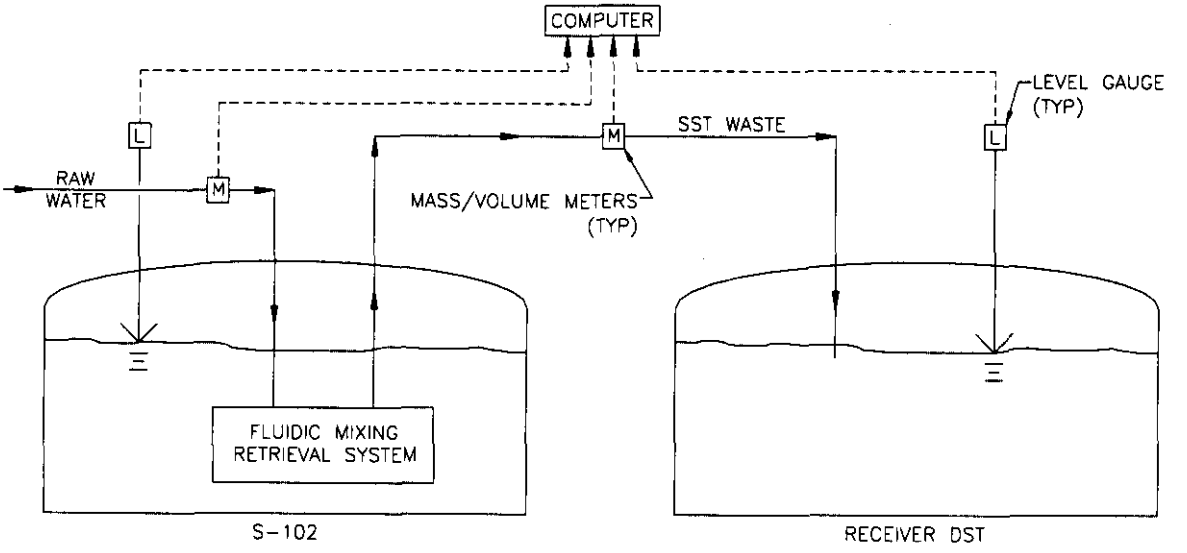


Table 6-1 provides a typical listing of the instrumentation used for dynamic leak testing; the table describes the data and why it may be collected.

Table 6-1 Instrumentation Requirements for Dynamic Leak Detection

Instrument	Measurement Function	Purpose
Level gauge	Liquid level inside SST	Direct or indirect measurement
Level gauge	Free liquid surface level inside DST	Direct measurement
Thermocouple	Air temperature inside SST	Instrument error
Thermocouple	Liquid temperature inside SST	Source material compensation
Thermocouple	Air temperature outside SST	Instrument error
Pressure gauge	Barometric pressure	Source material compensation
Pressure gauge	Static Pressure Inside DST (ventilation system)	Source material compensation
Pressure gauge	Transfer pipeline pressure	Source material compensation
Flow meter	Volumetric/mass flow out of SST	Direct measurement
Flow meter	Volumetric/mass flow into DST	Direct measurement
Psychometrics	Evaporation / condensation in SST	External inflow/outflow
Batch sample	Liquid/solids density inside SST	Source material compensation
Sensor and switch	Data acquisition and alarm	Record and process data inputs

Volumetric (Static)

Volumetric methods use direct measurement (e.g., surface level) or indirect measurement (e.g., differential pressure) to establish the liquid volume data from the known tank parameters. Leak detection is accomplished by calculating the rate of volume change over time and comparing this rate to a pre-determined "leak detection threshold" to determine whether the tank has an inflow, an outflow, or that the tank is "tight." Direct level-sensing instrumentation such as the ENRAF™ and FIC™ gauges are currently used in SSTs with a continuous liquid surface and are well suited for the volumetric method in tanks with a measurable air-liquid interface. A schematic of a static leak detection system is shown if Figure 6-4

Figure 6-4 Tank S-102 Static Leak Detection

(Based on Changes in Tank Liquid Level Only)

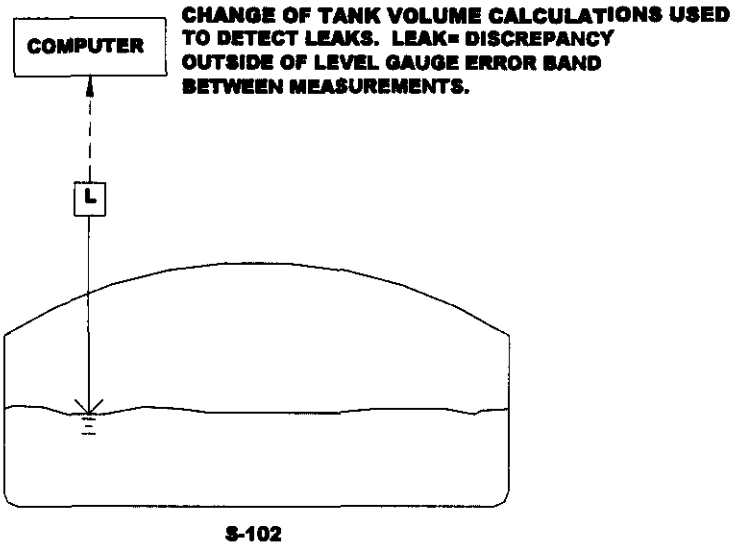


Table 6-2 provides a listing of the representative instrumentation that may be required for static leak testing. The table also describes the data and the reason it is being collected. Once the data collection and analysis are complete and have shown that a leak has not occurred, tank waste retrieval operations are resumed.

Table 6-2 Instrumentation Requirements for Static Leak Detection

Instrument	Measurement Function	Purpose
Level gauge	Liquid level inside SST	Direct or indirect measurement
Thermocouple	Air temperature inside SST	Instrument error
Thermocouple	Liquid temperature inside SST	Source material compensation
Thermocouple	Air temperature outside SST	Instrument error
Pressure gauge	Barometric pressure	Source material compensation
Psychrometrics	Evaporation / condensation in SST	External inflow/outflow
Batch sample	Liquid/solids density in SST	Source material compensation
Sensor and switch	Data acquisition and alarm	Data Recording and Processing

6.5 Preliminary Operations/Data Analysis Strategy

For dynamic leak detection, the retrieval system will be treated like a closed loop system consisting of the recovery tank, 241-S-102, the receiving tank, a DST, and the connecting transfer lines. Solids loading and specific gravity may be measured and used to compensate/reconcile the recovery volume. The discrepancy between the inflow and outflow from 241-S-102 will be compared to the volume in the DST (converted from surface level measurements) and the transfer line. Any discrepancy greater than the uncertainties in the volume calculations and estimates of 241-S-102 liquid inventory, including the error produced by all compensating measurements (thermal expansion, dissolution, solids loading, etc.) will be considered a leak in 241-S-102. This assumes that no leak is detected in the transfer line(s) or the DST. This assumption will be verified during the actual retrieval operations.

A static leak test will require that all retrieval operations be suspended for a period of time to allow the system to reach equilibrium and to conduct the leak detection test. Static leak detection is comprised of liquid waste level measurements in the SST being retrieved, as well as measurement of other liquid collection or dispersion points.

Once retrieval operations have been suspended, a waiting period will be observed to allow the liquids to gravity drain to retrieval system low points. Static testing will be performed once 241-S-102 has reached equilibrium. The frequency and duration of the static test will coincide with maintenance on retrieval equipment and during cross-site transfers. Additional static test will be determined during the design phase.. Data will be collected over a period of time (48 hours, for example), and measurements will include tank liquid waste levels and temperatures (to account for thermal expansion.)

7.0 TECHNOLOGY NEEDS AND UNCERTAINTIES

To implement the preferred alternatives identified, certain technology development are needed to resolve uncertainties. In addition, other uncertainties that are not related to a specific technology must be resolved. For each need, a problem statement is given and followed by a recommended path forward. None of the technology needs presented represent basic research. Rather, these technology needs represent; 1) application-specific development and testing to validate the design concepts presented in this report; and 2) advancement of technologies that have been proven in field tests, but have yet to be deployed in an operational environment; and 3) final selection of an ex-tank leak detection method.

7.1 Retrieval Release Criterion

The risk allocations established by the RPE calculation have not been formally accepted. It is uncertain which scenario is appropriate to develop the limiting SST closure source term. Additionally, the risk allocation process has not been finalized. If the risk to a receptor needs to be spread over all 12 tanks, the allowable contribution of each tank becomes much smaller and the leak and residual waste volumes correspondingly are reduced. The current approach assumed that a maximum of three tanks could be contributing to any single receptor at one time. Agreement by all parties is needed to establish this as an acceptable approach.

The current risk-based RRC may be unachievable, however a methodology for determining the programmatic RRC, or comparing the risk of retrieval to the risk of doing nothing needs to be established and agreed upon. This approach needs to be developed during conceptual design.

The RPE-based Retrieval Release Protection Strategy is a cornerstone of the design concepts presented in this report. These need to be managed through integration of the RPE calculations with the LDMM and waste retrieval system preliminary engineering activities.

7.2 Interstitial Liquid Level Measurement

The primary problem with deploying an interstitial liquid measurement technology is making accurate measurements in the material at the bottom of the tanks. This material can consist of multiple layers of partially or fully saturated solids. Capillary action can draw liquids up into the pores of the unsaturated solids, causing a moisture gradient to form; in this case, there is no clear demarcation of the liquid level. In addition, while measuring a supernatant layer is relatively straightforward, measuring an interstitial liquid or moisture level is more difficult because direct level-sensing instruments cannot be used. As a result, inferential sensors must be employed. Further, because the solids in question are also radioactive and highly conductive, many standard industrial bulk density and liquid content measuring methods become impractical in this application. Thus, the problem becomes one of identifying sensors that are tractable, readily deployable, affordable, and whose performance is consistent with the needs of the leak detection and leak monitoring systems.

Depending on the permeability of the solids as well as the rate of water in and waste out, the interstitial liquid levels (ILLs) shown in these figures will move up and down relative to the

exposed liquid surface in the pump well. The key to the problem is sensing these changes in ILL height and correlating them to measurable volumetric changes within the tank and the waste matrix.

ILL measurement likely will drive the performance of both the static and dynamic systems. Uncertainties associated with ILL measurement include the number of sensors necessary, appropriate location(s), and which ILL measurement technique to use. These uncertainties can be managed through implementation of the technology path forward.

Because sufficiently low programmatic risk is associated with this issue, testing and development can proceed in parallel with formal project definition. A technology testing and development program should be established to develop technical performance requirements for interstitial liquid level measurements. Once technical performance requirements have been established, an appropriate design concept can be further developed and tested for selection and incorporation into the LDMM system conceptual design.

Specific technology development concepts include the following activities:

- Perform a preliminary engineering evaluation of a gamma-spectrometer level-sensing probe. Base this probe on existing technology (e.g., the enhanced gamma-spectrometer tool used during the Tank AZ-101 mixer pump tests.)

- Consider in the conceptual design an improved detector, and windowing and probe depth control/sensing, to achieve 0.1-ft vertical (depth) resolution.

- Consider in the design development time, costs, and a deployment schedule.

- Estimate, based on the Tank AZ-101 gamma data, preliminary performance for leak detection.

- Using the tanks with liquid observation wells (LOWs), evaluate the applicability of this method.

- Conduct high-sample-rate ENRAF measurements (»1sample per minute) in a typical SST.

- Provide co-located psychrometric and tank liquid temperature data, and analyze the data to determine the short- and long-term noise influences on the ENRAF system. The same should be done with dip-tube measurements.

- Assess the detectable leak rate, as categorized by such items as data collection interval and, sample rate. Make an engineering evaluation of the method as it would apply to an SST.

7.3 Deployment Strategy

Conceptually, it is straightforward to balance inflow and outflow for rapid removal of free (i.e., drainable) liquids in the event a leak is detected. However, the engineering details of balancing the system have not been demonstrated. Alternative leak mitigation approaches are not sufficiently developed to use as contingencies. The uncertainty over which risk scenario is appropriate can be managed through implementation of the technology path forward.

7.4 Performance Evaluation Testing of Leak Detection, Monitoring, and Mitigation Systems

Specific technology development concepts include the following activities:

- Prepare a preliminary engineering evaluation of the performance ex-tank methods for SST leak monitoring. This evaluation should include an analysis of the feasibility of installing systems in and around the tank farm. The evaluation should also evaluate technical performance of the methods in terms of size of detectable leaks, minimal detectable volume change, P_D, and P_{FA}. Also include development time, costs, and a development, test, as well as deployment schedule.

- Prepare a preliminary engineering evaluation of the performance of the volumetric methods for SST leak detection and monitoring. Include in the evaluation technical performance in terms of size of detectable leaks, P_D, and P_{FA}. Also include development time, cost, and a development, test, as well as deployment schedule.

7.5 Soil Contamination in Tank Farms

Actual soil contamination levels in the 241-S Tank Farm have not been accurately mapped. No surface contamination maps currently exist, and subsurface maps are limited to areas around drywells. This uncertainty has the potential to impact both the project cost and schedule because of the associated uncertainty in dose levels. The leak monitoring techniques that require baseline measurements (such as ERT and soil sampling) are sensitive to existing contamination. However, this uncertainty can be managed through establishment of an accurate and defensible baseline prior to startup, and continued surveillance throughout the project.

8.0 CONCLUSIONS

Preliminary engineering design concepts have been developed for leak detection, leak monitoring, and leak mitigation during fluidic mixing and pumping retrieval operations. These design concepts include preliminary engineering equipment lists and system specifications. Technology needs have been identified for further development of the design concepts presented.

Measurement of the solids and interstitial liquid levels will likely drive the performance of the preferred internal leak detection and leak monitoring methods. Measurement of these liquids during retrieval operations is a technology development challenge; however, the problem is well

defined and preliminary design concept solutions have been identified. External tank leak detection methods may show promise (in the FY 2001 testing) for leak detection and leak monitoring, particularly for retrieval of impermeable sludges where measurement of an interstitial liquid level may not be practical.

Based on the alternatives analyses and technology trade studies prepared in 1994, 1995, and 1996, and updated in 1998, with additional information provided from preliminary engineering activities associated with fluidic mixing and pumping retrieval of 241-S-102, the following LDMM alternatives were selected (PNNL 1994; PNNL 1995; WHC 1996d; LMHC 1998):

- Leak detection: In-tank volumetric system and ex-tank method;
- Leak monitoring: In-tank volumetric system and ex-tank method;
- Leak mitigation: Minimize the liquid inventory and campaign duration.

This report provides sufficient information and technical basis to proceed with formal project definition activities for LDMM as an integrated function associated with waste retrieval projects. Specific conclusions supported by this report include the following:

1. To create retrieval and closure action plans for each SST, a clear understanding is necessary of the performance and operational requirements for and the capabilities of viable technologies to detect, monitor, and mitigate potential leakage during retrieval operations.

2. Tank S-102 is a viable SST for deployment and operation of the LDMM technologies under consideration during fluidic mixing of sludges. The available tank characterization data indicate that the sludge and salt cake in 241-S-102 will be readily dissolved and mobilized, which supports the mixing and pumping strategy.

3. The Retrieval Release Protection Strategy, based on the Retrieval Performance Evaluation, provides a risk-based framework to establish a retrieval release criterion and target leak rates for expected retrieval durations.

4. The strategy for weighing the risk of retrieving waste versus doing nothing even if chosen technology cannot meet the risk curves for leak detection/ residual waste is acceptable with regulatory agencies and the public.

5. Functions and requirements for LDMM are mature, well defined, and integrated with the current waste retrieval system functions and requirements for fluidic mixing and pumping of waste from 241-S-102.

6. Sufficient technical basis exists to select the preferred in-tank and external alternatives for LDMM. These technologies can meet current accelerated deployment schedules, have been successfully applied in industry and at other DOE sites, are readily quantifiable, and have demonstrated the lowest life-cycle costs of all the evaluated alternatives.

7. The selected technologies are sufficiently mature that the SST Retrieval Program can proceed with integrated design and formal project definition of fluidic mixing and pumping waste retrieval technologies with volumetric leak detection and leak monitoring systems.

8. To create retrieval and closure action plans for each SST, a clear understanding is necessary of the performance and operational requirements for and the capabilities of viable technologies to detect, monitor, and mitigate potential leakage during retrieval operations.

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Glossary

Term	Units	Definition
Accuracy	Gal/hr	A measure of the closeness of an individual measurement or the average of a number of measurements to the true value.
Apparent Level Changes	In	Related to "System Noise". Recorded level changes that are manifested by error associated with the method but are not related to physical changes in waste/product level.
Bias	Gal/hr	The systematic or persistent distortion of a measurement process that causes errors in one direction.
Closure Source Term (Composite Source Term)	Risk	The RPE peak risk sum of Past Leak Risks, Residual Waste Risks, and Retrieval Release Risks. Must be less than 1.0×10^{-5} ILCR (sometimes referred to as Composite Source Term).
Dt	Gal/hr	"Detection Threshold". The detection threshold value at which the test is declared "Pass" or "Fail".
Duration	D, hr, Wk	Typically talking about campaign duration equal to the time when retrieval operations begin to the time when the retrieval campaign is declared complete.
Error, Random	Gal/hr	Essentially, the "noise histogram" associated with the leak detection system. Truly random errors should always average to zero bias in the leak detection system.
Error, System	Gal/hr	A consistent, repeatable error that introduces a bias to the measurement system. Typically, system errors can be diagnosed and compensated. However, diagnosis and compensation for system errors may be cost and time prohibitive if the system meets minimum and sufficient requirements without compensation.
Fail Test	None	The tank system is declared to be, "not tight within the statistical uncertainty of the method."
ILCR	Risk	"Incremental Lifetime Cancer Risk". The RPE calculates peak exposure over a 10,000 year period. The Washington State long-term human health risk for cancer risk is 1.0×10^{-5}.
I_p	None	Pressure Influence Coefficient. Calculated for a specific leak detection system to compensate for barometric pressure changes in level.
I_T	None	Temperature Influence Coefficient. Calculated for a specific leak detection system to compensate for temperature changes in level.
Lc	Inch, cm	Compensated level data.

Term	Units	Definition
Lo	Inch, cm	Uncompensated level data.
LR	Gal/hr	"Leak Rate". The measured leak rate of a tank system.
m-VR	Gal/hr	"Mean Volume Rate". The average (mean) volume rate recorded for the leak detection system in a non-leaking tank.
N	None	Number of samples for a given statistical population.
Noise, Ambient	Gal/hr	The random error associated with a leak detection system that can be attributed (and compensated) to fluctuations in the system such as ambient air temperature, ambient waste/product temperature, and barometric pressure.
Noise, System	Gal/hr	The random error associated with a leak detection system that can be attributed (and compensated) to fluctuations in the system such as instrument error and operator error.
Pass Test	None	The tank system is declared to be, "not leaking, within the statistical uncertainty of the method."
P_D	%	"Probability of Detection". The probability that a release equal to or greater than the target leak detection rate will be detected and "Truly" declared a release by the leak detection method. Typically equal to 95%.
P_{FA}	%	"Probability of False Alarm". The probability that a release less than the target leak detection rate will be detected and "Falsely" declared a release by the leak detection method. Typically less than 5%. (Similar to a Type I, "False Positive" error in statistics)
PLR	Risk	"Past Leak Risk". The RPE computation of peak ILCR associated with a given Past Leak Volume.
PLV	Gal, Ft^3	"Past Leak Volume". The Past Leak Volume associated with a given SST selected for retrieval.
P_{MD}	%	"Probability of Missed Detection". Indicates the probability of missing detection against a specified TLDR. Typically computed as $1 - P_D$. (Similar to a Type II, "False Negative" error in statistics)
Precision	Gal/hr	A measure of the agreement amount replicate measurements of the same property, under prescribed similar conditions.
Programmatic Based Release Volume	Gal, Ft^3	Maximum Release Volume regardless of risks. This negotiated volume is based on programmatic considerations such as worker safety, available technology, operational impact, and lifecycle cost. Initially assumed to be 50,000gal based on previous definitions of catastrophic leaks.

Term	Units	Definition
Risk Based Release Volume	Gal, Ft^3	Maximum Release Volume based on RPE peak risk calculations and the Washington State long-term health risk standard for cancer risk of 1.0×10^{-5}.
RPE	None	"Retrieval Performance Evaluation". A risk-based method for evaluation of long-term human health risks resulting from closure of SSTs.
RRC	Gal, Ft^3	"Retrieval Release Criterion". The volume of released material that must be detected over the duration of the retrieval campaign.
RRR	Risk	"Retrieval Release Risk". The allocated risk to retrieval releases based on an initial RPE Closure Source Term equal to or less than the Washington State long-term health risk standard for cancer risk of 1.0×10^{-5}.
RWR	Risk	"Residual Waste Risk". The RPE calculated peak risk to long-term human health using the assumed residual waste volume for a specific retrieval technology on a specific SST.
RWV	Gal, Ft^3	"Residual Waste Volume". The residual waste volume assumed to be left in a SST at completion of a retrieval campaign.
SPL	Gal/hr	"System Performance Limit". Indicates limit of performance of the leak detection system for the specific case $P_D = 95\%$ and $P_{FA} = 5\%$. In petroleum industry, this specific value is referred to as Minimum Detectable Leak Rate (MDLR) and is used to compare the performance of one leak detection system to another.
s_y-VR	Gal/hr	Standard Deviation of Volume Rate
t	s, m, hr	"Time". Often used with subscripts 0, 1, 2, 3 . . . etc. to indicate progression through a test.
T	°F, °C	Temperature
t_c	None	"t critical". The critical t-statistic used to estimate bias in a leak detection system.
TLDR (VRC, TLR)	Gal/hr	"Target Leak Detection Rate". The leak detection rate computed by using the RPE established retrieval release criterion and the retrieval method estimated duration. TLDR = RRC/Duration (sometimes referred to as Target Leak Rate and Volume Rate Criterion).
t_s	None	"t statistic". A statistical shape parameter related to the student's t-test used to quantify performance of a leak detection system.

Term	Units	Definition
VR	Gal/hr	"Volume Rate". The measured rate at which volume is increasing or decreasing in the tank system.
ΔP	Psi	"Differential Pressure". The change in pressure of a defined system.

Appendix K

Procurement/Performance Outline Specification

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1.0 SCOPE

This procurement specification addresses the performance requirements of the Waste Retrieval System for the Hanford Site 241-S-102. This specification will include requirements for the fabrication, inspection, testing, documentation, packaging, shipping and on-site technical support to be provided by the vendor.

The SOW does not include installation or operational acceptance testing to be performed on the Hanford Site.

1.1 Background

The mission of the 241-S-102 Waste Retrieval Project is to retrieve radioactive waste from 241-S-102 and to transfer the waste to the double-shall tank (DST) system for staging in support of eventual processing at the future Waste Treatment Complex. Goals established in the *Hanford Federal Facility Agreement and Consent Order*, Tri-Party Agreement (TPA) for this initial waste retrieval project include the retrieval to safe storage of approximately 490 curies of mobiles, long-lived radioisotopes and 99% of the tank contents by volume (per the U.S. Department of Energy's (DOE) Best-Basis Inventory (BBI) data, dated August1, 2000). The retrieval technology deployed will seek to improve upon the baseline retrieval method, sluicing, in the areas of recovery, risk reduction, and cost effectiveness. The project will also deploy systems and implement appropriate operating strategies during retrieval to support leak detection, monitoring, and mitigation (LDMM) requirements.

The proposed technology to support the initial waste retrieval of 241-S-102 includes a fluidic mixing and transfer pumping system, consisting of one or more "charge vessels" installed inside the tank that can be used to relatively small quantities of solvent (water) to dissolve and mix the waste within the SST. This proposed system does not rely on moving parts that come in contact with the waste. The fluidic process will produce a solution of slurry that can be readily pumped from 241-S-102 to the DST system.

This specification details the requirements for the fabrication, inspection, testing, documentation, packaging and shipping of the fluidic mixing and transfer pumping system.

2.0 APPLICABLE DOCUMENTS

The following documents, of the exact issue/revision shown, form a part of this specification. Any conflicting requirements shall be brought to the attention of the Buyer for resolution prior to proceeding with the work.

2.1 Drawings

See attached drawings (Attachment 1) to this specification.

2.2 Codes And Standards

Equipment and services furnished in accordance with this Specification shall comply with the following codes and standards to the extent referenced herein. Unless otherwise noted, the document with addenda, amendments, and revisions in effect on the date of the purchase contract will apply.

Title 10, Code of Federal Regulations, Part 830.120, Quality Assurance Requirements

ASME B&PV Code, B31.3

AWS D1.1

ASTM

3.0 TECHNICAL REQUIREMENTS

This section defines the technical requirements of the 241-S-102 Waste Retrieval Pumping System.

3.1 General Requirements

The Seller shall accept complete responsibility for all work performed in compliance with this Specification. Review or approval of data or procedures by the Buyer with regard to work performed to accomplish the requirements of this specification does not constitute acceptance of any material or components, which will not fulfill the requirements established by this specification. The requirements of this specification shall be met.

Alternative fabrication details proposed by the Seller shall be submitted to the Buyer in writing. These shall not be made part of the purchase contract without written approval from the Buyer.

3.2 Design Requirements

3.3 Material Requirements

All materials used for fabrication of the Waste Retrieval Pumping System shall be in accordance with the Drawings. The Seller may propose to supply alternative materials, components, or parts other than those specified, if in the opinion of the Seller, the substitution is more economical, better qualified for the performance requirements, and is equivalent to and in accordance with the applicable requirements.

3.3.1 Structural Materials

All Waste Retrieval Pumping System structural materials shall be in accordance with the applicable ASTM standard listed on the Drawings. These materials shall be purchased in accordance with the requirements of the applicable ASTM specifications.

3.3.2 Other Materials

Standard products incorporated into the Waste Retrieval Pumping System design have been designated on the Drawing as ASTM materials or by the manufacturer's callout as applicable. These materials shall be purchased in accordance with the applicable requirements or the manufacturer's standard specifications.

4.0 FABRICATION

All cutting, forming, machining, and fitting operations shall be performed in accordance with approved shop drawings, the provisions of this specification, and manufacturer's practices, as applicable.

A fabrication plan/traveler shall be submitted to the Buyer, for review, approval and insertion of the Buyer's hold points prior to start of fabrication per Section 8.0.

5.0 INSPECTION AND TESTING REQUIREMENTS

The following inspections and testing shall be performed for the Waste Retrieval Pumping System. Inspection and test plans shall be prepared and submitted to the Buyer for review and approval prior to performing the inspections and tests per Section 8.0.

Inspection and test reports shall be prepared by the Seller and submitted to the Buyer per Section 8.0.

5.1 Dimensional Verification

The Waste Retrieval Pumping System shall undergo dimensional inspections by the seller to verify critical dimensions of all final assemblies. The purpose of these inspections is to ensure quality of workmanship and to guarantee that the critical dimensions of the Waste Retrieval Pumping System meets the dimensional requirements of the drawings.

The seller shall furnish all shop inspection and test facilities, materials, and qualified labor necessary for performance of inspections, or for any modifications resulting from the inspections. The seller shall repair or replace any portion of the Work, which is not in compliance with the purchase contract as determine by these inspections.

5.2 Functional Tests

The Waste Retrieval Pumping System shall be erected to ensure the process for waste retrieval from 241-S-102 is feasible.

6.0 QUALITY REQUIREMENTS

When subcontracting any portion of this work, the Seller shall pass down the applicable requirements to the subtier subcontractors.

The Seller shall either have a documented Quality Assurance Program or shall prepare a Quality Assurance Project Plan to demonstrate how the following quality requirements will be satisfied for this procurement. The basis for the documented QA program or QA Project Plan shall be ASME NQA-1 (1989 or later edition). The Quality Assurance Program or Project Plan shall be submitted for approval with the Seller's proposal per Section 8.0.

The Seller shall submit all "Accept-As-Is" and Rework Non-Conformance Reports (NCRs) to the Buyer for review and approval prior to proceeding with Corrective Actions.

6.1 Quality Requirements For Shipping Release

The seller shall not ship the Waste Retrieval Pumping System until all the tests and inspections have been performed and the documentation package is complete.

Along with the documentation package identified in Section 8 of this specification, the seller shall submit to the buyer a Certificate of Compliance to this specification and the applicable drawings in Attachment 1. As a minimum the Certificate of Compliance shall include but not be limited to the following information:

A. Purchase Order number
B. Procurement Specification and drawing numbers, including any approved changes, waivers, or deviations applicable to the equipment
C. A certification by the person who is responsible for the Seller's quality assurance function

7.0 PACKAGING AND SHIPPING REQUIREMENTS

Packaging of the Waste Retrieval Pumping System will be performed to protect them from dirt or damage during transport. All items shall be identified with the following:

contract number, package contents, package weight (if greater than 50 lbs), and any special handling instructions.

On the date of shipment the seller shall provide the buyer with the following: the carrier bill of lading and a list of the items being shipped. The seller shall be totally responsible for the safe delivery of the Waste Retrieval Pumping System. Any damage to the Waste Retrieval Pumping System as a result of improper packaging, in transit handling, or shipping, shall be repaired at the expense of the seller.

Delivery of the Waste Retrieval Pumping System shall be F.O.B. to the location specified in the buyer's purchase order. Unloading will be the responsibility of the buyer.

7.1 Special Handling And Assembly Instructions

The seller shall prepare Special Handling and Assembly Instructions for the buyer's assembly of the Waste Retrieval Pumping System. These instructions shall be submitted to the Buyer with the shipment of the Waste Retrieval Pumping System. The content of these instructions is described in Section 8.1.3.

8.0 DOCUMENT AND RECORD SUBMITTAL REQUIREMENTS

This section contains the requirements for document and record submittals for the Waste Retrieval Pumping System. Table 1.0 gives detailed list of the submittals and the submittal requirements.

Along with the Certificate of Compliance to this specification and the applicable drawings in Attachment 1, the seller shall submit to the buyer a documentation package identified in this section of the specification.

8.1 Documents

The following documents will be shipped with the Waste Retrieval Pumping System.

8.1.1 As-Built Drawings

The seller shall prepare as-built drawings for all assembly, sub-assembly, and piece parts associated with the Waste Retrieval Pumping System. The seller shall submit one reproducible copy of all as-built drawings to the buyer. The shop drawings are to be full-size and legible.

8.1.2 Inspection and Test Procedures/Plans

The seller shall provide the inspection and test procedures or plans used for each test and inspection performed associated with the Waste Retrieval Pumping System. Each

procedure or plan shall include identification of each characteristic or attribute evaluated, the measuring and test equipment used, the inspection/testing personnel used and other requirements as required by Code, Standard and Contract. The seller shall submit one copy of each inspection and test procedures to the buyer.

8.1.3 Special Handling and Assembly Instructions

The seller shall prepare Special Handling and Assembly Instructions including caution statements associated with handling and assembling the Waste Retrieval Pumping System, a parts list, listing of tools required to assemble the system, numbered set of assembly steps identifying the parts and tools required for the particular step, numbered set of disassembly steps identifying the parts and tools required for the particular step.

8.1.4 Operations and Maintenance Manual

The Seller shall prepare Operations and Maintenance Manuals associated with the operations and maintenance of the Waste Retrieval Pumping System.

8.2 RECORDS

The Seller shall prepare assemble and submit to the Buyer, two legible, reproducible copies of the final records package. The package shall be submitted with the shipment of the containment enclosure and shall include the following:

A. The Seller shall prepare and submit for approval for the Buyer, an Index of Records. The Index of Records shall include records identified in Table 1 as well as any documents used by the Seller's QA Program to trace the record to the equipment.

B. All test and inspection reports including test and inspection results shall be compared to the acceptance criteria. These reports shall contain the signature of the authorized representative or the agency performing the tests.

C. Record of all deviations affecting the Seller's approved drawings, if any.

Table 1. List of Submittals

Submittal No.	Description	Specification Section	Required Timeframe
1	Quality Assurance Program/Plan		With Proposal
2	Fabrication Plan/Traveler		1 week after kickoff meeting
3	Inspection/Test Plans		2 weeks prior to activity
4	Inspection/Test Reports		With Shipment
5	WPS/PQR/WPQR as applicable		2 weeks prior to

			activity
6	NDE Procedures and Personnel certifications		2 weeks prior to activity
7	Special Handling Procedures		2 weeks prior to activity
8	Operations and Maintenance Manual		With Shipment
9	As-Built Drawings		With Shipment
10	Non-Conformance Reports		Prior to Corrective Action
11	Final Data Package: Completed Fabrication Traveler(s), CMTRs, MSDSs, etc.		With Shipment