Appendix C
Direct Evaporation Process

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ACRONYMS

BFS	blast furnace slag
CERCLA	Comprehensive Environmental Response, Compensation and Liability Act
DBE	design basis element
DF	decontamination factor
DOE	Department of Energy
DWPF	Defense Waste Processing Facility
ETS	Evaporative Tank System
FGE	fissile gram equivalent
GAC	granulated activated carbon
HEME	high-efficiency mist eliminator
HEPA	high-efficiency particulate air (filter)
INEEL	Idaho National Engineering and Environmental Laboratory
INTEC	Idaho Nuclear Technology and Engineering Center
LET&D	Liquid Effluent Treatment and Disposal Facility
NGLW	newly generated liquid waste
OPC	ordinary Portland cement
PEWE	Process Effluent Waste Evaporator
PFD	Process Flow Diagram
POG	process off-gas
RCRA	Resource Conservation and Recovery Act
SBW	sodium bearing waste
SCR	selective catalytic reduction (process or reactor)
T&FR	technical and functional requirements
TCLP	Toxicity Characteristic Leaching Procedure
THC	total hydrocarbons
TFF	Tank Farm Facility
VOG	vessel off-gas
WAC	waste acceptance criteria
WESP	wet electrostatic precipitator
WIPP	Waste Isolation Pilot Plant

Appendix C
Details of the Direct Evaporation process

C-1. BACKGROUND

Evaporation is a common practice at U.S. Department of Energy (DOE) facilities in the treatment of radioactive waste. The Idaho National Engineering and Environmental Laboratory (INEEL) currently operates two evaporators to concentrate dilute aqueous, acidic wastes, the Process Effluent Waste Evaporator (PEWE) and the Evaporative Tank System (ETS) (former called the High Level Liquid Waste Evaporator). The PEWE has been in operation since 1984 and the ETS since 1987. Unlike these current evaporators, the concept behind the direct evaporation process is to continue the evaporation of the feed to the point that upon cooling, the concentrated waste will solidify into a form acceptable for disposal.

The predecessors of the direct evaporation concept for treatment of sodium bearing waste (SBW) were the freeze crystallization and evaporation/precipitation concepts proposed and tested by John McCray in the mid-1990s (McCray, 1994; McCray, 1995), and a concept of SBW evaporation followed by vitrification with spent high efficiency particulate air (HEPA) filters proposed by Robert Kirkham in 1992 (Kirkham, 2003). In June 1994, small-scale evaporation tests at reduced pressures were performed on SBW simulants followed by cooling to promote precipitation (McCray, 1994). The evaporation/precipitation process was proposed as a means to reduce the volume of stored liquid waste by 70% by evaporation. The process was designed to produce a sodium nitrate low-level waste product (McCray, 1995). Sodium nitrate crystals would have been separated from the evaporator bottoms, and the liquid treated by additional processing such as calcination.

In September 1997, Robert Kirkham performed initial tests to determine whether it was possible to evaporate SBW to the extent that it would solidify upon cooling (Kirkham, 1998). The intent at the time was to then ship the solidified waste to another site such as Hanford, where it would be re-liquefied and blended with a much larger quantity of similar waste in a treatment facility that would produce a final waste form. The tests showed that evaporation to a solidified waste form was feasible, with the initial 500 ml sample being concentrated to a liquid-free solid of about 180 ml (Kirkham, 1998).

Development of the direct evaporation process for treatment of SBW was resumed in 2002 (McCray, 2002). Scoping tests were performed by heating 750 ml samples of starting waste simulant in a 1-liter flask to determine evaporator temperature, pressure and extent of evaporation. Two other tests were performed, one to represent an “in-can” approach where the waste would be evaporated in its shipping container, and another in external equipment at vacuum. Conclusions from these tests included the following:

- WM-180 simulant solidification could be accomplished by means of in-container evaporation or by a separate evaporation vessel. The expected mass reduction is approximately 65-72% and corresponding volume reduction 74-81%.

- At ambient pressure, a temperature greater than 130°C is required to reach sufficient concentration. If the pressure is reduced to 550 mm Hg, the evaporation can be carried out below 100°C.

- The solidified waste product is hygroscopic and deliquescent. A thin layer of silica gel on top of the solidified waste was shown to absorb moisture accumulated on the solid waste surface.

- The acidic evaporator condensate contained mercury above the Resource Conservation and Recovery Act (RCRA) wastewater limit, but Pb, Cr and Cd below regulatory concerns. Entrainment carryover fractions of all species measured did not exceed 0.02%.

- Acid, mercury and most anion concentrations in the condensate rapidly increased toward the end of the evaporation.

- There was no evidence of expansion or contraction of the concentrated waste as it cooled and solidified.

An engineering feasibility study of the direct evaporation process was also performed in 2002 (Kimmitt, 2003). The feasibility study was based on a process that included separate treatment of solids, processing the evaporator condensate through the PEWE evaporator and Liquid Effluent Treatment and Disposal (LET&D) fractionator, and grouting the LET&D bottoms. In addition to defining the process by preparation of process flow diagrams, mass balances and an equipment list, architectural drawings were prepared, the facility was described and project cost and schedule estimated. The total project cost was estimated to be $210 million at an 85% confidence level. The schedule assumed start of conceptual design in November 2002 and operation between October 2008 and November 2011.

In the spring of 2003, a series of sixteen direct evaporation small-scale test runs using WM-189 SBW simulant was conducted (Kirkham, 2003). A known quantity of feed was boiled down to a concentration endpoint suitable to produce a solid bottoms product upon cooling. The operating temperatures and pressures were varied for each run. From the results of these studies, the preferred operating pressure for SBW-simulant evaporation was determined to be 380 mm Hg. At this absolute pressure and a temperature below 125°C, a "hard" bottoms product was produced at a mass reduction ratio of 60%.

In April and June of 2003, two series of tests at LCI Corporation test facilities in South Carolina provided performance data using a 1.4 ft^2 agitated thin-film evaporator. The first test used simulated SBW without solids; the second test used a feed of simulated SBW blended with tank heel solids (Griffith, 2003a; Griffith, 2003b). The first series included four runs with WM-189 simulant and two with WM-180 simulant; the second series included four runs of WM-189 simulant without undissolved solids and fourteen runs with several different undissolved solids. All of the bottoms samples solidified after cooling, demonstrating successful operation over a reasonably wide range of operating conditions. Test results showed that bottoms temperature could be used to control the process. Acceptable evaporator operation was demonstrated for all feeds for bottoms temperatures ranging from 110 to 118°C. No operational problems were experienced in the runs with solids, demonstrating that the SBW solids can be processed through the evaporator.

Development work performed in FY 2002 determined that the LET&D bottoms could be grouted with a waste loading of 35 wt% (Herbst, 2002). Continued testing of this formulation in 2003 demonstrated that the concentrations of hazardous metals in the leachate from Toxicity Characteristic Leaching Procedure (TCLP) tests of the grout were less than the Land Disposal Restrictions Universal Treatment Standards, even if the mercury level in the LET&D bottoms was more than 3 times the expected level (Raman, 2003).

An engineering study was performed in 2003 to evaluate alterative schemes for processing the evaporator overhead or condensate (Barnes, 2003a). Five schemes were evaluated:

1. A revised baseline process which replaced the PEWE with new equipment and processed tank solids through the SBW evaporator

2. A scheme in which the SBW evaporator feed was neutralized prior to evaporation

3. A scheme in which the nitric acid in the evaporator overhead is reduced in an SCR reactor

4. A scheme that includes alkaline scrubbing of evaporator vapor with the resulting salt waste grouted

5. A scheme that includes alkaline scrubbing of evaporator vapor with the resulting salt recycled to the SBW evaporator.

Although it produces a higher volume of RH waste, the alkaline scrub scheme with recycled salt showed significant advantages over the other schemes. Testing of this scheme was recommended, and initial tests performed in November 2003 at the LCI facility. The results from these tests showed that MgO or aluminum hydroxide added to the feed to simulate either scrubbing with MgO or neutralization of condensate with either reagent resulted in acceptable evaporator bottoms products.

Process information for two direct evaporation schemes is provided in this Appendix. One scheme, referred to as the "revised baseline" includes evaporation of a mixed SBW liquid/undissolved solids feed, condensing the evaporator overhead, processing the condensate through the existing LET&D facility and grouting the LET&D bottoms. Of all direct evaporation alternatives, this scheme has the least risk because all major operations have been demonstrated. The second process discussed in this Appendix is the alkaline scrub with recycle to the evaporator. Testing of this scheme has been performed with a feed simulating the expected recycle, but no tests have been performed yet of the scrubber or with actual recycle.

Section C--2 describes the process as shown on the Process Flow Diagrams (PFDs), which are given in Section C-4. PFDs 1-5 show the revised baseline process. PFDs 1, 2A and 5 show the alkaline scrub process. Section C-5 discusses the basis for the process design, including major requirements, assumptions and variations or options that have been considered for process equipment and configurations. Section C-5 also discusses the basis for the mass balance, including feed compositions and rates, operating conditions, and assumed or expected equipment performance.

C-2. PROCESS DESCRIPTION

C-2.1 Waste Tanks (PFD-1)

PFD-1 shows the seven existing storage tanks that will hold the feed to the direct evaporation process. Tanks VES-WM-180 and VES-WM-189 presently contain SBW near their administrative capacity limits. Tank VES-WM-188 is presently approximately 80% full of SBW, and will be filled to capacity as new wastes are generated and concentrated by the ETS. Over the past few years solids that were in five tanks have been flushed to Tank VES-WM-187, which is being used as a collection tank for flush water and solids from operations to clean and close Tank Farm Facility (TFF) tanks. Upon flushing one more tank, VES-WM-181, the collection of solids in WM-187 will be complete. Then prior to SBW treatment new mixing pumps will be installed in VES-WM-187, VES-WM-188 and VES-WM-189 and waste transfers will be made back and forth between these three tanks to distribute the solids somewhat evenly between them.

After 2005, newly generated liquid waste (NGLW) will be stored in the three tanks, VES-WM-100, VES-WM-101, and VES-WM-102. The NGLW can be blended with SBW during the solids blending transfers or can be held in the three NGLW tanks and transferred directly to the treatment process feed tank.

Existing steam jets in each of the tanks plus an existing airlift in VES-WM-189 will be used to transfer the SBW liquid/solids mixture from the TFF to the Direct Evaporation SBW Feed Tank. Waste will be transferred to the Direct Evaporation facility intermittently in batches at a rate of about 50 gpm. Transfers of approximately 8,500 gallons would provide a four-day supply of feed to the treatment process.

All equipment shown on PFD-1 is existing except for the mixing pumps (P-287, P-288 and P-289), which would be installed in tanks WM-187, WM-188 and WM-189 to keep solids in suspension.

C-2.2 SBW Evaporator (PFD-2)

SBW will be received from the TFF by the SBW Feed Tank, equipped with an air sparge (or other means of mixing the tank contents) and ability to mix fluid in the tank by use of the discharge pump. The air sparge and pump discharge recycle will keep the solids homogeneously suspended in the tank liquid. The SBW liquid/solids mixture will be continuously pumped at a rate of 1.5 gpm to the SBW Evaporator, a thin film type evaporator that is expected to operate at about 120°C and about 8.6-psia pressure. The evaporator is operated at a vacuum to keep the temperature below that at which "red oil" could form. Red oil is an explosive nitrated organic which can form above 130°C.

Evaporator concentrate will fall directly from the bottom of the evaporator through a short transfer pipe into its final waste container. Evaporator vapor will exit the top of the evaporator passing through an internal mist eliminator and then an external demister. The demister provides separation of entrained liquid and solids from the evaporator vapor. Liquid collected in the demister is periodically pumped to the SBW Feed Tank. The mesh pads in the demister can also be washed with condensate. Vapor from the demister is condensed by heat exchange with cooling water. Condensed liquid drains from the Condensate Demister to the Condensate Tank. Tests to date have shown the evaporator vapor to be totally condensable, but if any noncondensible gases were present in the condenser effluent, they would be superheated and HEPA-filtered before being boosted in pressure and released to the atmosphere through the Idaho Nuclear Technology and Engineering Center (INTEC) stack.

The evaporator is heated with 150 psig steam that is generated within the new facility.

The SBW Feed Tank and Neutralization Tank are vented to a vessel off-gas (VOG) collection header. VOG passes through a demister, followed by a superheater, HEPA filter, and blower, and is then discharged through the INTEC stack. Liquid collected in the VOG demister would be pumped to the SBW Feed Tank.

Potential corrosion in the Condensate Tank by hydrofluoric acid is controlled by the addition of aluminum nitrate solution, which will react with hydrofluoric acid and form soluble aluminum fluoride complexes. Aluminum nitrate solution is received from a supplier into the Aluminum Nitrate Tank and pumped as needed to the Condensate Tank. Condensate collected in the Condensate Tank is pumped to the LET&D, an existing fractionator at INTEC. A separate pump can transfer condensate to the evaporator vapor demister to provide washing of mesh pads.

All equipment shown on PFD-2 is new equipment.

C-2.3 LET&D Fractionator (PFD-3)

The existing LET&D Fractionator would be used to concentrate the condensate, thereby reducing the amount of waste that would require disposal. The condensate is fed by gravity from the LET&D Feed Tank to one of two identical fractionators, each containing15 sieve trays. A reboiler supplies heat to the

liquid in the lower section of the column. Vapors from the boiling liquid rise through sieve trays. Fractionation occurs as the vapor contacts the liquid flowing across the trays and down the column.

Because the feed would be much more concentrated in nitric acid than typical PEWE condensate, the fractionators may need to be modified to allow feeding at a lower tray than is presently used. The fractionator typically recovers at least 99% of the nitric acid from the feed into the bottoms product. The bottoms product is usually 12 molar nitric acid and contains a high fraction of the other impurities in the feed condensate including HCl, fluorides, and mercury compounds such as $HgCl_2$.

The fractionator overhead is steam with trace impurities. A partial condenser provides reflux to the column. The effluent from the condenser goes to a vapor/liquid separator, with the vapor from the separator superheated, filtered and discharged via a blower to the INTEC-708 stack. When the desired density of the fractionator bottoms is reached, a portion of the solution is drained out of the column and stored in the Bottoms Tank. This recovered acid is cooled by heat exchange with cooling water prior to entering the Bottoms Tank.

Except for the feed and bottoms tank, all acid fractionation equipment (fractionator with reboiler and condenser, separator, superheater, filter and blower) is duplicated. A new tie-in would be required to the Bottoms Tank Pump discharge line to route the recovered acid to a new acid grouting facility. The recovered acid would be available for reuse in other INTEC activities. A 22,500-gal acid recycle tank, VES-NCR-171, is available to collect and store LET&D bottoms for use in the NWCF. However, the projected volume needed for expected INTEC operations is much less than the amount that would be generated by the direct evaporation process.

C-2.4 Acid Grouting (PFD-4)

LET&D bottoms would be transferred in batches to a Neutralization Tank. Once a batch was received, solid calcium hydroxide would be added to the tank to neutralize the recovered nitric acid. The Neutralization Tank is equipped with a mixer to ensure adequate mixing of the solid calcium hydroxide with the acid waste, and with a cooling jacket or cooling coils to remove heat generated by the neutralization reaction.

After the addition and mixing of calcium hydroxide is complete, the neutralized acid would be pumped to a hold tank where it is continuously fed to a grout mixer. Blended Portland cement and blast furnace slag (BFS) in a weight ratio of 3:1 cement:slag would be mixed with the neutralized waste in the grout mixer, which would discharge directly into 55-gal drums, the final waste container. Filled drums would be conveyed to a swipe/decontamination area where the drum exterior surface would be swiped to test for radioactive contamination. If contamination was found the drum would be decontaminated and re-swiped. Drums that pass the surface swipe would be transferred to a curing area and held for 24-72 hours to complete curing.

Following curing, the drum would be visually inspected for free water. If water were found, silica gel would be added. Following inspection, the drum would move by conveyor to the pallet loading area. A gantry crane would place four drums on a pallet, which when full would be moved to temporary storage until a full load of drums (approximately 60) is available for shipment to the disposal site. An average of 14 drums would be produced per day, although, depending on the feed, as few as seven or as many as 17 drums would be produced in a day.

C-2.5 Canister Loading and Handling (PFD-5)

PFD-5 summarizes pictorially the steps in loading waste into canisters and loading canisters onto a transport truck. Concentrate from the evaporator will be discharged into RH-TRU canisters. During filling, the canister would be kept under vacuum by a pathway through the fill line and evaporator. When the waste in a canister reached a set fill level, the steam to the evaporator would be shut off and then the feed to the evaporator shut off. This procedure flushes the evaporator. The full canister would be moved out of the fill position to the cooling area. An empty canister would be moved into the fill position. Feed to the evaporator would be restarted and then steam.

The full canister would be moved to the cooling area. A vacuum line would be attached to maintain a slight negative pressure in the canister, a clamp-on cooler would be attached and cooling water lines connected to the cooler. The waste temperature and off-gas moisture level would be monitored during cooling. Upon reaching a set temperature and moisture level, a plug would be inserted into the pintle fill hole and the canister moved to lag storage.

Empty canisters with pre-welded lids would be lowered into the Treatment Facility using an overhead crane and placed in a staging area until needed. Each empty canister would be weighed. When needed, a canister would be moved into an airlock, then out of the airlock, and into position to be attached to the evaporator discharge. After filling and cooling, the canister would be visually inspected. After attaching the pintle plug, the canister would be moved into the airlock and after closing the airlock door a surface swipe is performed. If analysis shows no contamination, the canister would be weighed, the dose rate of the canister measured, and the canister moved out of the airlock. If surface contamination were found on the swipe, the canister would be decontaminated, dried, and re-swiped.

In separate operations, a cask would be loaded onto a transporter and the transporter would be positioned over the canister load-out port. The filled canister would be lifted out of the treatment facility and into the cask. An inner lid would be attached to the cask. The transporter would then be repositioned and the outer lid attached to the cask. The cask would then be rotated into the transport position; the transporter inspected and then would depart from the facility.

Through a combination of sampling the feed material, acceptable knowledge, and measurements made during packaging, the waste would be certified to meet the Waste Isolation Pilot Plant (WIPP) RH-TRU Waste Acceptance Criteria (WAC).

Equipment shown on PFD-5 is new equipment.

C-2.6 Alkaline Scrub Process (PFD-2A)

The alkaline scrub process is an alternative direct evaporation scheme that offers the potential for reducing the number of equipment items required, reducing the plot space and reducing the cost of the treatment facility. PFDs 1 and 5 as described above would be included, but PFD-3 and PFD-4 are eliminated. Changes to PFD-2, shown on PFD-2A, are described below.

As in the revised baseline process, overhead from the SBW evaporator would pass through both an internal mist eliminator and then an external demister vessel. However, the vapor from the demister would then enter a packed bed scrubber. The scrubber would contain magnesium oxide pellets that would react with nitric and hydrochloric acid vapors in the evaporator vapor. An aqueous scrub solution would be sprayed into the top of the column. As the liquid flows down through the bed, it would dissolve the products of the MgO/acid gas reactions. The scrub solution exiting the bed would be recycled to the top of the column, with a purge sent to the evaporator and makeup water added to maintain the liquid flow

rate. The scrubber temperature would be controlled by a cooler on the scrub circulation stream. The scrub solution would be purged to the evaporator.

MgO would be continually added to the bed to replace that removed by reaction and dissolution. The MgO would be carried into the bed as a slurry with make-up water. Other reactions would occur in the scrubber, such as the formation of magnesium hydroxide by reaction of MgO with steam. The scrubber may also remove some of the mercury from the evaporator vapor. However, the concentration of mercury in the vapor leaving the scrubber is determined by vapor-liquid equilibrium of the recirculated liquid and the exiting gas. As mercury builds up in the scrub solution over time, the concentration in the vapor will increase proportionately.

The scrubber effluent gas is superheated and then mercury is removed in a bed of sulfur-impregnated (S-) granulated activated carbon (GAC). The bed contains sufficient carbon to process the entire inventory of SBW and NGLW. Vapors exiting the GAC bed are HEPA-filtered and boosted in pressure to be exhausted through the INTEC stack.

C-3. PROCESS OPERATION

This section describes the operation of the direct evaporation process.

Prior to processing, mixing pumps would have been installed in Tanks WM-187, WM-188 and WM-189, and the solids initially in Tank WM-187 would be distributed between these three tanks by a series of waste transfers between these tanks. After these transfers, all concentrated NGLW in tanks WM-100, WM-101 and WM-102 would be transferred to WM-187. This NGLW transfer is needed to be able to continue using these smaller tanks to receive and collect NGLW. The four waste tanks – WM-180, WM-187, WM-188 and WM-189 - would then be sampled and the analytical results used to support qualification of the wastes from the treatment process.

After plant start-up activities are complete, waste from Tank WM-187 would be processed. Processing this tank first would free it up to receive flush water from the other tanks after they are emptied. Following the completion of processing Tank WM-187 waste, waste from one of the other tanks (WM-180, WM-188 or WM-189) would be processed. When waste has been withdrawn to heel level, estimated to be about 3000 gallons, processing of waste from a second of these three tanks would begin. Simultaneously, heel from the emptied tank would be flushed with water to Tank WM-187. After this sequence is repeated for another tank, the treatment process will be processing waste from the last tank, and heel from two tanks will have been collected in WM-187.

The contents of Tank WM-187, mostly flush water, would then be evaporated (using presently existing INTEC evaporators), with the concentrate sent to WM-100, WM-101 or WM-102 to be held for treatment. After completing treatment of waste in the final waste tank, its heel would be flushed to WM-187, which initially contains a dilute heel. The final evaporation of WM-187 would produce about 3000-4000 gallons of concentrate, which would either be treated in the SBW treatment facility or dispositioned with other NGLW collected during 2012. The heel in WM-187, dilute to begin with, would be flushed using multiple washes to the NGLW tanks. This waste, if concentrated separately from other wastes, would produce only an estimated 300 gallons of concentrate. Thus, flush from WM-187 would more likely be evaporated with other NGLW collected in late 2012, and the concentrate dispositioned with this NGLW.

Transfers of about 10,000 gallons from the Tank Farm to the Direct Evaporation Facility would be made once every 5 days. At a rate of 50 gpm, the transfer would take about 3.3 hours. Waste qualification would be based on analysis of samples taken from the TFF tanks, hence no holdup is

designed into the treatment facility feed tank for sample turnaround. The treatment facility would thus have a single tank to receive SBW from the TFF and feed it to a single operating evaporator. The evaporator is fed continuously while a canister is being filled. Feed is introduced into the evaporator and then steam to the evaporator steam jacket. Bottoms product falls directly into a waste canister. When the canister is full, the steam to the evaporator is shut off, followed by the SBW feed. The time interval required to replace the full canister with an empty one is estimated to be on average about 2.5 hours, longer when the facility starts up and then decreasing. When a new canister is in place, the feed is restarted to the evaporator and then the steam. The evaporator downtime fraction (ratio of downtime to total time) due to canister switch operations is expected to be about 0.2 for the revised baseline scheme or 0.3 for the alkaline scrubbing scheme.

A spare evaporator and evaporator overhead demister would be installed to reduce the risk of shutdown due to mechanical or other problems related to evaporator operation.

Vapors from the demister are condensed and condensate collected in a single condensate tank. Condensate would be collected for approximately six days and then sent to the LET&D at a rate of 500 gal/hr. The contents of the condensate tank would be processed in the LET&D in 20 hours.

The LET&D bottoms tank has a capacity of 200 gallons. The tank will be filled and transferred to the direct evaporation facility for grouting every 1.4–3.4 hours, depending on the feed case. The transfer rate would exceed the generation rate by about a factor of two. A 200-gallon batch of acid would be received in the neutralization tank and as acid is received, CaO would be added, neutralizing the waste. Mixing the contents of the neutralization would continue for about 15 minutes after feed had stopped. Periodically the neutralized acid would then be transferred to the Grout Feed Tank.

The Grout Feed Tank and Neutralization Tank need to have a combined capacity to supply a continuous feed to the grout mixer during the downtime for the LET&D. This requires a combined volume of about 3000 gallons. Assuming equal capacity for each of these two tanks, the Neutralization Tank would feed the Grout Feed Tank until it reached its capacity of 1500 gallons. Then transfers would be stopped until the Grout Feed Tank reached a low-level set point. Then the contents of the Neutralization Tank would again be transferred to the Grout Feed Tank. At some point, the Neutralization Tank would reach an “empty” level and remain so until operation of the LET&D resumed. However, waste in the Grout Feed Tank would continuously supply feed to the grout mixer during this time. A single grout mixer would be in operation at all times; a spare would be available but not installed.

C-4. PROCESS FLOW DIAGRAMS

Process flow diagrams are shown on the following pages:

Page			
25	T-1	Title Sheet and Legend	
26	PFD-1	Waste Tanks	(Existing TFF)
27	PFD-2	SBW Evaporator	(New equipment, baseline scheme)
28	PFD-2a	SBW Evaporator, Alkaline Scrub	(New equipment, alkaline scrub scheme)
29	PFD-3	LET&D Fractionator	(Existing equipment, baseline scheme)
30	PFD-4	Acid Grouting	(New equipment, baseline scheme)
31	PFD-5	Canister Loading and Handling	(New equipment)

REVISIONS		
REV	DESCRIPTION	EFFECTIVE DATE

PFD NO.	DRAWING TITLE
T-1	DIRECT EVAPORATION TITLE SHEET AND LEGEND
PFD-1	DIRECT EVAPORATION WASTE TANKS
PFD-2	DIRECT EVAPORATION SBW EVAPORATOR
PFD-2a	DIRECT EVAPORATION SBW EVAPORATOR, ALKALINE SCRUB SCHEME
PFD-3	DIRECT EVAPORATION LET&D FRACTIONATOR
PFD-4	DIRECT EVAPORATION ACID GROUTING
PFD-5	DIRECT EVAPORATION CANISTER LOADING AND HANDLING

VALVES & ACTUATORS

- BALL VALVE
- BUTTERFLY VALVE
- GATE VALVE
- ROTARY VALVE
- SLIDE VALVE
- CYLINDER OPERATED ACTUATOR
- DIAPHRAGM OPERATED ACTUATOR
- PRESSURE REGULATER

CONTROL ABBREVIATIONS

A	ANALYZER OR ANALYSIS
D	DENSITY OR SPECIFIC GRAVITY
F	FLOW
H	HAND
L	LEVEL
P	PRESSURE
PD	PRESSURE DIFFERENCE
PH	ACIDITY/ALKALINITY
T	TEMPERATURE
TD	TEMPERATURE DIFFERENCE

(* FROM ABOVE)

- (*S) — SWITCH
- (*C) — CONTROL OR CONTROLLER
- (*I) — INDICATOR

LEGEND

- MASS BALANCE STREAM NUMBER
- STEAM OR AIR JET
- MIXING PUMP
- BLOWER
- HEAT EXCHANGER
- CENTRIFUGAL PUMP
- REBOILER
- LIQUID MIXER
- UNDERGROUND TANK
- SOLID MIXER/AUGER
- STEAM GENERATOR
- HEPA FILTER BANK
- TANK
- FRACTIONATOR
- EVAPORATOR
- GAC BED
- BIN OR HOPPER WITH COOLING JACKET
- SURGE BIN AND FEEDER
- SOLIDS RECEIVING BIN OR HOPPER
- BALLOONS INDICATE NEW EQUIPMENT OR LINES
- KNOCK OUT DRUM OR MIST ELIMINATOR
- STACK
- PACKED BED SCRUBBER

DASH NO.	NEW ASSY	APPLICATION
SUBCONTRACT NO.		
HLQUILSTRUM:		
DESIGN:		
DRAWN:		
PROJECT NO.		
SPEC CODE		
FOR REVIEW/APPROVAL SIGNATURES SEE DAR NO.		
EFFECTIVE DATE:		

INEEL Idaho National Engineering & Environmental Laboratory BECHTEL BWXT IDAHO, LLC

DIRECT EVAPORATION
TITLE SHEET AND LEGEND
T-1

SIZE	CAGE CODE	INDEX CODE NUMBER				DWG- T-1	REV
		AREA	TYPE	CL	DWG		
D	01MF3				090		

SCALE: NONE SHEET 1 OF 1

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REVISIONS		
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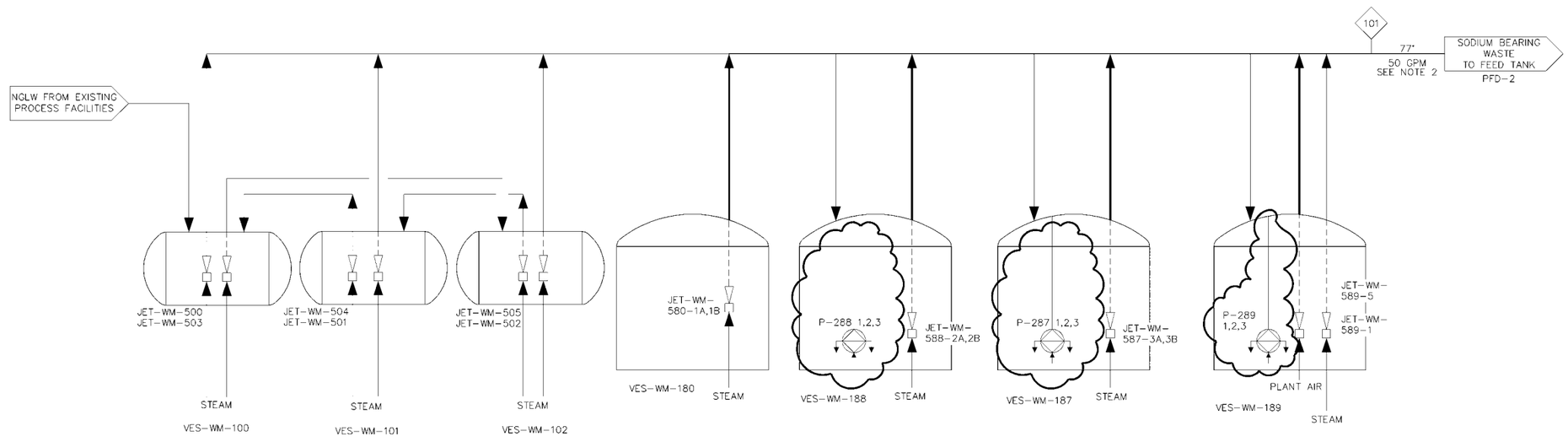

NOTES:

1. ALL EQUIPMENT ON THIS PROCESS FLOW DIAGRAM IS EXISTING EXCEPT P-287, P-288 AND P-289.
2. TRANFERS OF WASTE TO THE SBW FEED TANK WILL BE MADE APPROXIMATELY ONCE EVERY FIVE DAYS.

P-288-1, 2, 3
TANK 188 MIX
PUMPS

P-287-1, 2, 3
TANK 187 MIX
PUMPS

P-289-1, 2, 3
TANK 189 MIX
PUMPS

SUBCONTRACT NO.	INEEL Idaho National Engineering & Environmental Laboratory BECHTEL BWXT IDAHO, LLC
REQUESTER:	DIRECT EVAPORATION PFD-1 WASTE TANKS
DESIGN:	
DRAWN:	
PROJECT NO.	
SPCL CODE	
FOR REVIEW/APPROVAL SIGNATURES SEE DAR NO.	SIZE D · CAGE CODE 01MF3 · INDEX CODE NUMBER AREA TYPE CI ORIG 090 · DWG-PFD-1 · REV
EFFECTIVE DATE:	SCALE: NONE · SHEET 1 OF 1

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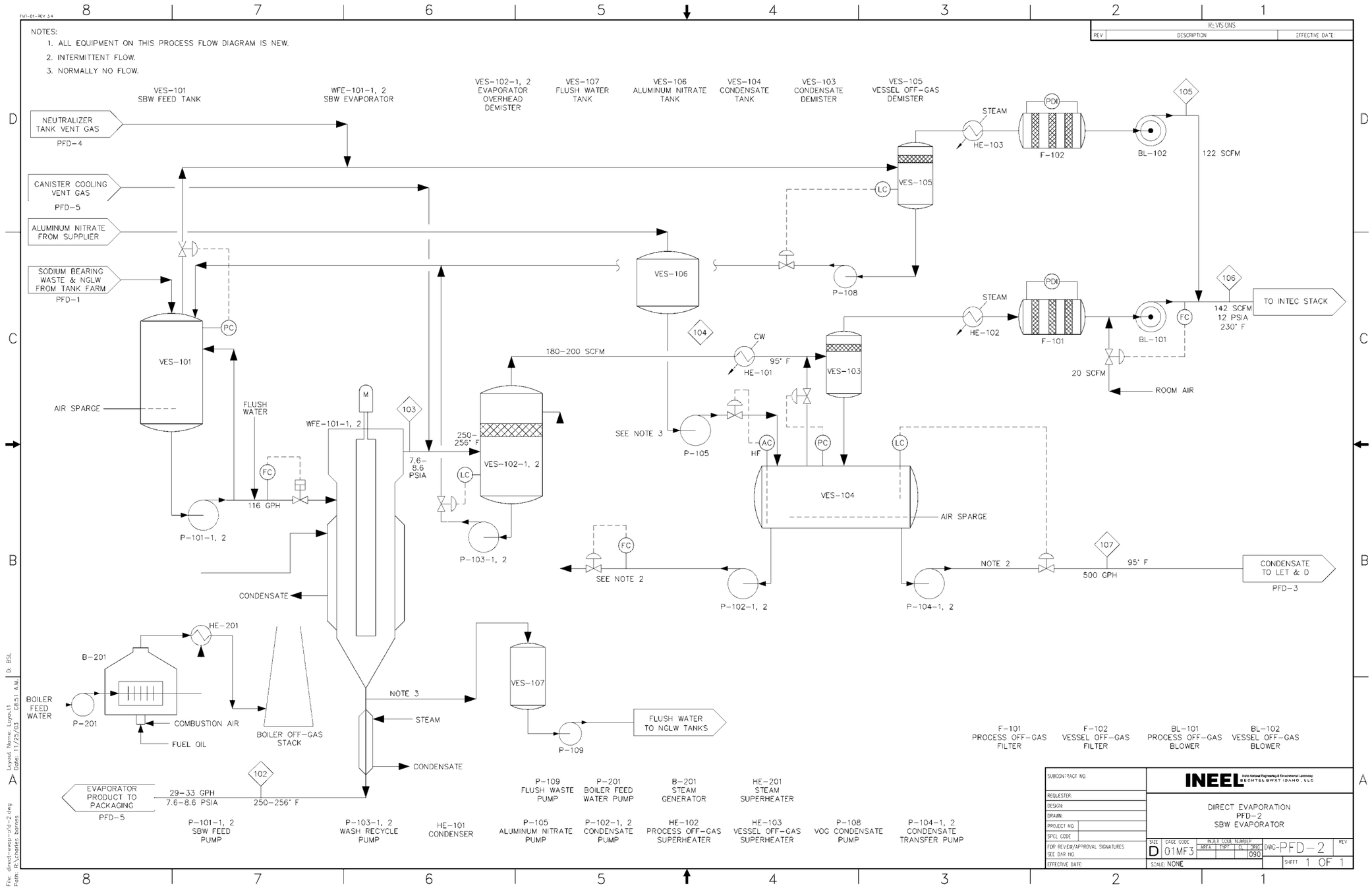
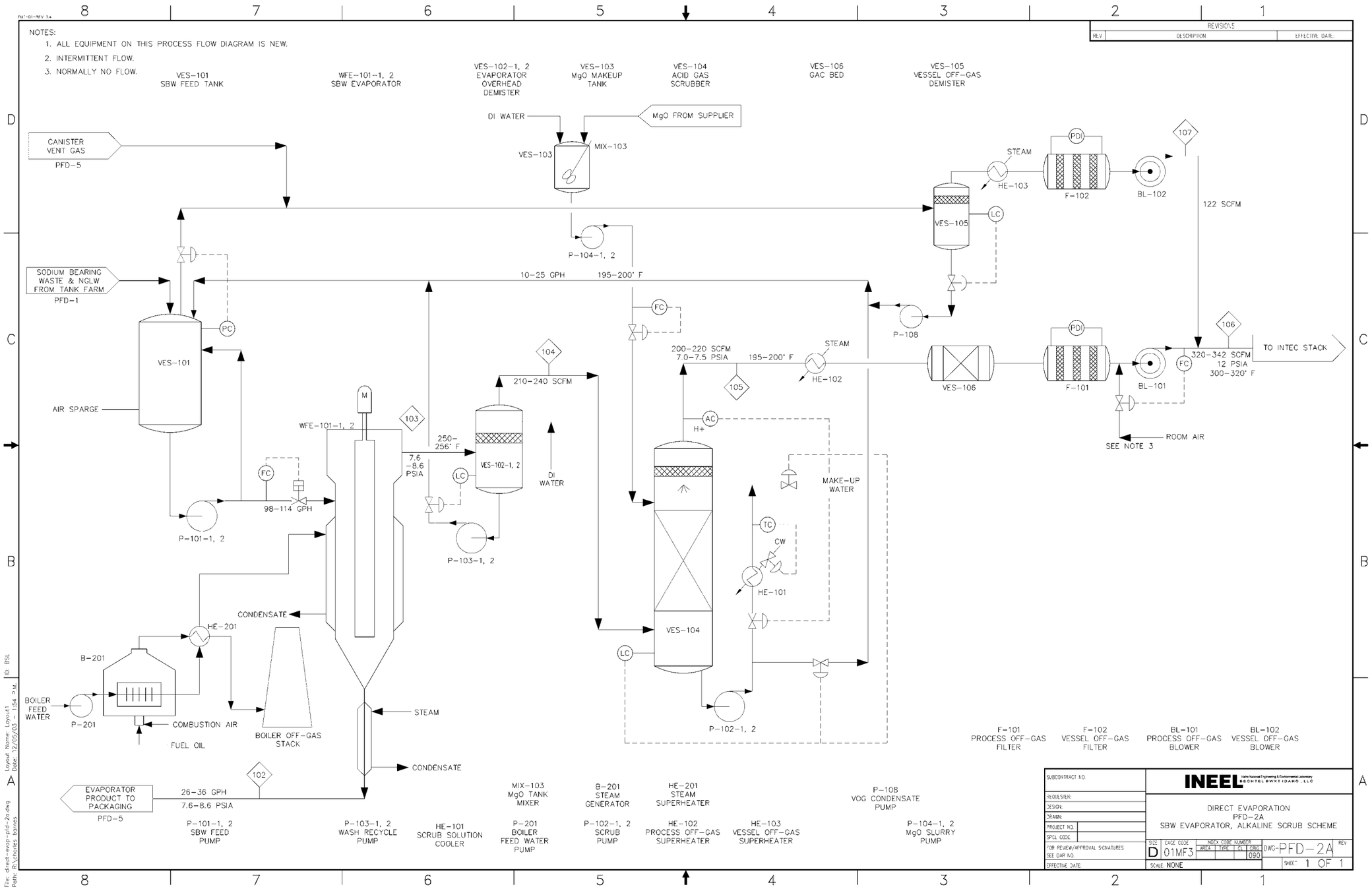

NOTES:
1. ALL EQUIPMENT ON THIS PROCESS FLOW DIAGRAM IS NEW.
2. INTERMITTENT FLOW.
3. NORMALLY NO FLOW.
REVISIONS
REV
DESCRIPTION
EFFECTIVE DATE
VES-101 SBW FEED TANK
WFE-101-1, 2 SBW EVAPORATOR
VES-102-1, 2 EVAPORATOR OVERHEAD DEMISTER
VES-107 FLUSH WATER TANK
VES-106 ALUMINUM NITRATE TANK
VES-104 CONDENSATE TANK
VES-103 CONDENSATE DEMISTER
VES-105 VESSEL OFF-GAS DEMISTER
NEUTRALIZER TANK VENT GAS
PFD-4
CANISTER COOLING VENT GAS
PFD-5
ALUMINUM NITRATE FROM SUPPLIER
SODIUM BEARING WASTE & NGLW FROM TANK FARM
PFD-1
STEAM
HE-103
F-102
PDI
BL-102
105
122 SCFM
LC
VES-105
VES-106
P-108
106
TO INTEC STACK
142 SCFM
12 PSIA
230° F
HE-102
F-101
BL-101
FC
20 SCFM
ROOM AIR
PC
VES-101
AIR SPARGE
FLUSH WATER
CW
95° F
HE-101
180-200 SCFM
104
VES-103
SEE NOTE 3
P-105
AC
HF
VES-104
AIR SPARGE
M
WFE-101-1, 2
103
250-256° F
VES-102-1, 2
7.6-8.6 PSIA
116 GPH
P-101-1, 2
P-103-1, 2
SEE NOTE 2
P-102-1, 2
P-104-1, 2
NOTE 2
107
95° F
500 GPH
CONDENSATE TO LET & D
PFD-3
CONDENSATE
HE-201
B-201
BOILER FEED WATER
P-201
COMBUSTION AIR
FUEL OIL
BOILER OFF-GAS STACK
NOTE 3
STEAM
CONDENSATE
VES-107
P-109
FLUSH WATER TO NGLW TANKS
EVAPORATOR PRODUCT TO PACKAGING
PFD-5
29-33 GPH
7.6-8.6 PSIA
102
250-256° F
F-101 PROCESS OFF-GAS FILTER
F-102 VESSEL OFF-GAS FILTER
BL-101 PROCESS OFF-GAS BLOWER
BL-102 VESSEL OFF-GAS BLOWER
P-101-1, 2 SBW FEED PUMP
P-103-1, 2 WASH RECYCLE PUMP
HE-101 CONDENSER
P-105 ALUMINUM NITRATE PUMP
P-109 FLUSH WASTE PUMP
P-102-1, 2 CONDENSATE PUMP
P-201 BOILER FEED WATER PUMP
HE-102 PROCESS OFF-GAS SUPERHEATER
B-201 STEAM GENERATOR
HE-103 VESSEL OFF-GAS SUPERHEATER
P-108 VOG CONDENSATE PUMP
P-104-1, 2 CONDENSATE TRANSFER PUMP
SUBCONTRACT NO.
REQUESTER:
DESIGN:
DRAWN:
PROJECT NO.
SPCL CODE
FOR REVIEW/APPROVAL SIGNATURES SEE DAR NO.
EFFECTIVE DATE:
INEEL
DIRECT EVAPORATION
PFD-2
SBW EVAPORATOR
SIZE D
CAGE CODE 01MF3
DWG-PFD-2
REV
SCALE: NONE
SHEET 1 OF 1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1. ALL EQUIPMENT ON THIS PROCESS FLOW DIAGRAM IS NEW.
2. INTERMITTENT FLOW.
3. NORMALLY NO FLOW.
REVISIONS
REV
DESCRIPTION
EFFECTIVE DATE
VES-101 SBW FEED TANK
WFE-101-1, 2 SBW EVAPORATOR
VES-102-1, 2 EVAPORATOR OVERHEAD DEMISTER
VES-103 MgO MAKEUP TANK
VES-104 ACID GAS SCRUBBER
VES-106 GAC BED
VES-105 VESSEL OFF-GAS DEMISTER
DI WATER
MgO FROM SUPPLIER
VES-103
MIX-103
CANISTER VENT GAS
PFD-5
STEAM
HE-103
F-102
BL-102
107
122 SCFM
VES-105
LC
P-104-1, 2
SODIUM BEARING WASTE & NGLW FROM TANK FARM
PFD-1
10-25 GPH
195-200° F
FC
PC
P-108
VES-101
104
200-220 SCFM
7.0-7.5 PSIA
195-200° F
STEAM
HE-102
105
VES-106
F-101
BL-101
106
320-342 SCFM
12 PSIA
300-320° F
TO INTEC STACK
210-240 SCFM
AIR SPARGE
M
WFE-101-1, 2
103
250-256° F
7.6-8.6 PSIA
VES-102-1, 2
DI WATER
AC
H+
ROOM AIR
SEE NOTE 3
MAKE-UP WATER
98-114 GPH
P-101-1, 2
P-103-1, 2
TC
CW
HE-101
CONDENSATE
HE-201
B-201
VES-104
BOILER FEED WATER
P-201
COMBUSTION AIR
FUEL OIL
BOILER OFF-GAS STACK
STEAM
CONDENSATE
P-102-1, 2
102
EVAPORATOR PRODUCT TO PACKAGING
PFD-5
26-36 GPH
7.6-8.6 PSIA
P-101-1, 2 SBW FEED PUMP
P-103-1, 2 WASH RECYCLE PUMP
HE-101 SCRUB SOLUTION COOLER
MIX-103 MgO TANK MIXER
P-201 BOILER FEED WATER PUMP
B-201 STEAM GENERATOR
P-102-1, 2 SCRUB PUMP
HE-201 STEAM SUPERHEATER
HE-102 PROCESS OFF-GAS SUPERHEATER
HE-103 VESSEL OFF-GAS SUPERHEATER
P-108 VOG CONDENSATE PUMP
P-104-1, 2 MgO SLURRY PUMP
F-101 PROCESS OFF-GAS FILTER
F-102 VESSEL OFF-GAS FILTER
BL-101 PROCESS OFF-GAS BLOWER
BL-102 VESSEL OFF-GAS BLOWER
SUBCONTRACT NO.
REQUESTER:
DESIGN:
DRAWN:
PROJECT NO.
SPCL CODE
FOR REVIEW/APPROVAL SIGNATURES SEE DWR NO.
EFFECTIVE DATE:
INEEL
Idaho National Engineering & Environmental Laboratory
BECHTEL BWXT IDAHO, LLC
DIRECT EVAPORATION
PFD-2A
SBW EVAPORATOR, ALKALINE SCRUB SCHEME
SIZE D
CAGE CODE 01MF3
INDEX CODE NUMBER
AREA TYPE CL CRIG 090
DWG-PFD-2A
REV
SCALE NONE
SHEET 1 OF 1
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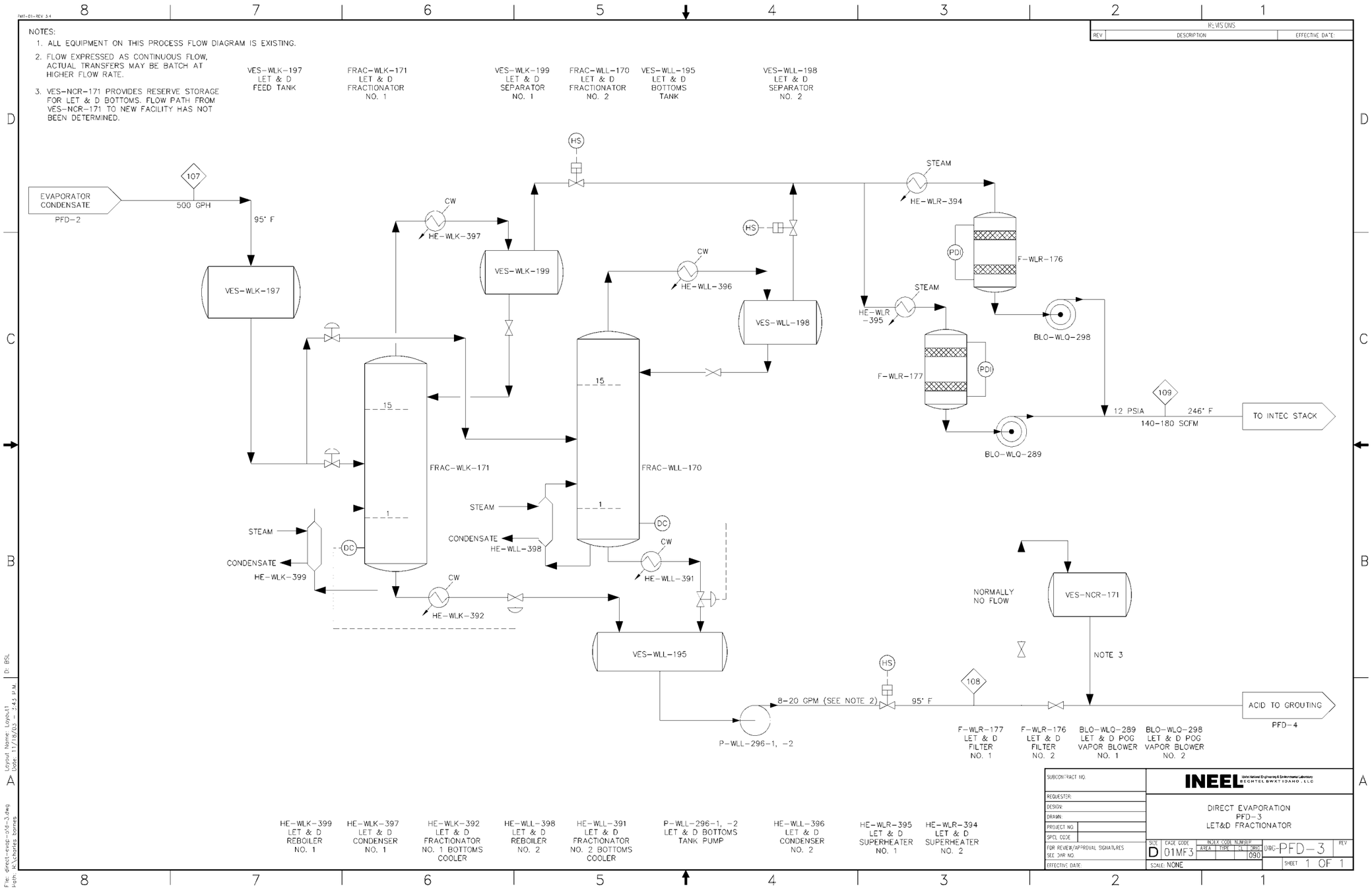
ID: BSL


NOTES:
1. ALL EQUIPMENT ON THIS PROCESS FLOW DIAGRAM IS EXISTING.
2. FLOW EXPRESSED AS CONTINUOUS FLOW, ACTUAL TRANSFERS MAY BE BATCH AT HIGHER FLOW RATE.
3. VES-NCR-171 PROVIDES RESERVE STORAGE FOR LET & D BOTTOMS. FLOW PATH FROM VES-NCR-171 TO NEW FACILITY HAS NOT BEEN DETERMINED.
REVISIONS
REV
DESCRIPTION
EFFECTIVE DATE
VES-WLK-197 LET & D FEED TANK
FRAC-WLK-171 LET & D FRACTIONATOR NO. 1
VES-WLK-199 LET & D SEPARATOR NO. 1
FRAC-WLL-170 LET & D FRACTIONATOR NO. 2
VES-WLL-195 LET & D BOTTOMS TANK
VES-WLL-198 LET & D SEPARATOR NO. 2
EVAPORATOR CONDENSATE
PFD-2
107
500 GPH
95° F
VES-WLK-197
CW
HE-WLK-397
VES-WLK-199
HS
CW
HE-WLL-396
VES-WLL-198
STEAM
HE-WLR-394
PDI
F-WLR-176
STEAM
HE-WLR -395
F-WLR-177
BLO-WLQ-298
BLO-WLQ-289
109
12 PSIA
246° F
140-180 SCFM
TO INTEC STACK
FRAC-WLK-171
FRAC-WLL-170
STEAM
CONDENSATE
HE-WLK-399
DC
STEAM
CONDENSATE
HE-WLL-398
DC
CW
HE-WLL-391
CW
HE-WLK-392
VES-WLL-195
NORMALLY NO FLOW
VES-NCR-171
NOTE 3
HS
108
8-20 GPM (SEE NOTE 2)
95° F
P-WLL-296-1, -2
F-WLR-177 LET & D FILTER NO. 1
F-WLR-176 LET & D FILTER NO. 2
BLO-WLQ-289 LET & D POG VAPOR BLOWER NO. 1
BLO-WLQ-298 LET & D POG VAPOR BLOWER NO. 2
ACID TO GROUTING
PFD-4
HE-WLK-399 LET & D REBOILER NO. 1
HE-WLK-397 LET & D CONDENSER NO. 1
HE-WLK-392 LET & D FRACTIONATOR NO. 1 BOTTOMS COOLER
HE-WLL-398 LET & D REBOILER NO. 2
HE-WLL-391 LET & D FRACTIONATOR NO. 2 BOTTOMS COOLER
P-WLL-296-1, -2 LET & D BOTTOMS TANK PUMP
HE-WLL-396 LET & D CONDENSER NO. 2
HE-WLR-395 LET & D SUPERHEATER NO. 1
HE-WLR-394 LET & D SUPERHEATER NO. 2
SUBCONTRACT NO.
REQUESTER:
DESIGN:
DRAWN:
PROJECT NO.
SPCL CODE
FOR REVIEW/APPROVAL SIGNATURES
SEE DWR NO.
EFFECTIVE DATE:
INEEL
DIRECT EVAPORATION
PFD-3
LET&D FRACTIONATOR
SIZE D
CAGE CODE 01MF3
INDEX CODE NUMBER
AREA TYPE SQ SEQ 090
DWG-PFD-3
REV
SCALE: NONE
SHEET 1 OF 1
File: direct-evap-old-3.dwg
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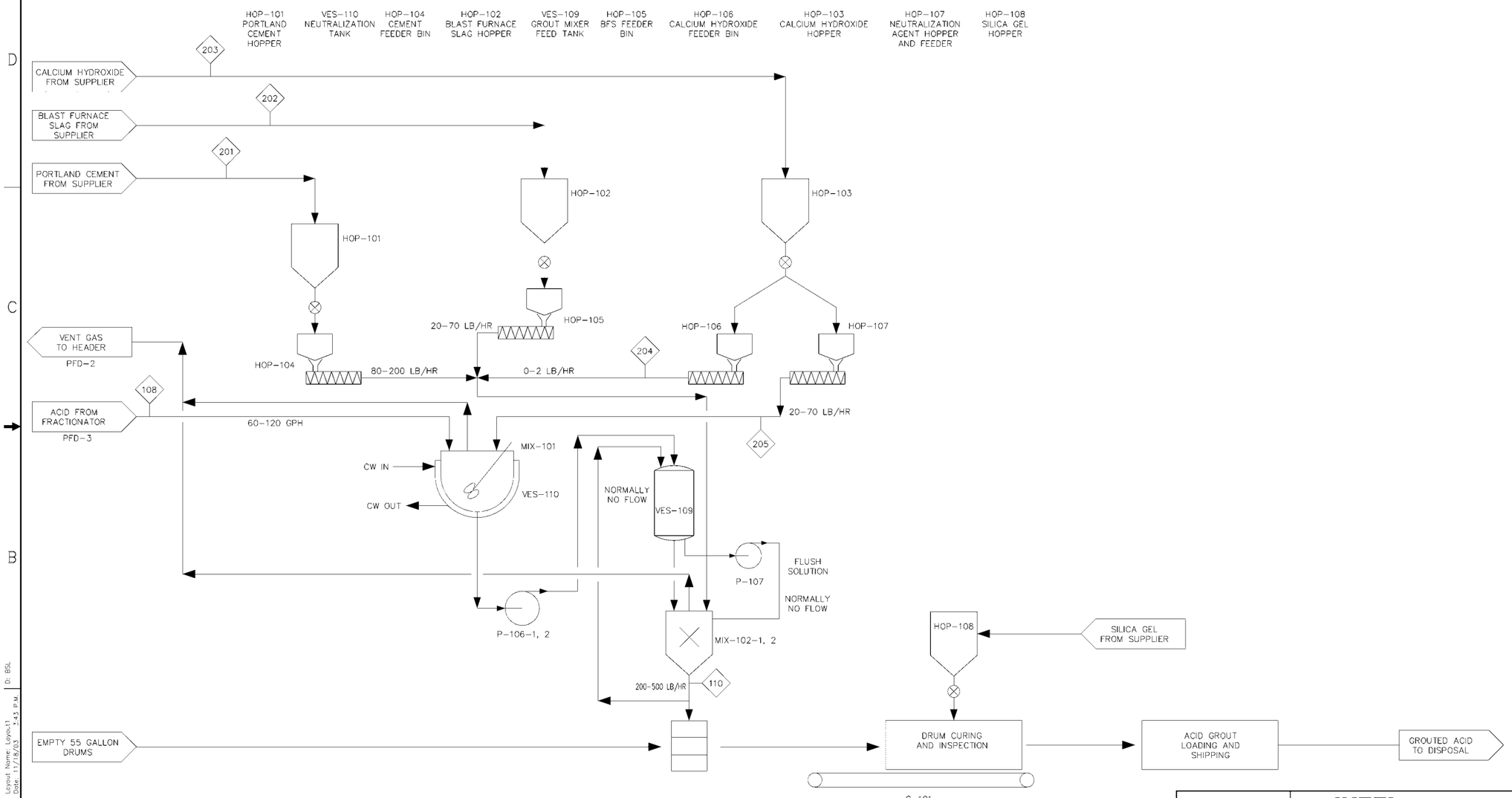
Layout Name: Layout1
Date: 11/18/03 - 3:43 P.M.
D: BSL

NOTES:
1. ALL EQUIPMENT ON THIS PROCESS FLOW DIAGRAM IS NEW.

REVISIONS		
REV	DESCRIPTION	EFFECTIVE DATE



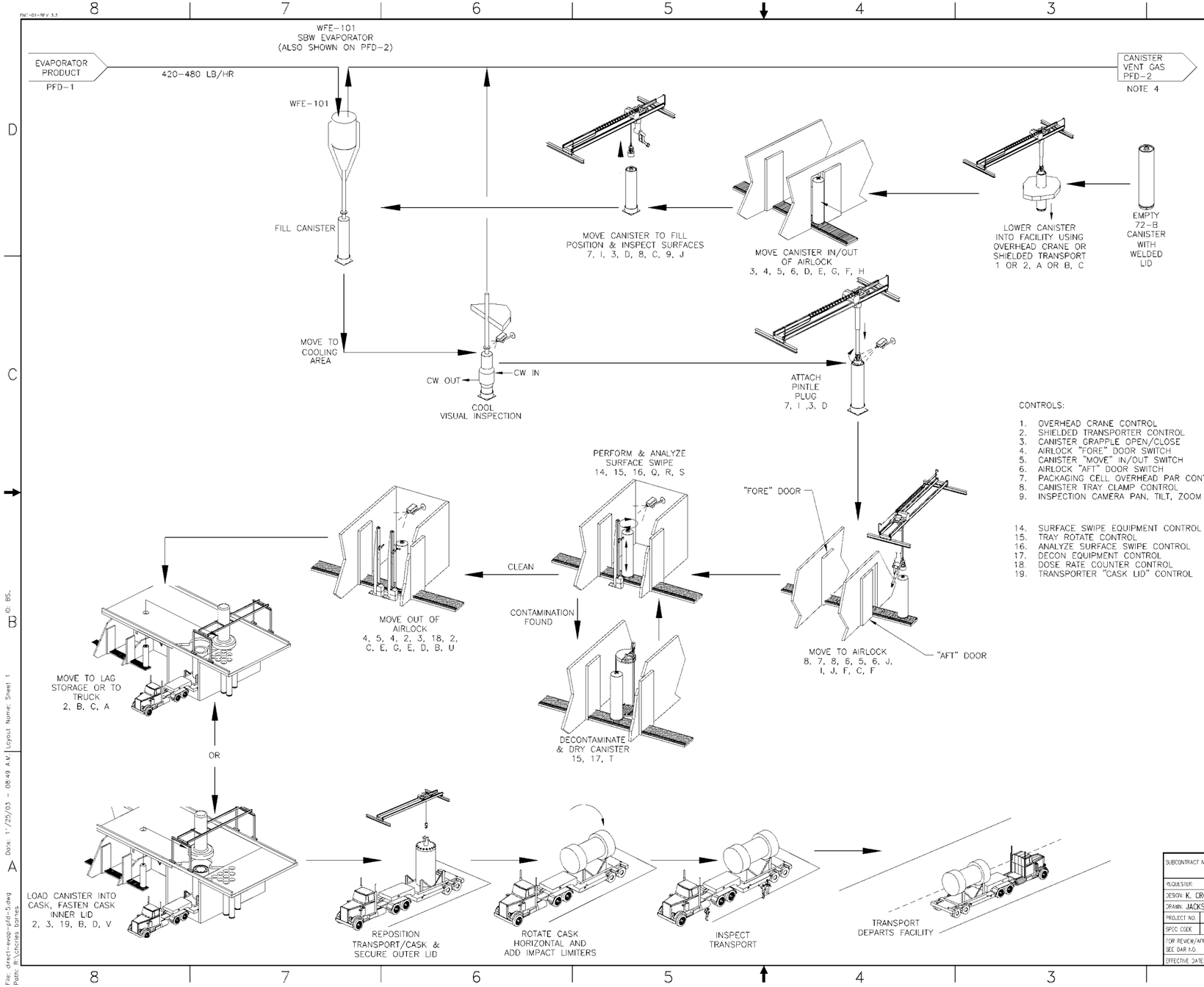
SUBCONTRACT NO.
REQUESTER
DESIGN:
DRAWN:
PROJECT NO.
SPECL CODE
FOR REVIEW/APPROVAL SIGNATURES SEE DWR NO.
EFFECTIVE DATE:

INEEL Idaho National Engineering & Environmental Laboratory
BECHTEL BWXT IDAHO, LLC

DIRECT EVAPORATION
PFD-4
ACID GROUTING

SIZE	CAGE CODE	INDEX CODE NUMBER				DWG-PFD-4	REV
		AREA	TYPE	EL	SEQ		
D	01MF3				090		

SCALE: NONE
SHEET 1 OF 1



REVISIONS		
REV	DESCRIPTION	EFFECTIVE DATE

NOTES

1. ALL EQUIPMENT SHOWN ON PFD-10 IS NEW.
2. STEPS SHOWN FOR HANDLING CANISTERS AND LOADING CASKS ARE ABBREVIATED.
3. DIRECT VIEW OF THE OPERATIONS THROUGH SHIELDED WINDOWS WITH CAMERA SUPPLEMENTS.
4. CANISTERS BEING FILLED ARE VENTED THROUGH THE SBW EVAPORATOR WFE-101 AND THE PROCESS OFFGAS TREATMENT EQUIPMENT. CANISTERS IN THE COOLING AREA ARE VENTED TO THE POG SYSTEM, BYPASSING THE EVAPORATOR.

CONTROLS:

1. OVERHEAD CRANE CONTROL
2. SHIELDED TRANSPORTER CONTROL
3. CANISTER GRAPPLE OPEN/CLOSE
4. AIRLOCK "FORE" DOOR SWITCH
5. CANISTER "MOVE" IN/OUT SWITCH
6. AIRLOCK "AFT" DOOR SWITCH
7. PACKAGING CELL OVERHEAD PAR CONTROL
8. CANISTER TRAY CLAMP CONTROL
9. INSPECTION CAMERA PAN, TILT, ZOOM

14. SURFACE SWIPE EQUIPMENT CONTROL
15. TRAY ROTATE CONTROL
16. ANALYZE SURFACE SWIPE CONTROL
17. DECON EQUIPMENT CONTROL
18. DOSE RATE COUNTER CONTROL
19. TRANSPORTER "CASK LID" CONTROL

SENSORS:

A. CRANE LOAD WEIGHT
B. TRANSPORTER LOAD WEIGHT
C. CANISTER PRESENT
D. CANISTER GRAPPLE OPEN/CLOSE
E. AIRLOCK "FORE" DOOR OPEN/CLOSE SWITCH
F. AIRLOCK "AFT" DOOR OPEN/CLOSE SWITCH
G. "FORE" CANISTER LOCATION SWITCH
H. "AFT" CANISTER LOCATION SWITCH
I. PACKAGING CELL OVERHEAD PAR SENSORS
J. CANISTER CLAMP OPEN/CLOSE

Q. SURFACE SWIPE EQUIPMENT SENSOR
R. SURFACE SWIPE ANALYSIS SENSOR
S. TRAY ROTATE SENSOR
T. DECON EQUIPMENT SENSOR
U. DOSE RATE COUNTER SENSOR
V. TRANSPORTER "CASK LID" POSITION

SUBCONTRACT NO.
REQUESTER:
DESIGN: K. CROFT
DRAWN: JACKSON
PROJECT NO.
SPEC CODE
FOR REVIEW/APPROVAL SIGNATURES SEE DAR NO.
EFFECTIVE DATE:

INEEL Idaho National Engineering & Environmental Laboratory
BECHTEL BWXT IDAHO, LLC

DIRECT EVAPORATION
CANISTER LOADING AND HANDLING
PFD-5

SIZE	CAGE CODE	INDEX CODE NUMBER				DWG	REV
		AREA	TYPE	CL	ORIG		
D	01MF3				090	DWG-PFD-5	

SCALE: NONE
SHEET 1 OF 1

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Date: 1/25/03 - 08:49 AM | Layout Name: Sheet 1 | ID: BS-

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C-5. PROCESS BASIS

This section includes a summary of technical and functional requirements, process assumptions, a discussion of variations of the direct evaporation process, the basis for the process shown on the process flow diagrams, and the basis for the mass balances.

C-5.1 Requirements

A draft technical and functional requirements document (T&FR) was prepared for the direct evaporation process (Barden, 2003). Most functional and performance requirements identified in the T&FR document are summarized below. For other requirements, including special requirements, design requirements, testing and maintenance requirements and codes, standards and regulations refer to the T&FR document. The T&FR document also provides the basis or reference for each requirement.

C-5.1.1 System Requirements

C-5.1.1.1 Retrieve Waste. The system shall have the capability to retrieve SBW from WM-180, WM-187, WM-188, and WM-189 and NGLW from WM-100, WM-101 and WM-102.

C-5.1.1.2 Treat Waste – Volume. The facility shall be capable of processing 1.2 million gallons of waste.

C-5.1.1.3 Treat Waste – Throughput. The facility design throughput shall provide the capability of processing all SBW including liquids and tank solids and NGLW collected through 2011 within 3.0 years. This time-period includes six months of hot start-up.

C-5.1.1.4 Treat Waste – Location. The waste shall be treated and packaged at the INEEL, within the INTEC security enclosure, or outside of the INTEC security enclosure with its own security system.

C-5.1.1.5 Treat Waste – Meet WIPP RH-TRU WAC for the Evaporator Bottoms. The activity and mass of each of the following radionuclides shall be established on a payload container basis: Am-241, Pu-238, Pu-239, Pu-240, Pu-242, U-233, U-234, U-238, Sr-90, and Cs-137. If these radionuclides do not account for at least 95% of the total waste product radioactivity, the mass and activity of additional radionuclides shall be determined until 95% of the waste product activity is accounted for.

1. Any RH-TRU waste product payload container shall have a dose rate at the surface of the container greater than 200 mrem/h and less than 1000 rem/h.

2. The ^{239}Pu fissile gram equivalent (FGE) in each payload container, plus its associated uncertainty expressed in terms of one standard deviation, shall be less than 325 ^{239}Pu FGE.

3. The TRU radionuclide alpha activity concentration, exclusive of the packaging, shall be greater than 100 nCi/g.

4. The ^{239}Pu equivalent curie (PE-Ci) quantities in a payload container shall not exceed 80 PE-Ci for direct loaded RH-TRU waste canisters and shall not exceed 240 PE-Ci for RH-TRU canisters loaded with three 30 gallon or 55 gallon drums.

5. The loaded payload container shall contain no detectable liquid.

6. The hydrogen gas generation rate within each payload container shall not exceed the limit specified in the applicable content code.

7. PCB concentrations in wastes destined for WIPP shall not exceed 50 ppm.

8. Concentrations of flammable volatile organic compounds in the payload container headspace shall not exceed 500 ppm. If calculations cannot show that the VOC concentration in the headspace is less than 500 ppm if all potentially flammable VOCs vaporized into the headspace, sampling of the containers shall be required.

9. The RH-TRU waste shall be placed in a WIPP approved RH-TRU waste canister.

10. The gross weight of a direct loaded RH-TRU canister shall not exceed 5250 lb.

11. Surface contamination on loaded RH-TRU payload containers, payload assemblies, and packages shall not exceed 20 dpm/100 cm^2 alpha and 200 dpm/100 cm^2 beta-gamma.

C-5.1.1.6 Treat Waste – Meet Mixed Low Level WAC for the Grouted Acid Waste.

1. SBW acid grout shall contain less than 10 nCi/g TRU alpha contamination so it may be sent to a qualified mixed low-level waste disposal facility.

2. SBW acid grout shall meet the Land Disposal Restrictions of a permitted near surface disposal unit.

C-5.1.1.7 Transfer Waste to WIPP. All transuranic wastes will be sent to WIPP for disposal. Facilities will be provided to transfer certified payload containers to WIPP-supplied transport vehicles. The SBW Treatment Project will be responsible to load the waste into approved transport casks and prepare those casks for shipment. WIPP will be responsible for providing the casks, trucks, drivers, and receipt of the waste at WIPP in Carlsbad, Mew Mexico.

1. RH-TRU waste shall be shipped in a RH-TRU 72-B cask.

2. The maximum number of payload containers in a RH-TRU 72-B cask is one.

3. The maximum weight of a loaded 72-B cask is 45,000 pounds.

4. All RH-TRU wastes intended for shipment to WIPP shall meet an approved content code listed in the RH-TRUCON.

5. Sufficient lag storage of RH-TRU waste shall be provided in order to meet WIPP requirements for waste qualification and shipping/receiving rates.

6. A cask loading station compatible with loading WIPP supplied RH-TRU 72-B casks delivered on WIPP supplied transport vehicles shall be provided. The facility shall provide the capability to receive RH-TRU 72-B cask transporters in an enclosed area, raise the cask for loading, load the waste payload assemblies into RH-TRU 72-B cask, and close and lower the RH-TRU 72-B cask onto the transporters.

7. One of the cask loading facilities shall have the capability to wash road grime from the transporters and shipping casks prior to moving into the loading area.

C-5.1.1.8 Close Facility.

1. The Direct Evaporation Facility shall be placed in standby after treating the volumes of waste identified above.

2. Prior to December 31, 2012, the Direct Evaporation Facility shall have all hazardous waste and hazardous waste residues removed and placed in safe shutdown until decommissioning.

C-5.1.2 Systems, subsystem, and major components

The direct evaporation facility shall utilize major support systems and utilities that are available at the INEEL. These include:

1. Analytical services.

2. Fire protection. This includes a manned fire station, central alarm system, and fire water lines near the waste treatment facility; it does not include fire protection within the physical structures designed and built or used by this project.

3. Electrical power. Both normal and standby electrical power are available for use near the INTEC Tank Farm from the INTEC electrical distribution system.

4. Steam

5. Telephone

6. Optical cable

7. Security

8. Medical

9. Radiation records

10. Central Facilities maintenance

11. Document control

12. Configuration management

13. Office buildings. The project shall provide adequate office space only for any operations staff, engineers, technicians, supervisors, and managers whose presence is required in the facility full-time during operations, plus limited turn-around office space.

14. Roads

15. Bus transportation.

C-5.1.3 Boundaries and interfaces

C-5.1.3.1 Liquid Waste Retrieval Feed System. The liquid waste retrieval system interfaces with Tank Farm Operations. All operations within the tank farm will be the responsibility of Tank Farm

Operations. Prior to operation of the SBW Treatment Facility, all SBW shall be contained in Tanks WM-180, WM-187, WM-188, and WM-189, and NGLW in WM-100, WM-101 and WM-102. Any modifications necessary to retrieve the SBW liquids and solids from these tanks will be the responsibility of this project.

C-5.1.3.2 Utility Interfaces.

1. Electric power will be obtained from existing sources at INTEC. The project shall provide the necessary equipment for distribution of power within the facility. The use of existing standby, emergency, or uninterruptible power supplies at INTEC shall be evaluated as the first choice during conceptual design.

2. The project shall tie in to the existing INTEC steam distribution piping at an appropriate location adjacent to the facility. If supplemental steam is required, electrical steam generation is preferred to avoid air permitting issues related to direct fired steam boilers.

3. The project shall tie in to the existing INTEC water systems piping (de-mineralized, de-ionized, distilled, fire water, etc.) at an appropriate location adjacent to the facility.

C-5.1.3.3 Sample Handling. Radioactive sample handling shall be compatible with the existing pneumatic sample transport system.

C-5.1.3.4 Tank Farm Closure Project. The system shall interface with the Tank Farm Closure Project. The Tank Farm Closure Project will sequentially remove all liquids and waste solids from the eleven Tank Farm tanks WM-180 through 190. The Tank Farm Closure Project will also clean the tanks to performance parameters, grout the tanks, piping and vaults, and close the tanks by December 2012 in accordance with the INTEC TFF Management Plan. The SBW Treatment project retrieves the wastes from tanks with the support of the TFC Project and treats it in the Direct Evaporation Facility.

C-5.1.3.5 Tank Farm Soils Project. The system shall interface with the Tank Farm Soils Project, which is responsible to remediate, as required, and close the Tank Farm under the Comprehensive Environmental Response, Compensation and Liability Act (CERCLA) program. The Tank Closure Project shall coordinate all work scope with the INTEC CERCLA Environmental Restoration Program (WAG 3) to ensure no conflicts.

C-5.1.3.6 LET&D Facility and Nitric Acid Recycle Hold Tank. The treatment process may interface with the LET&D facility, located in CPP-1618, and the Nitric Acid Recycle Hold Tank, located in CPP-659. Any modifications required to the LET&D treatment equipment, Nitric Acid Recycle Hold Tank, or associated piping and instrumentation will be the responsibility of the SBW Treatment Project. Operation of the LET&D facility and transfers of waste to and from the LET&D facility and the Nitric Acid Recycle Hold Tank will be coordinated with the SBW Treatment Project but the responsibility of INTEC Operations.

C-5.1.4 Operability

The operability requirements for the SBW facility shall support the completion of SBW treatment by December 31, 2011.

C-5.1.4.1 Operational Lifetime. The facility shall have an operational lifetime adequate to process all SBW and tank solids without replacement of any process piping or major system components (tanks, hoppers, reaction vessels, etc).

C-5.1.4.2 Installed Spares. Installed spares shall be provided for all rotating or reciprocating machinery located in remotely operated areas of the facility.

C-5.1.4.3 Annual Operation. The facility shall be designed to operate continuously for at least 200 days per year for at least three sequential years. Note that three-year window is based on a 6-month hot startup of the facility and a two and one-half year processing period for the entire inventory of SBW and NGLW.

C-5.2 Assumptions

Process designs considered for the direct evaporation process have been based on the following major assumptions. Additional assumptions used in the mass balance are identified in Section 2.5.4.

1. The SBW, both liquids and solids, and NGLW to be treated are not high-level waste.

2. The solidified SBW evaporator waste can be qualified for disposal at the WIPP.

3. No neutralization of waste prior to evaporation is required in order to satisfy WIPP's requirements for waste carrying the U-134 hazardous waste code.

4. The existing Evaporator Tank System (ETS) and LET&D acid fractionator will be available for use if needed to process SBW evaporator condensate.

5. The grouted acid waste can be disposed of at a mixed low-level waste disposal site, such as Hanford or Envirocare, provided that the waste meets the site's WAC.

6. Toxic Substance Control Act regulations do not apply.

7. The facility will not require Nuclear Regulatory Commission licensing.

C-5.3 Process Variations

Many variations of the direct evaporation process are possible. Some have been tested and evaluated while others have not. In general, variations in the process could be categorized as differences in (a) how tank solids are treated, (b) the type of evaporator used, (c) details of how the evaporator concentrate is handled and packaged, (d) how the evaporator overhead vapors are processed, and (e) what existing INTEC facilities or equipment are used.

C-5.3.1 Initial and Revised Baseline Process

The FY 2002 direct evaporation feasibility study (Kimmitt, 2003) defined a process that included separate solids processing, dilution of evaporator condensate to process it through the PEWE and LET&D, and grouting the LET&D bottoms after dilution. The process defined in the FY 2002 feasibility study was synthesized prior to most development work and trade-off studies. It was intended that the cost estimate developed as part of the study be conservative, i.e., there would be low risk of exceeding the estimate due to later changes in the process.

Later evaluations and results of testing led to several improvements to this process scheme, including:

1. Direct grouting of 12 molar LET&D bottoms rather than dilution to 3 molar prior to grouting,

2. Coprocessing solids through the SBW evaporator rather than separate processing, and
3. Using an additional mist eliminator rather than processing the condensate through the PEWE.

Initial attempts to develop a grout formulation for the LET&D acid obtained from processing the evaporator condensate indicated that because of highly exothermic reactions, dilution of the acid to about 3 molar would be needed prior to grouting. Grout tests determined that an acceptable grout could be made with this diluted acid and a 47.5% waste loading (Herbst, 2002). This formulation was used in the initial baseline process. However, subsequent tests showed that 12 molar could be successfully grouted without dilution using a waste loading of 35% (Herbst, 2002). This improved formulation resulting in a reduction in the grout volume by a factor of 3.1.

The initial baseline process assumed that heel solids would be processed separately from the SBW. This configuration was selected due to concerns regarding the ability of evaporator systems to accommodate the high solids loading of an SBW/heel solids mixture. While coprocessing heel solids with SBW is not trivial, the ability to coprocess would provide significant benefits both in terms of cost and overall reduced system complexity. Coprocessing of these two waste streams would remove several major components including the heel solids feed tank and associated pumps, the heel solids canister loading station, and the FUNDABAC® filter with its associated pumps, valves, filter cake drying system and monitors. An evaluation of different evaporator types was completed using the assumption of solids coprocessing (Packer, 2003) and found that several evaporator types will likely be able to process the mixed liquid/solids feed. Tests of a simulant containing undissolved solids were performed in June 2003, and were successful (Griffith, 2003b). As a result of the above benefits and based on the results from tests of solids-containing feeds, solids coprocessing was selected over separate processing for the present flowsheet.

The initial baseline process condensed the evaporator vapor, and then utilizing existing treatment equipment, re-evaporated the condensate in the PEWE. The PEWE bottoms was returned to the SBW evaporator feed tank, while the PEWE overhead was fractionated in the existing LET&D, releasing water vapor to the atmosphere and producing a concentrated acid that was grouted. Because the PEWE has an acceptance criteria limit of 50 mg/L chloride (PRD-166, 1999), the SBW evaporator condensate would need to be diluted with deionized water by a factor of about 8. The primary function of the PEWE is to concentrate dilute aqueous wastes, allowing the overhead to be processed by the downstream, contact-handled LET&D and reducing the volume of the original waste. Since the PEWE equipment already exists, the costs to process the SBW evaporator condensate are operating rather than capital. The major operating cost is to re-vaporize not only the condensate but also about eight times the condensate volume due to required dilution, and also to then condense this dilute acid and re-vaporize it again in the LET&D reboilers.

An alternative to processing the condensate through the PEWE is a new demister. At the INEEL, evaporators with various mist eliminator designs have been used to consistently achieve decontamination factors (DFs) in the range needed by the direct evaporation process. These DFs have been achieved using a combination of mist eliminator units. The PEWE consistently achieves a DF of 10^6. Its mist eliminator system consists of a baffle, followed by 8-inches of 931 York style (or equivalent) knitted mesh, 6-inches of York style 326 knitted mesh, and 6-inches of York style 421 knitted mesh. The EVS typically achieves a DF on the order of 10^5 with a cyclone followed by 6 inches of York style 421 knitted mesh. Based on this information, it is reasonable to assume that a multiple effect demister can be designed for the direct evaporation process that will result in a DF of 10^6 or greater.

Incorporating the above changes – grouting of LET&D bottoms without dilution, coprocessing solids in the evaporator, and replacing the PEWE with a new demister – into the process synthesized in

FY 2002 results in the present process flow diagrams and is called the "revised baseline" direct evaporation process.

C-5.3.2 Alternative Evaporator Types

An initial evaluation of evaporators for the direct evaporation process (Packer, 2003) reviewed the capabilities of thermosiphon evaporators, kettle evaporators, falling film evaporators, rising film evaporators, forced circulation evaporators, thin film evaporators, in-canister evaporation and evaporator combinations. The evaluation concluded that several evaporator types might be applicable to SBW evaporation; the types with the most promise being forced circulation evaporators and the agitated thin film evaporators (Packer, 2003). As of the end of CY 2003, three successful pilot tests had been performed with an agitated thin film evaporator (Griffith, 2003a; Griffith 2003b, Griffith, 2004). Testing of a forced circulation evaporator was planned for FY 2004, but due to the success of the agitated thin film evaporator, was cancelled.

C-5.3.3 Alternative Condensate Treatment Schemes

Vapor from the evaporator contains water, nitric acid, and small concentrations of HCl, HF, mercury, ^{3}H, and carryover nonvolatile species. The concentration of nonvolatiles, including both radionuclides and RCRA hazardous metals, will depend on the evaporator design and whether additional de-entrainment equipment is added as part of the evaporator or subsequent to it. Concentrations of volatile species will depend primarily on the extent of evaporation.

Treatment of the evaporator vapor is required to render the vapor stream into forms that can either be released to the atmosphere or disposed at a waste repository or both. If processed into a waste, the evaporator vapor would first be condensed, then possibly concentrated, and the concentrate solidified while the water vapor would be released to the atmosphere. Alternatively, various technologies could be used to decompose or react nitric acid to form nitrogen that could be released to the atmosphere. A third type of treatment could be used to remove the contaminants, including nitric acid, from the vapor without condensing the water vapor. Each of these options for treating the condensate is summarized in the sections below. Additional information is available in the Condensate Treatment Alternatives Evaluation (Barnes, 2003a).

C-5.3.3.1 Alternatives to Processing Condensate through the PEWE. Because the condensate would require a high dilution with water in order to process it in the PEWE, alternatives have been considered. A new demister, as discussed above, was selected for the revised baseline process. Other alternatives are reviewed in this section.

Use of the EVS is a possible option for the removal of radionuclides from the SBW evaporator overheads. Bottoms product from the EVS would be recycled back to the SBW feed tank. Chlorine feed limits (if any) to the EVS for a given waste stream have in the past been established in Run Plans based on the calculated amount of chlorine expected in the EVS overheads and subsequently sent to the PEWE. Because the PEWE would be bypassed in this option, chloride feed limits to the EVS would likely be based upon those ultimately established for the LET&D. The EVS option, while feasible, is presently not recommended for the direct evaporation process. The cost associated with re-evaporating the evaporator overheads and the possible EVS modification expenses would likely make this option more costly than incorporating a new mist eliminator system.

HEPA filtration of the evaporator's overheads would be expected to provide decontamination sufficient to allow downstream equipment to be contact-handled. The use of a HEPA filter would require as a minimum the installation of a reheater to raise the temperature of the evaporator overheads 20-30°F

above its dew point temperature. A stand-alone mist eliminator upstream of the HEPA would also be considered desirable to prevent any liquid that may bypass the evaporator's internal mist eliminator from wetting the HEPA filters. Before HEPA filtration can be considered as a viable option for this application, however, validation tests would need to be carried out to determine if an appropriate sealant is available to accommodate the acidic environment of the evaporator overheads.

Wet Electrostatic Precipitators (WESPs) are used in industry to remove particles smaller than 1 micron. Depending upon the vapor velocities through the WESP, removal efficiencies have been reported as high as 99.99% for particle sizes between 0.4 and 1.0 micron[a]. These units come in a variety of materials of construction to accommodate acidic and basic gas streams. While DFs would be expected to be very high, a WESP is not considered an economically attractive option due to its high capital cost and the large footprint required to house the unit.

C-5.3.3.2 Alternatives to Grouting Acid in Condensate. An alternative to grouting the acid recovered from the condensate is to chemically react the acid to form nitrogen that can then be released to the atmosphere. Selective catalytic reduction (SCR) is one of several methods that could be used to reduce the nitric acid in the evaporator vapor to diatomic nitrogen gas. SCR was selected to represent these options because of its widespread use in industry. Vapor from the evaporator would be routed through a secondary mist eliminator or other solids separator, and then reheated and HEPA filtered to remove the majority of the radioactive contamination. The off-gas stream at this point in the process would consist primarily of nitric acid and water vapor, with small amounts of tritium, iodine, and mercury. This off-gas stream would be preheated to approximately 400°C prior to entering the SCR reactor. The SCR reactor would be a packed bed of hydrogen mordenite or similar zeolite catalyst.[b] Ammonia would also be injected into the reactor as the reducing agent. In the reactor, nitric acid and NO_x (formed during reheating) would be reduced to nitrogen and oxygen. Significant cost savings associated with this scenario could be realized in these areas:

- *Operating Costs* – by eliminating or reducing the need to operate the PEWE and LET&D, operating expenditures would be reduced

- *Waste Disposal Costs* – by eliminating a secondary waste stream (grout), costs associated with characterization and disposal could be reduced

- *Capital Costs* – by eliminating the acid waste stream, significant money could be saved by eliminating the need for a new grout facility[c].

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[a] AirPol Inc., 2002, personal communication to Bart Packer

[b] A hydrogen mordenite or zeolite catalyst is preferred over a precious metal or vanadium/tungsten catalyst due to the presence of mercury in the off-gas. It is believed that mercury would rapidly poison these types of catalysts.

[c] The savings from elimination of the grout plant need to be compared against the capital cost to install the SCR and associated off-gas monitoring and treatment equipment. However, before a capital estimate can be made for the SCR equipment, a regulatory analysis should be performed to determine how the facility would be permitted (i.e., if the facility will require permitting to MACT standards, additional off-gas cleanup unit operations and monitoring instrumentation will also be required).

However, there are also several drawbacks to implementing the SCR technology. The most significant concerns include:

- *Safety Concerns* – The transportation, storage, and use of anhydrous ammonia presents a personnel safety hazard. Alternatives to anhydrous ammonia could be considered, but these alternatives introduce additional process complexities (i.e., the use of aqueous ammonia would require a vaporizer and a larger storage facility; the use of urea would require a decomposition reactor to convert it to ammonia).

- *Permitting Concerns* – Evaporation is a relatively low-temperature process (i.e., <130°C). It is conceivable that inclusion of the SCR (which operates at 400 – 550°C) could result in classification of the process as a miscellaneous thermal treatment unit by the EPA and/or State regulators. Such a designation would likely require a more involved permitting process, and could include requirements such as a trial burn and adherence to MACT air emissions standards. If MACT compliance were imposed, it would also be necessary to add a thermal or catalytic oxidizer for control of total hydrocarbons (THC) and CO, and a carbon bed for control of mercury emissions. It is likely that these additional permitting requirements would negatively impact both project cost and schedule.

- Based on a process simulation of this scheme (see Barnes, 2003a), five reactor stages would be required to destroy the HNO_3 in the off-gas from the SBW evaporator. This is not typical for an SCR installation and would add cost, plot space, and complexity to the process.

Due to feasibility issues discussed above, and due to potential safety, permitting, and schedule issues associated with this scenario, it is not recommended.

C-5.3.3.3 Alkaline Scrub Process. This scheme involves scrubbing the evaporator vapor using an alkaline scrubbing agent to both remove contaminants and convert acids to salts that can be returned to the SBW evaporator. The alkaline scrubber would neutralize and remove nitric acid from the vapor, neutralize and remove other trace acids such as HCl and HF, remove oxidized forms of mercury and remove carry-over particulate. A purge from the scrubber would be recycled to the evaporator. The scrubbed vapor could then be released to the atmosphere after superheating and HEPA filtration[d]. The volume of primary waste would increase due to the recycled salts, but no secondary waste grout is produced, eliminating all grouting and grout packaging equipment and reducing the plot space and facility size needed relative to the revised baseline process.

The scrub purge that is returned to the evaporator would have a neutral pH and, thus, would be expected to have a minimal effect on feed and evaporation chemistry. Magnesium oxide is recommended as the scrubbing agent because of its ability to hydrate in the concentrated waste as it cools. The scrub purge would add about 12-28% to the feed rate. Other comparisons are shown in Table C-1. For reference Table C-1 also show a comparison to the initial baseline process, which is described in the FY 2002 feasibility study (Kimmitt, 2003). The higher evaporator bottoms volume of the revised baseline compared to the initial baseline process is due to a 30 wt% increase in feed mass due to the addition of solids, an updated feed volume estimate and a small change in the assumed degree of evaporation.

The caustic scrubbing process would have capital cost savings over the revised baseline process, due to the elimination of the grouting facility. Based on unit costs of $\$13,352/m^3$ for disposal or RH

d. Additional test data for this process is needed to confirm that no other removal steps would be required.

wastes at WIPP and $1,854/m^3 for disposal of CH low-level mixed waste, the caustic scrub process would have a disposal cost of $2.6 million greater than the revised baseline cost. The savings in capital cost is $20 million (see Barnes, 2003a).

Table C-1. Comparison of alkaline scrubbing process to the baseline process.[a]

Ratios	Initial Baseline Process	Revised Baseline Process	Alkaline Scrub Process
Relative Evaporator Feed Ratio	1.00	1.00	1.23
Relative Evaporator Bottoms Volume	0.71	1.00	1.30
Relative Evaporator Reboiler Duty	1.00	1.00	1.07
Relative Condenser Duty	1.00	1.00	0.21
Relative Grout Volume	2.56	1.00	0
Volumes	**m^3**	**m^3**	**m^3**
Evaporator Bottoms	727	1021	1387
Tank Solids	106	0	0
Grouted Acid	3550	1387	0

a Waste volumes shown in this table differ slightly from those shown in later sections of this report because the two sets of estimates were based on different revisions of the Feed Composition Report (Barnes, 2003b).

The present alkaline scrub process (see PFD-2A) shows a packed bed MgO scrubber. Magnesium oxide and magnesium hydroxide are commonly used in water treatment and commercial forms are available that could be used in a packed bed. MgO scrubbers have been used for SO_2 removal from off-gas of coal-fired boilers and other industrial processes. MgO scrubbers in these facilities are often venturi-type scrubbers or other slurry-based systems. However, to minimize maintenance of the scrubber, a packed bed may be preferable. Nitric acid vapor in the scrubber feed would react with bed particles forming magnesium nitrate, which would be dissolved by the down-flowing aqueous stream. A portion of the scrubber effluent liquid would be purged to the evaporator, and the remainder recycled to the top of the bed. The liquid stream would be nearly solids-free. Bed material would be continually added to the top of the bed; however, it's expected that the rate of addition would only be a small fraction, about 1%, of the volume of the bed per hour.

Other scrubber types, such as moving bed, fluidized bed, or slurry systems designs, could also be considered.

C-5.3.3.4 Condensation/Fractionation/Neutralization Option. Another possible flow scheme would condense the evaporator vapor, concentrate the acid using the LET&D, and neutralize the concentrated acid with either MgO or aluminum hydroxide. The resultant salt solution would be recycled to the evaporator. This scheme is similar to the alkaline scrub process, except that the existing LET&D is used, and the scrubber is replaced by a neutralization tank. While this scheme retains the use of the LET&D and hence incurs its operating expenses, it does not require a scrubber nor is it likely that it would require a GAC bed, and would thus have no spent carbon waste. The scheme would require a neutralization tank, either a new tank or possible modifications to an existing tank. Because no testing has yet been performed of a scrubber in an SBW evaporation process, neutralization of the LET&D bottoms presents less technical risk than scrubbing. A cost comparison of this scheme versus the alkaline scrub scheme has not been performed.

C-5.3.3.5 Neutralization of SBW Feed. An indirect method to eliminate condensate treatment is to neutralize the SBW feed to the evaporator. Partial neutralization of the feed would convert a large fraction of the nitric acid in the feed to nitrate salts, greatly reducing the quantity of nitric acid in the condensate that would need to be treated and disposed as a secondary waste. Complete neutralization of the feed has the potential for elimination of the secondary waste completely.

However, this scheme has several disadvantages. As SBW is neutralized, a point is reached at which dissolved aluminum in the waste will precipitate in a gelatinous form. Other species such as iron may also precipitate. The precipitated solids may present handling problems transferring the waste to the evaporator and scaling problems in the evaporator. The solids loading in the waste may be high, resulting in extremely high viscosities, as the waste is concentrated in the evaporator, so that evaporation becomes infeasible or requires high maintenance equipment. In addition, neutralization could cause chemistry changes that would prevent the concentrated product from complete solidification upon cooling. For these reasons, and because the alkaline scrub and condensation/fractionation/neutralization options retains the benefits of this process without some of the disadvantages, neutralization of the feed has not be given further consideration.

C-5.3.3.6 Removal of Mercury and/or Chloride from Noncondensable Gases. Small concentrations of mercury, as volatilized chloride or other forms, and hydrochloride acid vapor will be present in the evaporator overhead. Rates of mercury released to the atmosphere are expected to be well under regulatory or risk-based limits. For the revised baseline scheme, or other schemes in which the evaporator vapor is totally condensed, the emissions of mercury should be undetectable. However, for the alkaline scrub process or others in which the evaporator vapor is not totally condensed, mercury emissions would likely exceed MACT standards. While it is not known whether regulators would apply MACT requirements to this process, reduction in mercury emissions could be required. Mercury could be removed in the gas phase with a carbon bed. Alternatively, the vapor could be condensed and mercury removed from the condensate by either ion exchange or sulfide precipitation. The treated condensate would then need to be vaporized.

Present mass balances show mercury concentrations of approximately 100 mg/kg in the grouted acid. This concentration is well below the Land Disposal Restriction limits for mercury of 260 mg/kg, and thus mercury removal from the condensate is not required for schemes in which the condensate is grouted.

The need for chloride removal is based on WAC for the LET&D and will need to be reviewed for the revised baseline case after LET&D criteria are established. Testing is needed to confirm that an alkaline scrubber can remove HCl to levels meeting emission requirements.

Additional information about methods to remove mercury and chloride are contained in Barnes (2003a), Soelberg (2003) and O'Brien (2003).

C-5.3.3.7 Acid Fractionation Options. The LET&D is an existing INTEC fractionator that currently processes condensate from the Process Equipment Waste Evaporator. To utilize the LET&D in the direct evaporation process, a new line would be needed from the SBW facility to the LET&D in CPP-1618. Based on the location of the Direct Evaporation Facility defined in the Feasibility Study (Kimmet, 2003), just north of the TFF, a line of approximately 1000 ft would be needed to carry condensate to the LET&D. Also, because the evaporator condensate would be about 10-15 times higher in acid concentration than PEWE condensate, column modifications would be required to introduce the feed on a lower tray. Modifications in piping and/or fluid transfer equipment may also be needed to use the Nitric Acid Recycle Hold Tank.

Alternatively, a new fractionator could be designed and built to perform concentration of the SBW evaporator overhead.

C-5.4 Basis for Flow Diagrams

C-5.4.1.1 Waste Tanks (PFD-1). PFD-1 shows the SBW feed tanks VES-WM-180, VES-WM-187, VES-WM-188 and VES-WM-189, and the NGLW tanks VES-WM-100, VES-WM-101 and VES-WM-102. These tanks are all existing tanks and currently in use. New mixing pumps would be installed in VES-WM-187, VES-WM-188 and VES-WM-189 to distribute solids evenly between these three tanks. The basis for the number of pumps (3 per tank) and the blending scenario has been documented by Wood (2002).

A follow-on study (Morrell, 2003) evaluated different mixing pumps and recommended submersible pumps over long shaft pump technology. Both Wood and Morrell recommend mockup testing of the mixing pumps. Mockup testing is needed to confirm and further define the basis for the mixing pumps.

Based on present estimates of total tank solids, it is anticipated that new pumps will be required in three tanks. If future tank samples indicate the total solids are significantly less than current estimates, pumps would only be installed in two tanks.

C-5.4.1.2 SBW Evaporator (PFD-2). PFD-2 shows the SBW Evaporator, evaporator overhead demister, condenser, and other demisters, superheaters and HEPA filters for both process and vent gases.

An evaluation of different evaporator types (Packer, 2003) concluded that several types were likely feasible, including agitated thin film, in-can, thermosiphon, and semi-batch kettle evaporator. Three series of tests have been performed with an agitated thin film evaporator and have been very successful (Griffith, 2003a; Griffith, 2003b, Griffith, 2004). Based on the results of these tests, an agitated thin film evaporator is shown on PFD-2.

Based on DFs achieved by INEEL existing evaporators, sufficient decontamination can be achieved by the use of multiple mesh pads. The evaporator will have an internal demister pad, and then the vapor will pass through an external demister. Entrained liquid captured by the mesh pads will be pumped to the SBW Feed Tank. To maintain a high removal efficiency and minimal pressure drop, condensate will be pumped intermittently to the pads to wash off solids that have accumulated.

The condenser removes sufficient heat from the evaporator overhead to effect total condensation, preventing release of nitric acid to the atmosphere. At the expected operating pressure, ASPEN Plus predicts a bubble point temperature for the overhead of 83°C, hence total condensation should be achievable using cooling water as the coolant. The amount of nitric acid, HCl, and HF carried into the off-gas will be dependent on the efficiency of the demister.

Off-gas from the demister is superheated to avoid condensation in the downstream HEPA filters. The HEPA filters serve as the final protection against release of nonvolatile hazardous and radioactive species.

C-5.4.1.3 LET&D (PFD-3). Equipment contained in the existing LET&D is shown on PFD-3. The equipment includes a feed tank, a bottoms tank and spared 15-tray acid fractionators with reboilers, partial condensers, vapor liquid separators, superheaters, off-gas filters and vapor blowers.

Each of the two fractionators was designed to process 550 gallons per hour of feed (INTEC RCRA Interim Status Document ISD-1, 2002). Typically, 99% of the acid in the feed is recovered in the bottoms product while 1% is lost in the vapor from the overhead separators exhausted to the stack (Interim Status Document ISD-1, 2002).

A new line from the SBW Direct Evaporation Facility to CPP-604 would be required. In addition, modifications to the fractionators would be required to allow feed to enter on a lower tray.

C-5.4.1.4 Acid Grouting (PFD-4). PFD-4 shows equipment to grout and package the recovered nitric acid from the LET&D. Neutralization of this 12 molar acid with calcium hydroxide followed by grouting with a combination of BFS and Portland cement is based on demonstration tests in 2002 and 2003 (Herbst, 2002; Raman, 2003).

C-5.4.1.5 Canister Loading and Handling (PFD-5). An initial concept for packaging the concentrated SBW waste was identified and briefly described in the Direct Evaporation Feasibility Study (Kimmitt, 2003). Additional details for a related packaging system (for calcine waste) were developed in a separate study (Clark, 2003) and are summarized on PFD-5. Several packaging requirements are inherent in SBW evaporator waste that were not present for the calcine packaging system, i.e., filling the canister with hot waste, cooling of waste in the canister, and possible addition of absorbent on top of the waste. Translating these additional requirements into a mechanical design has not yet been done.

C-5.4.1.6 Alkaline Scrub (PFD-2A). The basis for the alkaline scrub process is an evaluation (Barnes, 2003a) that showed that this process had advantages – reduced footprint, less equipment, a single waste form – than the revised baseline scheme. The scrubbing agent assumed in Barnes' evaluation was caustic. Later tests showed that the use of caustic would result in an unsatisfactory evaporator product. Tests performed in FY 2004 have shown that a simulated waste that includes neutralization of overhead with MgO produces a good waste product. Based on the results of these tests, MgO was selected as the scrubbing agent.

C-5.5 Basis for Mass Balances

Mass balances were developed for the Direct Evaporation alternative to provide a basis for sizing equipment, determining feed chemical requirements, determining utility requirements, estimating emissions and determining waste volumes, compositions and properties. The sections below document the basis for the mass balance. The basis is capsulated in succinct statements, called "design basis elements" (DBEs), shown in italics in the following paragraphs. The DBEs are amplified with background information, references, explanation, and, in some cases, a discussion of uncertainties.

C-5.5.1 Feeds

Feeds to the Direct Evaporation process include NGLW and SBW from the INTEC TFF.

C-5.5.1.1 Tank Farm Waste Feeds. According to present Tank Farm management plans (Barnes, 2002b), waste presently in the TFF tanks will be consolidated into four tanks, WM-180, WM-187, WM-188 and WM-189 by the end of 2005. Tanks WM-180, WM-188 and WM-189 will contain liquid SBW with relatively small quantities of undissolved solids, while WM-187 will be used as a collection tank for solids and dilute liquid wastes. Waste generated after 2005 will be collected in WM-100, WM-101 and WM-102. Shortly before treatment, transfers will be made between tanks to distribute solids that have been collected in WM-187 between the three tanks WM-187, WM-188 and WM-189.

DBE #1: Solids that have been collected in Tank WM-187 will be distributed between Tanks WM-188, WM-189 and WM-187 by waste transfers between these tanks prior to feeding to the treatment process.

Pumps will be installed in these three tanks to homogeneously mix the solids with the tank liquid. Approximately equal amounts of waste from WM-188 and WM-189 will first be transferred to Tank WM-187, and then similar volumes of the mixed solids/liquid slurry in WM-187 will be returned to Tanks WM-188 and WM-189 to restore these tanks to their full capacity. The tank-blending scenario is described in more detail by Wood (2002) and Barnes (2003b).

Mass balances are shown in Section C-6 for four feed cases. The feed cases correspond to present estimates of waste quantities and compositions that would be transferred from Tanks WM-180, WM-187, WM-188 and WM-189 after waste in these tanks is blended. The WM-187 mass balance case represents a blend of the waste in WM-187, after transfers to Tanks WM-188 and WM-189, with newly generated liquid waste (NGLW). Whether the NGLW is added to WM-187 or sent directly from WM-100, WM-101 or WM-102 to the SBW Treatment Facility feed tanks is of no consequence to the mass balance.

DBE #2: Four waste compositions, corresponding to waste in Tanks WM-180, WM-188, WM-189 and a combined residual in WM-187 plus NGLW, are assumed to adequately envelope the waste fed to the SBW Treatment Facility for conceptual design purposes.

Table C-2 shows the variability of feed composition between the tanks for major species. Additional variation in feed composition is possible due to (a) uncertainties in sample analyses (b) uncertainties in the amount of waste solids in the feed (c) uncertainties in solids composition (d) uncertainties in NGLW quantity and composition and (e) potential changes in the tank mixing or Tank Farm Management scenario. The magnitude of some of these uncertainties is known or can be estimated, and is generally within the range shown in Table C-2. Feed composition uncertainties and expected composition ranges are discussed in more detail by Barnes (2003a and 2003b).

Table C-2. Feed concentration variations.

	Minimum	Maximum	Max/Min
H+	1.07E+00	2.43E+00	2.28
Al+3	3.61E-01	6.08E-01	1.68
B+3	1.04E-02	1.83E-02	1.76
Ca+2	3.47E-02	6.13E-02	1.77
Cs+	2.57E-05	8.42E-05	3.27
Cl-	1.80E-02	2.86E-02	1.59
Cr+3	3.36E-03	5.13E-03	1.53
F-	3.32E-02	5.61E-02	1.69
Fe+3	1.92E-02	2.97E-02	1.54
Mg+2	1.10E-02	1.94E-02	1.76
Hg+2	1.46E-03	5.44E-03	3.73
NO_3-	4.93E+00	6.63E+00	1.34
PO_4-3	1.95E-02	1.75E-01	8.95
K+	1.76E-01	3.13E-01	1.78
Na+	1.35E+00	1.89E+00	1.40
SO_4-2	4.05E-02	9.08E-02	2.24
Zr+4	1.32E-03	6.66E-02	50.33

C-5.5.2 Stream Factor, Operating Schedule and Feed Rate

The Technical and Functional Requirements (Barden, 2003) specifies a 3-year processing time that includes six months of hot start up. A stream factor of 200 days per year is assumed. The average feed rate is thus:

1,029,450 gal / (2.5 yrs * 200 d/yr * 24 hr/day) = 85.8 gal/hr or 1.43 gal/min

Because of downtime for canister change-out, feed to the evaporator is intermittent, and the actual feed rate is expected to be 1.8 gpm for the revised baseline scheme and 2 gpm for the alkaline scrubber scheme.

DBE #3: The total SBW waste inventory will be processed over 2.5 years, during 200 24-hr operating days per year and an average feed rate of 1.4 gpm.

C-5.5.3 Tank Mixing and Feed Transfer from Tank Farm

In an evaluation of options for processing solids in the calciner, R. Wood (2003) and D. Morrell (2003) recommend mixing the solids in the TFF tanks. The concept of mix pumps in the tanks was taken from an earlier conceptual design (ICF Kaiser, 1995) for tank heel removal. While mock-up tests are recommended to validate the effectiveness of this mix scheme, the studies by Wood and Morrell included an assessment of mixing pump performance and issues (see Section 3 of Wood).

Transfers of waste to the treatment facility will be made using existing steam jets. The mass balance assumed that the volume of waste increases by 5% due to steam used to in the jets. This increase is based on past transfers of waste to the NWCF.

DBE #4: Mix pumps installed in TFF tanks are assumed to keep solids uniformly distributed throughout the tank waste. Waste will be transferred to the treatment facility using existing steam jets, diluting the waste by 5%.

C-5.5.4 Evaporation and Disengagement

This section documents the basis for and assumptions used in the mass balance of the SBW evaporator and demister.

C-5.5.4.1 Evaporation Temperature and Pressure. Lab and pilot-scale testing of the direct evaporation process indicate that the optimal operating pressure is around 390 mm Hg absolute (7.5 psia) (Kirkham, 2003). Lowering the pressure beyond this value results in film boiling, while increasing the pressure results in a higher endpoint temperature (i.e., > 130°C) and visible NO_2 generation. Hence, for the material balances, the minimum evaporator operating vacuum pressure was selected in order to achieve a predicted endpoint temperature between 120°C and 126°C.

DBE #5: An evaporator pressure of 8.6 psia was assumed for the mass balances. At this pressure, the APEN model predicted temperatures of 117-124°C for the revised baseline scheme and 120-126°C for alkaline scrub scheme.

C-5.5.4.2 Extent of Evaporation. In lab scale testing for WM-189 simulant, it was observed that the product would set up "rock hard" when concentrated above 59.8 wt% (Kirkham, 2003). The maximum concentration achieved was 64.7 wt%. Hence, for the revised baseline material balance for WM-189, the extent of evaporation was specified near the middle of this range at 62 wt%. However, for other tank compositions, mass balance modeling showed that the extent of evaporation needed to be increased in order to tie up all water in the bottoms product as $Al(NO_3)_3 \cdot 9H_2O$, $Ca(NO_3)_2 \cdot 4H_2O$, and $Na_2(SO_4) \cdot 10H_2O$. Hence, for the other revised baseline cases, the extent of evaporation was adjusted in the mass balance until all free water was tied up.

For the alkaline scrubber cases, the extent of evaporation was adjusted in the mass balance model to maintain a bottoms temperature of less than 125°C. Water in the bottoms will be tied up as hydrated nitrates of aluminum, iron, magnesium and other metals. Because of the use of magnesium as the scrubbing agent, which forms both $Mg(NO_3) \cdot 2H_2O$ and $Mg(NO_3) \cdot 6H_2O$, an acceptable product can be produced over a range of water concentrations. The mass balances assume magnesium nitrate solidifies as dihydrate unless this results in an endpoint evaporator temperature greater than 125°C, in which case, the amount of water is increased to maintain a temperature less than 125°C.

DBE #6: Extent of evaporation was set at 62 wt% for the WM-189 revised baseline material balance to match laboratory results. Extent of evaporation for the WM-180, WM-187, and WM-188 revised baseline material balances was adjusted to tie up all free water as $Al(NO_3)_3 \cdot 9H_2O$, $Ca(NO_3)_2 \cdot 4H_2O$, and $Na_2(SO_4) \cdot 10H_2O$. For all alkaline scrubber material balances, the extent of evaporation was adjusted for formation of a combination of $Mg(NO_3)_2 \cdot 2H_2O$ and $Mg(NO_3)_2 \cdot 6H_2O$ that maintained the evaporator temperature equal to or below 126°C.

C-5.5.4.3 Evaporation and Disengagement Decontamination Factors/Entrainment. The DF for the evaporator was specified as 10,000 based on PEWE performance, and consistent with that determined for most feed components achieved in wiped film evaporator tests conducted at Oak Ridge

(Boring, 1994). Also, discussions with LCI personnel indicated that entrainment for a wiped film evaporator should be essentially zero for the gas flow rates recently tested during SBW trials at LCI (see Griffith, 2003a). According to LCI, the gas velocity would have to double before any entrainment would be expected to occur. This is also consistent with the observation of zero liquid collected by the mist eliminator during the LCI tests.

The DF for the demister was specified as 100. Perry's Chemical Engineers' Handbook states that wire mesh mist eliminators can achieve a collection efficiency of 99.8% (i.e., DF = 500). However, this may be overly optimistic based on testing within the DOE complex. Testing of a high-efficiency mist eliminator (HEME) at Hanford only achieved a DF of 400, and Defense Waste Processing Facility (DWPF) uses a DF of 50 for their HEME (see Wood, 2001). A conventional mist eliminator (i.e., not a HEME) cannot reasonably be expected to perform even this well. However, by sequencing correspondingly finer meshes, it should be possible to achieve a DF of 100 using standard demister designs.

The DFs assumed for the evaporator and demister must be verified in pilot-scale tests to eliminate the uncertainty associated with these assumptions.

DBE #7: The DF for the evaporator was specified as 10,000 and the DF for the mist eliminator was specified as 100, yielding a combined DF of 106.

C-5.5.4.4 Partitioning of Volatile Species. Partitioning of volatile chemical species such as chloride, fluoride, and iodine was estimated using Aspen vapor liquid equilibrium (VLE) models. Property data for this model has been tuned to match prior sampling results from the existing EVS and PEWE evaporators.

Partitioning of mercury was based on lab and pilot-scale test results (Kirkham, 2003, Griffith, 2003a) which indicate that only 3-10% of the mercury is partitioned to the evaporator condensate, while the remainder is partitioned to the bottoms product. This was accomplished in the Aspen model by diverting 90% of the mercury predicted in the condensate to the bottoms product. For the alkaline scrubber material balances, ASPEN predicted that over 99.9% of the mercury remained in the bottoms. This may have been due to an interaction with the magnesium and related species, or due to dilution of the feed by the scrub recycle. The FY 2004 direct evaporation tests with MgO (Griffith, 2004) did not include mercury in the simulant, so this improved retention has not been experimentally verified.

Tritium was assumed to partition the same as water in the model, which was predicted using Aspen VLE models. Radioactive iodine was assumed to partition the same as chloride in the model. Ruthenium and cesium were treated as nonvolatile species in the model (i.e., a DF of 10^6 was applied over the evaporator and demister combination). The DFs assumed for radioactive species must be verified in pilot-scale tests (likely using surrogates) to eliminate the uncertainty associated with these assumptions.

DBE #8: Aspen VLE models were used for partitioning of halides. Aspen VLE models were also used for partitioning mercury, but a correction was accomplished by diverting 90% of the mercury in the condensate to the bottoms product in order to better match experimental data. Ruthenium and cesium were treated as nonvolatile species in the material balance. For all alkaline scrubber material balances, no correction was needed.

C-5.5.5 Condensate Treatment – Revised Baseline Scheme

The basis for and assumptions used in the mass balance of the condenser, condensate tank, and grout facility are documented in this section for the revised baseline case. The basis for the evaporator vapor treatment for the alkaline scrubber scheme is given in Section C-5.5.9.

C-5.5.5.1 Condenser Temperature and Pressure Drop. The condenser temperature was specified at 35°C, which represents a reasonable value based on typical cooling water supply temperatures. The pressure drop through the condenser and demister combination was assigned a value of 15 inches H_2O. These process parameters are not perceived to significantly impact process feasibility, but will influence the size of the condenser and process off-gas (POG) blower. Hence, a more rigorous effort should be made to quantify these parameters as part of detailed design.

DBE #9: The condenser temperature was specified at 35°C, and the pressure drop across the condenser and demister combination was assigned a value of 15 inches H_2O.

C-5.5.5.2 Demister Efficiency. Particulate and droplet carryover through the condenser and demister was assigned a DF of 10,000. This value has been used commonly in existing NWCF process models. However, pilot-scale testing should be performed to validate this value, as overestimation of this DF could adversely impact downstream HEPA filter change-out frequency.

DBE #10: The DF for the condenser/demister combination was specified as 10,000.

C-5.5.5.3 Aluminum Nitrate Addition. Addition of aluminum nitrate may be required in order to complex fluoride in the condensate prior to processing in the LET&D. However, the amount is expected to be very small (<0.2 liter/day of 2.2 M aluminum nitrate), and hence was not included in this mass balance. Based on model predictions of HF in the condensate a total of 20 gallons of 2.2 molar aluminum nitrate will be sufficient to process all the waste.

DBE #11: Aluminum nitrate addition to complex fluoride in the feed to LET&D will be less than 0.2 liters per day.

C-5.5.5.4 LET&D Acid Recovery Efficiency. The LET&D was modeled in Aspen as a 16-tray distillation column with a molar reflux ratio of 0.82. The distillate to feed ratio was varied to achieve a 12 molar acid product. Acid recovery was estimated by Aspen based on vapor-liquid equilibrium. For all four waste feeds, acid recovery is estimated to exceed 99%. This is consistent with past LET&D performance.

DBE #12: Acid recovery in the LET&D is predicted to exceed 99% for all four waste feeds based on Aspen VLE calculations.

C-5.5.5.5 Partitioning of Volatile Species in LET&D. Partitioning of volatile chemical species such as chloride, fluoride, and iodine was estimated using Aspen VLE models. Property data for this model has been tuned to match prior sampling results from the existing EVS and PEWE evaporators.

Tritium was assumed to partition the same as water in the model, which was predicted using Aspen VLE models. Radioactive iodine was assumed to partition the same as chloride in the model. Ruthenium and cesium were treated as nonvolatile species in the model (i.e., a DF of 10^6 was applied over the evaporator and demister combination).

DBE #13: Aspen VLE models were used for partitioning of halides in the LET&D. Ruthenium and cesium were treated as nonvolatile species in the material balance for the LET&D.

C-5.5.5.6 Acid Grout Formulation. The acid grout formulation and grout density used in the material balance were taken from Herbst (2002, Table 3) and are based on lab-scale testing. The formulation on a weight basis is as follows:

- 35.0 % 12 molar acid (LET&D bottoms)
- 12.5 % $Ca(OH)_2$
- 13.1 % BFS
- 39.4 % ordinary Portland cement (OPC).

Grout density was assumed to be 2.06 g/cm^3 as reported in the same tests (Herbst, 2003).

DBE #14: Grout density was assumed to be 2.06 g/cm^3. The following grout formulation was used in the mass balance: 35.0 wt.% 12 M nitric acid, 12.5 wt.% $Ca(OH)_2$, 13.1 wt.% BFS, and 39.4 wt.% OPC.

C-5.5.5.7 Acid Grout Packaging. The mass balance assumes that of the acid grout will be packaged in 55-gal drums. A capacity of 200 L (52.8 gal) of grout per drum was assumed.

DBE #15: Acid grout will be packaged in 55-gal drums. A drum capacity of 200 L (52.8 gal) of waste was assumed.

C-5.5.6 Off-gas Treatment

The basis for and assumptions used in the mass balance of the process and VOG systems are documented in this section.

C-5.5.6.1 Process Off-gas and Vessel Off-gas Superheater Outlet Temperature. The POG and VOG superheater outlet temperatures were specified at 100°C in order to reduce the potential for condensation in the HEPA filters. This temperature is significantly above the dew point for these off-gas streams, but was over-specified in order to effectively tolerate process upsets. For the alkaline scrubber material balances, the process off superheater outlet temperature was increased to 120°C, which is the optimal operating temperature for the S-GAC bed based on laboratory testing.

DBE #16: POG and VOG superheater outlet temperatures were specified at 100°C in order to reduce the potential for condensation in the downstream HEPA filters. For the alkaline scrubber material balances, the POG superheater outlet temperature was specified at 120°C for optimal performance of the mercury removal S-GAC beds.

C-5.5.6.2 Off-gas Mercury Removal. For the revised baseline scheme, or other schemes in which the evaporator vapor is totally condensed, the emissions of mercury should be undetectable. However, for the alkaline scrub process or others in which the evaporator vapor is not totally condensed, mercury emissions would likely exceed MACT standards. While it is not known whether regulators would apply MACT requirements to this process, reduction in mercury emissions could be required. Mercury could be removed in the gas phase with a fixed bed of sulfur impregnated granular activated carbon (S-GAC). The size of this bed is not expected to be large, since the model predicts that >99.9% of the mercury would be retained in the evaporator bottoms.

DBE #16a: For the alkaline scrubber process, a bed of S-GAC downstream of the POG superheater is assumed to remove 99.9% of the mercury from the POG.

C-5.5.6.3 HEPA Filter Efficiency. Each HEPA housing was assumed to contain three filters (either three HEPAs, or a prefilter and two HEPAs). A DF of 1000 (efficiency = 99.9%) was assumed for the first HEPA, a DF of 500 (efficiency = 99.8%) was assumed for the second HEPA, and a DF of 1 (efficiency = 0.0%) was assumed for the third HEPA. These DFs are in line with the recommendations of DOE AE Standard 1554-4 4.2(b)1. Hence, the overall DF for a HEPA bank is 500,000.

DBE #17: A HEPA filter bank DF of 500,000 was assumed.

C-5.5.6.4 Process Off-gas and Vessel Off-gas Rates. Off-gas flow rates in the material balances were calculated by the Aspen model, and are a result of numerous process parameters. However, some assumptions were made that impact the off-gas flow rate, including the following:

- The airlift flow transferring waste from WM-189 was assumed to be 23 L air/L SBW. Although only one TFF tank has an airlift, this air rate was used in the mass balance for all four tank wastes for both the revised baseline and alkaline scrub schemes.

- The sparge air flow to the SBW feed tank flow was assumed constant at 143 ft^3/min for all four tank wastes for both the revised baseline and alkaline scrub schemes.

- The vacuum control air flow was arbitrarily assumed to be constant at 22.5 ft^3/min for all four waste tanks for the revised baseline scenario only.

These values are engineering estimates only, and will need to be refined as part of final design. This is especially true for the vacuum control airflow rate – this flow could be significantly different from the assumed value.

DBE #18: Off-gas flow rates were calculated by Aspen based on numerous other model inputs. However, the following input assumptions were made that will impact off-gas flow rate: (1) airlift flow to the TFF tank was assumed to be 23 L air / L SBW, (2) sparge air flow to the SBW feed tank was assumed to be constant at 143 ft^3/min, and (3) vacuum control air flow was assumed to be 22.5 ft^3/min (revised baseline scenario only).

C-5.5.6.5 Process Off-gas and Vessel Off-gas Blower Outlet Conditions. Off-gas blowers were modeled as single-stage isentropic compressors in Aspen with an isentropic efficiency of 72%. Outlet pressures were specified as 12.3 psia based on atmospheric pressure at INTEC. Based on these specifications, the model calculated the outlet temperature for the blowers (range = 119°C to 180°C). The higher temperature of 180°C is at the upper limit for many blowers; hence, it may be necessary to implement a two-stage blower scenario with intercooling. This should be investigated as part of detailed design.

DBE #19: For purposes of the mass balance, single stage blowers were assumed. An outlet pressure of 12.3 psia was specified.

C-5.5.7 Evaporator Product Packaging

The basis for and assumptions used in the mass balance of the evaporator product packaging system is documented in this section.

C-5.5.7.1 Canister Volume. Canisters would be used for packaging of the evaporator product. A capacity of 800 L of waste per canister was assumed.

DBE #20: Evaporator product will be packaged in canisters. An average canister waste fill volume of 800 L was assumed.

C-5.5.7.2 Cooling Time. The material balance does not assume a specific cooling time for RH canisters. This parameter will, however, impact interim storage requirements, canister loading system design and operational procedures. Unaided cooling of 5-gallons of product in a bucket required approximately 18 hours to reach 40°C (Griffith, 2003a). Cooling profiles were recorded for the waste in 15-gal drums generated in the November 2003 tests (Griffith, 2004). At 50 hours the centerline temperature for waste from a 62% mass reduction run with magnesium recycle was about 38°C (see Griffith, 2004, Figure 25). Data for cooling of waste in canisters is needed. In lieu of this data, it was assumed that with cooling jackets, three days would be sufficient cooling time per canister, achieving the maximum required production rate of three canisters per day with one canister packaging line.

C-5.5.8 Utilities

The basis for and assumptions used in the mass balances relative to utility availability and usage is documented in this section.

C-5.5.8.1 Steam. Based on pilot-scale tests (Griffith, 2003a), the temperature of the steam should be approximately 50-60°C above the operating temperature of the evaporator. Hence, 150 psig steam (t_{sat} = 185°C) was assumed for the material balances. It is also assumed that a new boiler and superheater at INTEC would be required to support the direct evaporation process. Aspen was used to calculate the steam usage, based on 150 psig saturated steam as an input, and 147 psig condensate returning from the evaporator.

DBE #21: 150 psig saturated steam was assumed as the heat source for the evaporator. A 3 psig pressure drop was assumed in the evaporator jacket, resulting in 147 psig condensate returning from the evaporator.

C-5.5.8.2 Cooling Water. Cooling water is used in several locations throughout the process. It was assumed in the revised baseline that cooling water would be sufficient to condense the evaporator vapor (i.e., a chiller will not be required). For purposes of the material balances, the supply temperature of the cooling water was assumed to be 20°C (68°F). The maximum allowable return temperature was assumed to be 50°C (122°F).

DBE #22: For the material balances, cooling water was assumed to be available with a supply temperature of 20°C (68°F). The maximum allowable return temperature was assumed to be 50°C (122°F).

C-5.5.8.3 Air. The material balances assume that pressurized air at 50 psig will be available to airlift waste to the SBW feed tank. In addition, atmospheric air is assumed available for use in various process locations, such as for vacuum control on the POG system.

DBE #23: 50 psig and atmospheric air are assumed to be available for process use.

C-5.5.9 Alkaline Scrub Scheme.

Assumptions used in the mass balance for the unique sections of the alkaline scrub process are provided in this section. Sections C-5.5.1, C-5.5.2, C-5.5.3, C-5.5.4, C-5.5.6, C-5.5.7 and C-5.5.8 also apply to the alkaline scrub process.

C-5.5.9.1 Liquid to Vapor Ratio. Lab or pilot-scale testing is needed to evaluate the optimal L/V for the caustic scrubber. Perry's Chemical Engineer's Handbook (5th edition) cites that scrub flows of 4.3 to 11 gpm/1000 cfm have been used for sulfuric acid and phosphoric acid scrubbers (Perry, 1973). These corresponded to L/V molar ratios of 1 to 2. A conservative value of slightly over 2 was assumed for the liquid to vapor molar ratio of the scrubber.

DBE #24: A liquid to vapor molar rate of about 2.0 was assumed for the MgO scrubber.

C-5.5.9.2 Scrub Cooler Duty. In the material balances, the duty of the scrub cooler was varied to achieve the desired L/V in the scrubber. Hence, the scrub cooler outlet temperature varies for each case depending on the flow rate, acid content, and composition of the evaporator vapor inlet stream. For the four SBW waste tanks to be processed, the temperature varies from a low of 38°C for WM-188 to a high of 65°C for WM-180. Correspondingly, the estimated cooler duty varies between 20 kW for WM-180 to 42 kW for WM-188.

DBE #25: Scrub cooler duty was varied in the material balances to achieve the desired scrubber L/V ratio.

C-5.5.9.3 Scrub Purge Rate. The scrub purge rate was varied for each case in order to keep the concentration of salts in the scrub low enough to minimize plugging the off-gas HEPA filters from salts in entrained mist. Hence, the purge rate was adjusted to limit the concentration of magnesium nitrate in the scrub system to about 3 molar. The scrub salts concentration must also be kept below magnesium nitrate solubility of about 6 molar to avoid precipitation.

DBE #26: The scrub purge rate was set to limit $Mg(NO_3)_2$ concentration in the scrub solution to about 3 molar.

C-5.5.9.4 Make-up MgO Concentration and Addition Rate. The MgO make-up concentration was assumed to be a slurry at 20 wt%. The make-up rate was set to match the HNO_3 input from the evaporator off-gas while maintaining the scrub slightly acidic.

DBE #27: MgO was slurried with water to a concentration of 20 wt% and added to the scrubber to replace bed material removed by reaction with nitric acid vapors and dissolution in the scrub liquid.

C-6. MASS BALANCES

A summary of waste products generated materials consumed in the direct evaporation process is shown in Table C-3. Mass balances with stream compositions are shown in Tables 4-7 for the revised baseline scheme and in Tables C-8 through C-11 for the alkaline scrub scheme. Tables C-12 and C-13 show additional properties of the waste products.

Table C-3. Products from and consumable feeds for the direct evaporation process.

	WM-180	WM-187	WM-188	WM-189	Total containers	Total m3
Products						
Revised Baseline Scheme						
Canisters of SBW evaporator waste	340	182	354	382	1,259	1,007
Drums of grouted LET&D bottoms	971	712	1,997	2,161	5,841	1,168
Alkaline Scrub Scheme						
Canisters of SBW evaporator waste	425	224	501	529	1,678	1,342
Drums of spent GAC					2	0.3
Consumables						
Revised Baseline Scheme	**lb**	**lb**	**lb**	**lb**	**Total lb**	
Portland cement	2.91E+05	2.13E+05	5.98E+05	2.87E+05	1.39E+06	
Blast furnace slag	9.69E+04	7.10E+04	1.99E+05	9.58E+04	4.63E+05	
Calcium hydroxide	9.23E+04	6.77E+04	1.90E+05	9.12E+04	4.41E+05	
Alkaline Scrub Scheme	**lb**	**lb**	**lb**	**lb**	**Total lb**	
Granulated activated carbon					290	
Magnesium oxide	4.9E+04	3.6E+04	1.0E+05	1.1E+05	3.0E+05	

Table C-4. Revised baseline mass balance, Tank WM-180 waste.

PFD Sheet #	PFD-1	PFD-2	PFD-2	PFD-2	PFD-2	PFD-2	PFD-2	PFD-3
Stream #	101	102	103	104	105	106	107	108
Stream Name	SBW Feed	Evap. Bottoms	Evap. Overheads Vapor	Mist Eliminator Vapor	VOG Offgas Vapor	POG + VOG Offgas Vapor	LET&D Feed Liquid	LET&D Acid Liquid
Rate or Volume Flow (actual)	85.8	21.3	2.68E+04	2.73E+04	1.17E+04	1.37E+04	65.7	7.87
Volume Flow (standard, wet)*			1.15E+04	1.15E+04	7.34E+03	8.57E+03		
Volume Flow (standard, dry)*			2.76E+02	2.76E+02	7.13E+03	8.36E+03		
Rate Units	gal/hr	gal/hr	ft3/hr	ft3/hr	ft3/hr	ft3/hr	gal/hr	gal/hr
Temperature, °C	25	124	124	122	108	109	35	35
Temperature, °F	77	255	255	252	226	229	95	95
Pressure, psia	12.3	8.6	8.6	8.4	12.0	12.0	12.0	12.2
Specific Gravity	1.24	1.75	3.43E-04	3.36E-04	7.46E-04	7.44E-04	1.04	1.16
Chemical Composition	Mol/Liter	Mol/Liter	lb/wscf	lb/wscf	lb/wscf	lb/wscf	Mol/Liter	Mol/Liter
H+	1.07E+00	2.47E-01	6.29E-05	6.29E-05	3.83E-11	8.49E-09	1.31E+00	1.09E+01
OH-								
Al+3	5.83E-01	2.35E+00	9.77E-08	9.77E-10			7.61E-07	6.35E-06
Sb+5	1.39E-06	5.60E-06	1.05E-12	1.05E-14			1.82E-12	1.52E-11
As+5	4.47E-04	1.80E-03	2.08E-10	2.08E-12			5.84E-10	4.87E-09
Ba+2	5.00E-05	2.01E-04	4.27E-11	4.27E-13			6.53E-11	5.45E-10
Be+2	7.82E-06	3.15E-05	4.38E-13	4.38E-15			1.02E-11	8.52E-11
B+3	1.04E-02	4.19E-02	6.99E-10	6.99E-12			1.36E-08	1.13E-07
Cd+2	7.16E-04	2.88E-03	5.00E-10	5.00E-12			9.35E-10	7.81E-09
Ca+2	3.69E-02	1.49E-01	9.20E-09	9.20E-11			4.82E-08	4.03E-07
Cr+3	3.36E-03	1.35E-02	1.09E-09	1.09E-11			4.39E-09	3.67E-08
Co+2	1.83E-05	7.37E-05	6.70E-12	6.70E-14			2.39E-11	1.99E-10
Cs+	2.57E-05	1.04E-04	2.13E-11	2.13E-13			3.36E-11	2.81E-10
Cu+2	6.32E-04	2.55E-03	2.50E-10	2.50E-12			8.25E-10	6.89E-09
Fe+3	1.92E-02	7.75E-02	6.68E-09	6.68E-11			2.51E-08	2.10E-07
Pb+2	1.26E-03	5.08E-03	1.62E-09	1.62E-11			1.65E-09	1.38E-08
Hg+2	1.46E-03	5.71E-03	5.16E-07	5.15E-07	2.97E-11	2.54E-11	2.39E-10	2.00E-09
Mn+4	1.27E-02	5.13E-02	4.34E-09	4.34E-11			1.66E-08	1.39E-07
Ni+2	1.39E-03	5.59E-03	5.06E-10	5.06E-12			1.81E-09	1.51E-08
K+	1.76E-01	7.09E-01	4.28E-08	4.28E-10			2.30E-07	1.92E-06
Se+4	7.67E-05	3.09E-04	3.77E-11	3.77E-13			1.00E-10	8.37E-10
Ag+	6.08E-06	2.45E-05	4.07E-12	4.07E-14			7.93E-12	6.62E-11
Na+	1.89E+00	7.60E+00	2.70E-07	2.70E-09			2.46E-06	2.06E-05
Tl+3	2.75E-05	1.11E-04	3.49E-11	3.49E-13			3.59E-11	2.99E-10
U+4	3.61E-04	1.46E-03	5.34E-10	5.34E-12			4.72E-10	3.94E-09
V+3	8.76E-04	3.53E-03	2.77E-10	2.77E-12			1.14E-09	9.55E-09
Zn+2	9.51E-04	3.83E-03	3.86E-10	3.86E-12			1.24E-09	1.04E-08
Zr+4	1.32E-03	5.33E-03	7.50E-10	7.50E-12			1.73E-09	1.44E-08
Cl-	2.86E-02	9.04E-02	1.35E-05	1.35E-05	1.26E-11	1.80E-09	7.88E-03	1.15E-09
F-	4.02E-02	1.62E-01	3.71E-08	3.22E-08	3.82E-13	4.65E-12	3.57E-05	2.98E-04
SO4-2	4.96E-02	2.00E-01	2.96E-08	2.96E-10			6.48E-08	5.41E-07
NO3-	4.92E+00	1.58E+01	3.85E-03	3.85E-03	2.35E-09	5.19E-07	1.30E+00	1.09E+01
PO4-3	1.95E-02	7.86E-02	1.15E-08	1.15E-10			2.55E-08	2.13E-07
Am+4	3.16E-08	1.27E-07	4.77E-14	4.77E-16			4.12E-14	3.44E-13
Br-	1.55E-07	4.91E-07	1.66E-10	1.66E-10	1.55E-16	2.21E-14	4.30E-08	
Ce+4	4.36E-05	1.76E-04	3.79E-11	3.79E-13			5.69E-11	4.75E-10
Eu+3	2.58E-07	1.04E-06	2.43E-13	2.43E-15			3.36E-13	2.81E-12
Gd+3	1.61E-04	6.47E-04	1.57E-10	1.57E-12			2.10E-10	1.75E-09
Ge+4	4.48E-09	1.81E-08	2.02E-15	2.02E-17			5.85E-15	4.89E-14
In+3	7.05E-07	2.84E-06	5.03E-13	5.03E-15			9.21E-13	7.69E-12
I-	1.35E-06	4.31E-06	2.19E-09	2.19E-09	2.05E-15	2.92E-13	3.57E-07	6.20E-13
La+3	4.68E-06	1.89E-05	4.04E-12	4.04E-14			6.11E-12	5.10E-11
Li+	4.44E-04	1.79E-03	1.92E-11	1.92E-13			5.80E-10	4.84E-09
Mg+2	1.10E-02	4.43E-02	1.66E-09	1.66E-11			1.43E-08	1.20E-07
Mo+6	1.88E-04	7.56E-04	1.12E-10	1.12E-12			2.45E-10	2.05E-09

Table C-4. Revised baseline mass balance, Tank WM-180 waste (Continued).

Stream #	101	102	103	104	105	106	107	108
Stream Name	SBW Feed	Evap. Bottoms	Evap. Overheads Vapor	Mist Eliminator Vapor	VOG Offgas Vapor	POG + VOG Offgas Vapor	LET&D Feed Liquid	LET&D Acid Liquid
Chemical Composition	Mol/Liter	Mol/Liter	lb/wscf	lb/wscf	lb/wscf	lb/wscf	Mol/Liter	Mol/Liter
Nd+3	1.51E-05	6.08E-05	1.35E-11	1.35E-13			1.97E-11	1.65E-10
Np+4	8.73E-06	3.52E-05	1.29E-11	1.29E-13			1.14E-11	9.52E-11
Nb+5	4.46E-04	1.80E-03	2.58E-10	2.58E-12			5.83E-10	4.87E-09
Pd+4	3.13E-05	1.26E-04	2.07E-11	2.07E-13			4.08E-11	3.41E-10
Pu+4	9.98E-06	4.02E-05	1.51E-11	1.51E-13			1.30E-11	1.09E-10
Pr+4	4.26E-06	1.71E-05	3.73E-12	3.73E-14			5.56E-12	4.64E-11
Rh+4	1.84E-06	7.40E-06	1.17E-12	1.17E-14			2.40E-12	2.00E-11
Rb+	2.83E-06	1.14E-05	1.50E-12	1.50E-14			3.69E-12	3.08E-11
Ru+3	1.26E-04	5.08E-04	7.93E-11	7.93E-13			1.65E-10	1.38E-09
Sm+3	2.80E-06	1.13E-05	2.62E-12	2.62E-14			3.66E-12	3.05E-11
Si+4	3.08E-03	1.24E-02	5.37E-10	5.37E-12			4.02E-09	3.35E-08
Sr+2	1.08E-04	4.34E-04	5.86E-11	5.86E-13			1.41E-10	1.17E-09
Tc+7	5.30E-06	2.13E-05	3.19E-12	3.19E-14			6.91E-12	5.77E-11
Te+4	1.47E-06	5.93E-06	1.17E-12	1.17E-14			1.92E-12	1.60E-11
Tb+4	1.08E-09	4.34E-09	1.06E-15	1.06E-17			1.41E-15	1.17E-14
Th+4	1.05E-10	4.23E-10	1.51E-16	1.51E-18			1.37E-16	1.15E-15
Sn+4	7.38E-05	2.97E-04	5.45E-11	5.45E-13			9.64E-11	8.05E-10
Ti+4	1.34E-04	5.41E-04	4.00E-11	4.00E-13			1.75E-10	1.47E-09
Y+3	3.49E-06	1.41E-05	1.93E-12	1.93E-14			4.56E-12	3.81E-11
O-2 (oxides)	1.33E-02	5.34E-02	1.32E-09	1.32E-11			1.73E-08	1.45E-07
H2O	4.76E+01	2.48E+01	4.58E-02	4.58E-02	1.35E-03	1.16E-03	5.34E+01	2.66E+01
O2		1.86E-10	1.65E-07	1.65E-07	1.69E-02	1.70E-02	8.54E-05	
N2		2.27E-10	2.76E-07	2.76E-07	5.58E-02	5.60E-02	1.36E-04	
C (organic)	1.78E-02	7.06E-02	1.92E-07	1.91E-07	2.42E-13	2.58E-11	3.34E-04	2.79E-03
H (organic)	1.78E-02	7.06E-02	1.61E-08	1.60E-08	2.03E-14	2.17E-12	3.34E-04	2.79E-03
SiO2, BFS, or OPC Additives								
Gas Stream Bulk Composition (wet basis)	mol.% or ppmv	mol.% or ppmv	mol.% or ppmv	mol.% or ppmv	mol.% or ppmv	mol.% or ppmv	mol.% or ppmv	mol.% or ppmv
H2O, mol.%			97.60	97.60	2.89	2.49		
O2, mol.%			0.0002	0.0002	20.39	20.48		
N2, mol.%			0.0004	0.0004	76.72	77.04		
CO2, mol.%								
HNO3, mol. %			2.40	2.40	0.000001	0.0003		
CO, ppmv								
NO, ppmv								
NO2, ppmv								
C (organic), ppmv			6	6	0.00001	0.0008		
H (organic), ppmv			6	6	0.00001	0.0008		
PM (mg/wscm)			1	0.01				
Gas Stream Bulk Composition (dry basis)	mol.% or ppmv	mol.% or ppmv	mol.% or ppmv	mol.% or ppmv	mol.% or ppmv	mol.% or ppmv	mol.% or ppmv	mol.% or ppmv
O2, mol.%			0.01	0.01	21.00	21.00		
N2, mol.%			0.02	0.02	79.00	79.00		
CO2, mol.%								
HNO3, mol. %			99.90	99.96	0.000002	0.0003		
CO, ppmv								
NO, ppmv								
NO2, ppmv								
C (organic), ppmv			256	254	0.00001	0.0009		
H (organic), ppmv			256	254	0.00001	0.0009		
PM (mg/dscm)			59	1				

Table C-4. Revised baseline mass balance, Tank WM-180 waste (Continued).

Stream #	101	102	103	104	105	106	107	108
Stream Name	SBW Feed	Evap. Bottoms	Evap. Overheads Vapor	Mist Eliminator Vapor	VOG Offgas Vapor	POG + VOG Offgas Vapor	LET&D Feed Liquid	LET&D Acid Liquid
Canister Rate, canisters/day		2.42						
Total Canisters Generated		340						
Drum Rate, drums/day								
Total Drums Generated								
Radiological Composition	Ci/L	Ci/L	Ci/wscm	Ci/wscm	Ci/wscm	Ci/wscm	Ci/L	Ci/L
Ra-226	4.04E-12	1.63E-11	4.02E-16	4.02E-18	1.26E-25	1.09E-25	5.27E-18	4.40E-17
Ac-227	1.90E-11	7.66E-11	1.89E-15	1.89E-17	5.94E-25	5.14E-25	2.48E-17	2.07E-16
Th-228	1.58E-09	6.36E-09	1.57E-13	1.57E-15	4.93E-23	4.27E-23	2.06E-15	1.72E-14
Th-230	4.30E-10	1.73E-09	4.28E-14	4.28E-16	1.34E-23	1.16E-23	5.62E-16	4.69E-15
Th-232	3.49E-16	1.41E-15	3.48E-20	3.48E-22	1.09E-29	9.44E-30	4.56E-22	3.81E-21
Pa-231	4.41E-11	1.78E-10	4.39E-15	4.39E-17	1.38E-24	1.19E-24	5.75E-17	4.80E-16
Pa-233	1.45E-06	5.82E-06	1.44E-10	1.44E-12	4.52E-20	3.91E-20	1.89E-12	1.58E-11
U-232	1.04E-09	4.18E-09	1.03E-13	1.03E-15	3.24E-23	2.80E-23	1.35E-15	1.13E-14
U-233	4.04E-11	1.63E-10	4.02E-15	4.02E-17	1.26E-24	1.09E-24	5.28E-17	4.41E-16
U-234	1.04E-06	4.18E-06	1.03E-10	1.03E-12	3.24E-20	2.81E-20	1.36E-12	1.13E-11
U-235	3.79E-08	1.53E-07	3.78E-12	3.78E-14	1.19E-21	1.03E-21	4.95E-14	4.14E-13
U-236	5.63E-08	2.27E-07	5.60E-12	5.60E-14	1.76E-21	1.52E-21	7.35E-14	6.14E-13
U-237	3.17E-09	1.28E-08	3.16E-13	3.16E-15	9.91E-23	8.58E-23	4.14E-15	3.46E-14
U-238	2.24E-08	9.04E-08	2.23E-12	2.23E-14	7.01E-22	6.06E-22	2.93E-14	2.45E-13
Np-236	1.88E-12	7.58E-12	1.87E-16	1.87E-18	5.88E-26	5.09E-26	2.46E-18	2.05E-17
Np-237	1.46E-06	5.89E-06	1.46E-10	1.46E-12	4.57E-20	3.95E-20	1.91E-12	1.59E-11
Pu-236	2.08E-09	8.38E-09	2.07E-13	2.07E-15	6.49E-23	5.62E-23	2.71E-15	2.27E-14
Pu-238	9.48E-04	3.82E-03	9.44E-08	9.44E-10	2.96E-17	2.56E-17	1.24E-09	1.03E-08
Pu-239	1.44E-04	5.80E-04	1.43E-08	1.43E-10	4.49E-18	3.89E-18	1.88E-10	1.57E-09
Pu-240	7.81E-06	3.15E-05	7.77E-10	7.77E-12	2.44E-19	2.11E-19	1.02E-11	8.51E-11
Pu-241	5.71E-04	2.30E-03	5.68E-08	5.68E-10	1.78E-17	1.54E-17	7.45E-10	6.22E-09
Pu-242	6.02E-09	2.43E-08	5.99E-13	5.99E-15	1.88E-22	1.63E-22	7.86E-15	6.56E-14
Pu-244	5.16E-16	2.08E-15	5.13E-20	5.13E-22	1.61E-29	1.39E-29	6.73E-22	5.62E-21
Am-241	6.87E-05	2.77E-04	6.84E-09	6.84E-11	2.15E-18	1.86E-18	8.97E-11	7.49E-10
Am-242m	7.50E-09	3.02E-08	7.47E-13	7.47E-15	2.34E-22	2.03E-22	9.79E-15	8.18E-14
Am-243	1.09E-08	4.39E-08	1.08E-12	1.08E-14	3.40E-22	2.94E-22	1.42E-14	1.19E-13
Cm-242	6.19E-09	2.49E-08	6.16E-13	6.16E-15	1.93E-22	1.67E-22	8.08E-15	6.75E-14
Cm-243	1.78E-08	7.17E-08	1.77E-12	1.77E-14	5.56E-22	4.81E-22	2.32E-14	1.94E-13
Cm-244	1.11E-06	4.45E-06	1.10E-10	1.10E-12	3.45E-20	2.99E-20	1.44E-12	1.20E-11
Cm-245	1.87E-10	7.54E-10	1.86E-14	1.86E-16	5.85E-24	5.06E-24	2.44E-16	2.04E-15
Cm-246	1.23E-11	4.95E-11	1.22E-15	1.22E-17	3.84E-25	3.32E-25	1.60E-17	1.34E-16
Cm-247	2.92E-18	1.18E-17	2.91E-22	2.91E-24			3.81E-24	3.18E-23
H-3	1.73E-05	9.02E-06	1.48E-05	1.48E-05	2.98E-07	2.57E-07	1.94E-05	9.64E-06
Be-10	1.48E-12	5.96E-12	1.47E-16	1.47E-18	4.62E-26	4.00E-26	1.93E-18	1.61E-17
C-14	6.21E-11	2.50E-10	6.18E-15	6.18E-17	1.94E-24	1.68E-24	8.10E-17	6.77E-16
Co-60	3.98E-06	1.60E-05	3.96E-10	3.96E-12	1.24E-19	1.08E-19	5.19E-12	4.34E-11
Ni-59	9.14E-08	3.68E-07	9.09E-12	9.09E-14	2.85E-21	2.47E-21	1.19E-13	9.96E-13
Ni-63	2.42E-05	9.73E-05	2.40E-09	2.40E-11	7.54E-19	6.53E-19	3.15E-11	2.63E-10
Se-79	2.26E-07	9.10E-07	2.25E-11	2.25E-13	7.05E-21	6.10E-21	2.95E-13	2.46E-12
Rb-87	1.45E-11	5.82E-11	1.44E-15	1.44E-17	4.51E-25	3.91E-25	1.89E-17	1.58E-16
Sr-90	1.95E-02	7.86E-02	1.94E-06	1.94E-08	6.10E-16	5.27E-16	2.55E-08	2.13E-07
Y-90	1.95E-02	7.86E-02	1.94E-06	1.94E-08	6.10E-16	5.27E-16	2.55E-08	2.13E-07
Zr-93	1.09E-06	4.40E-06	1.09E-10	1.09E-12	3.41E-20	2.95E-20	1.43E-12	1.19E-11
Nb-93m	8.42E-07	3.39E-06	8.38E-11	8.38E-13	2.63E-20	2.28E-20	1.10E-12	9.18E-12
Nb-94	5.89E-07	2.37E-06	5.86E-11	5.86E-13	1.84E-20	1.59E-20	7.69E-13	6.42E-12
Tc-98	1.27E-12	5.12E-12	1.27E-16	1.27E-18	3.97E-26	3.44E-26	1.66E-18	1.39E-17
Tc-99	9.03E-06	3.64E-05	8.99E-10	8.99E-12	2.82E-19	2.44E-19	1.18E-11	9.84E-11

Table C-4. Revised baseline mass balance, Tank WM-180 waste (Continued).

	101	102	103	104	105	106	107	108
Stream Name	SBW Feed	Evap. Bottoms	Evap. Overheads Vapor	Mist Eliminator Vapor	VOG Offgas Vapor	POG + VOG Offgas Vapor	LET&D Feed Liquid	LET&D Acid Liquid
Radiological Composition	Ci/L	Ci/L	Ci/wscm	Ci/wscm	Ci/wscm	Ci/wscm	Ci/L	Ci/L
Ru-106	4.81E-07	1.94E-06	4.79E-11	4.79E-13	1.50E-20	1.30E-20	6.28E-13	5.25E-12
Rh-102	4.25E-10	1.71E-09	4.23E-14	4.23E-16	1.33E-23	1.15E-23	5.55E-16	4.63E-15
Rh-106	4.81E-07	1.94E-06	4.79E-11	4.79E-13	1.50E-20	1.30E-20	6.28E-13	5.25E-12
Pd-107	8.15E-09	3.28E-08	8.11E-13	8.11E-15	2.54E-22	2.20E-22	1.06E-14	8.88E-14
Cd-113m	1.64E-06	6.60E-06	1.63E-10	1.63E-12	5.12E-20	4.43E-20	2.14E-12	1.79E-11
In-115	4.96E-17	2.00E-16	4.94E-21	4.94E-23	1.55E-30	1.34E-30	6.48E-23	5.41E-22
Sn-121m	3.30E-08	1.33E-07	3.28E-12	3.28E-14	1.03E-21	8.91E-22	4.30E-14	3.59E-13
Sn-126	2.12E-07	8.56E-07	2.11E-11	2.11E-13	6.64E-21	5.74E-21	2.77E-13	2.32E-12
Sb-125	7.91E-06	3.19E-05	7.87E-10	7.87E-12	2.47E-19	2.14E-19	1.03E-11	8.62E-11
Sb-126	2.84E-08	1.14E-07	2.82E-12	2.82E-14	8.86E-22	7.67E-22	3.70E-14	3.09E-13
Te-123	1.89E-19	7.61E-19	1.88E-23	1.88E-25			2.47E-25	2.06E-24
Te-125m	1.55E-06	6.26E-06	1.55E-10	1.55E-12	4.85E-20	4.20E-20	2.03E-12	1.69E-11
I-129	2.40E-08	7.60E-08	5.13E-09	5.12E-09	4.80E-15	6.83E-13	6.72E-09	9.84E-16
Cs-134	5.14E-06	2.07E-05	5.11E-10	5.11E-12	1.60E-19	1.39E-19	6.70E-12	5.60E-11
Cs-135	4.42E-07	1.78E-06	4.40E-11	4.40E-13	1.38E-20	1.20E-20	5.77E-13	4.82E-12
Cs-137	2.59E-02	1.04E-01	2.58E-06	2.58E-08	8.09E-16	7.00E-16	3.38E-08	2.83E-07
Ba-137m	2.45E-02	9.88E-02	2.44E-06	2.44E-08	7.66E-16	6.63E-16	3.20E-08	2.67E-07
La-138	9.42E-17	3.79E-16	9.37E-21	9.37E-23	2.94E-30	2.54E-30	1.23E-22	1.03E-21
Ce-142	1.47E-11	5.94E-11	1.47E-15	1.47E-17	4.61E-25	3.98E-25	1.92E-17	1.61E-16
Ce-144	3.24E-07	1.31E-06	3.23E-11	3.23E-13	1.01E-20	8.77E-21	4.23E-13	3.54E-12
Pr-144	3.24E-07	1.31E-06	3.23E-11	3.23E-13	1.01E-20	8.77E-21	4.23E-13	3.54E-12
Nd-144	7.93E-16	3.19E-15	7.89E-20	7.89E-22	2.48E-29	2.14E-29	1.03E-21	8.64E-21
Pm-146	2.51E-08	1.01E-07	2.50E-12	2.50E-14	7.84E-22	6.78E-22	3.28E-14	2.74E-13
Pm-147	8.80E-05	3.55E-04	8.76E-09	8.76E-11	2.75E-18	2.38E-18	1.15E-10	9.60E-10
Sm-146	1.36E-13	5.48E-13	1.35E-17	1.35E-19	4.25E-27	3.68E-27	1.78E-19	1.48E-18
Sm-147	3.63E-12	1.46E-11	3.62E-16	3.62E-18	1.13E-25	9.82E-26	4.74E-18	3.96E-17
Sm-148	1.87E-17	7.52E-17	1.86E-21	1.86E-23			2.44E-23	2.04E-22
Sm-149	1.66E-18	6.67E-18	1.65E-22	1.65E-24			2.16E-24	1.81E-23
Sm-151	1.74E-04	6.99E-04	1.73E-08	1.73E-10	5.42E-18	4.69E-18	2.27E-10	1.89E-09
Eu-152	1.26E-06	5.06E-06	1.25E-10	1.25E-12	3.93E-20	3.40E-20	1.64E-12	1.37E-11
Eu-154	4.51E-05	1.82E-04	4.49E-09	4.49E-11	1.41E-18	1.22E-18	5.89E-11	4.92E-10
Eu-155	8.20E-05	3.30E-04	8.16E-09	8.16E-11	2.56E-18	2.22E-18	1.07E-10	8.94E-10
Gd-152	7.01E-19	2.82E-18	6.98E-23	6.98E-25			9.15E-25	7.64E-24
Ho-166m	2.27E-11	9.15E-11	2.26E-15	2.26E-17	7.09E-25	6.14E-25	2.96E-17	2.48E-16
Other Stream Data:								
TRU, nCi/gm	9.57E+02	2.73E+03					1.48E-03	1.11E-02
Heat Generation, W/m3	2.92E-01	1.18E+00					1.04E-06	3.51E-06
Mass Flow, kg/hr	4.04E+02	1.41E+02	2.60E+02	2.60E+02	2.47E+02	2.88E+02	2.60E+02	3.47E+01

Table C-4. Revised baseline mass balance, Tank WM-180 waste (Continued).

PFD Sheet #	PFD-3	PFD-4	PFD-4	PFD-4	PFD-4	PFD-4	PFD-4
Stream #	109	110	201	202	203	204	205
Stream Name	LET&D Offgas Vapor	Acid Grout Solid	OPC Grout Additive	BFS Grout Additive	Ca(OH)2 Total Additive	Ca(OH)2 Grout Additive	Ca(OH)2 Neutraliz. Additive
Rate or Volume Flow (actual)	1.69E+04	219	86.0	28.7	27.3	0.87	26.4
Volume Flow (standard, wet)*	1.06E+04						
Volume Flow (standard, dry)*	1.70E+00						
Rate Units	ft3/hr	lb/hr	lb/hr	lb/hr	lb/hr	lb/hr	lb/hr
Temperature, °C	119	64	25	25	25	25	25
Temperature, °F	246	148	77	77	77	77	77
Pressure, psia	12.3	12.2	12.3	12.3	12.3	12.3	12.3
Specific Gravity	4.71E-04	2.06	1.2	1.2	0.48	0.48	0.48
Chemical Composition	lb/wscf	Wt. %	Wt. %	Wt. %	Wt. %	Wt. %	Wt. %
H+	4.13E-07	8.88E-06					
OH-		1.77E-01			4.59E+01	4.59E+01	4.59E+01
Al+3		5.15E-06					
Sb+5		5.55E-11					
As+5		1.10E-08					
Ba+2		2.25E-09					
Be+2		2.31E-11					
B+3		3.68E-08					
Cd+2		2.64E-08					
Ca+2		6.76E+00			5.41E+01	5.41E+01	5.41E+01
Cr+3		5.73E-08					
Co+2		3.53E-10					
Cs+		1.12E-09					
Cu+2		1.32E-08					
Fe+3		3.52E-07					
Pb+2		8.57E-08					
Hg+2		1.20E-08					
Mn+4		2.29E-07					
Ni+2		2.67E-08					
K+		2.25E-06					
Se+4		1.99E-09					
Ag+		2.15E-10					
Na+		1.42E-05					
Tl+3		1.84E-09					
U+4		2.82E-08					
V+3		1.46E-08					
Zn+2		2.04E-08					
Zr+4		3.95E-08					
Cl-	1.45E-05	1.23E-09					
F-		1.70E-04					
SO4-2		1.56E-06					
NO3-	3.14E-09	2.03E+01					
PO4-3		6.07E-07					
Am+4		2.51E-12					
Br-	1.79E-10						
Ce+4		2.00E-09					
Eu+3		1.28E-11					
Gd+3		8.27E-09					
Ge+4		1.07E-13					
In+3		2.65E-11					
I-	2.36E-09	2.36E-12					
La+3		2.13E-10					
Li+		1.01E-09					
Mg+2		8.75E-08					
Mo+6		5.90E-09					

Table C-4. Revised baseline mass balance, Tank WM-180 waste (Continued).

Stream #	109	110	201	202	203	204	205
Stream Name	LET&D Offgas Vapor	Acid Grout Solid	OPC Grout Additive	BFS Grout Additive	Ca(OH)2 Total Additive	Ca(OH)2 Grout Additive	Ca(OH)2 Neutraliz. Additive
Chemical Composition	lb/wscf	Wt. %	Wt. %	Wt. %	Wt. %	Wt. %	Wt. %
Nd+3		7.14E-10					
Np+4		6.78E-10					
Nb+5		1.36E-08					
Pd+4		1.09E-09					
Pu+4		7.98E-10					
Pr+4		1.97E-10					
Rh+4		6.19E-11					
Rb+		7.91E-11					
Ru+3		4.18E-09					
Sm+3		1.38E-10					
Si+4		2.83E-08					
Sr+2		3.09E-09					
Tc+7		1.68E-10					
Te+4		6.15E-11					
Tb+4		5.61E-14					
Th+4		7.99E-15					
Sn+4		2.87E-09					
Ti+4		2.11E-09					
Y+3		1.02E-10					
O-2 (oxides)		6.95E-08					
H2O	4.70E-02	2.03E+01					
O2	1.42E-07						
N2	1.98E-07						
C (organic)		1.01E-03					
H (organic)		8.44E-05					
SiO2, BFS, or OPC Additives		5.25E+01	1.00E+02	1.00E+02			
Gas Stream Bulk Composition (wet basis)	mol.% or ppmv	mol.% or ppmv	mol.% or ppmv	mol.% or ppmv	mol.% or ppmv	mol.% or ppmv	mol.% or ppmv
H2O, mol.%	99.98						
O2, mol.%	0.0002						
N2, mol.%	0.0003						
CO2, mol.%							
HNO3, mol. %	0.02						
CO, ppmv							
NO, ppmv							
NO2, ppmv							
C (organic), ppmv							
H (organic), ppmv							
PM (mg/wscm)							
Gas Stream Bulk Composition (dry basis)	mol.% or ppmv	mol.% or ppmv	mol.% or ppmv	mol.% or ppmv	mol.% or ppmv	mol.% or ppmv	mol.% or ppmv
O2, mol.%	1.05						
N2, mol.%	1.67						
CO2, mol.%							
HNO3, mol. %	97.25						
CO, ppmv							
NO, ppmv							
NO2, ppmv							
C (organic), ppmv							
H (organic), ppmv							
PM (mg/dscm)							

Table C-4. Revised baseline mass balance, Tank WM-180 waste (Continued).

Stream #	109	110	201	202	203	204	205
Stream Name	LET&D Offgas Vapor	Acid Grout Solid	OPC Grout Additive	BFS Grout Additive	Ca(OH)2 Total Additive	Ca(OH)2 Grout Additive	Ca(OH)2 Neutraliz. Additive
Canister Rate, canisters/day							
Total Canisters Generated							
Drum Rate, drums/day		6.90					
Total Drums Generated		971					
Radiological Composition	Ci/wscm	Ci/kg	Ci/kg	Ci/kg	Ci/kg	Ci/kg	Ci/kg
Ra-226	8.78E-30	1.32E-17					
Ac-227	4.13E-29	6.23E-17					
Th-228	3.43E-27	5.17E-15					
Th-230	9.35E-28	1.41E-15					
Th-232		1.14E-21					
Pa-231	9.57E-29	1.44E-16					
Pa-233	3.14E-24	4.74E-12					
U-232	2.25E-27	3.40E-15					
U-233	8.78E-29	1.32E-16					
U-234	2.26E-24	3.40E-12					
U-235	8.24E-26	1.24E-13					
U-236	1.22E-25	1.84E-13					
U-237	6.89E-27	1.04E-14					
U-238	4.87E-26	7.35E-14					
Np-236	4.09E-30	6.17E-18					
Np-237	3.18E-24	4.79E-12					
Pu-236	4.52E-27	6.81E-15					
Pu-238	2.06E-21	3.11E-09					
Pu-239	3.13E-22	4.71E-10					
Pu-240	1.70E-23	2.56E-11					
Pu-241	1.24E-21	1.87E-09					
Pu-242	1.31E-26	1.97E-14					
Pu-244		1.69E-21					
Am-241	1.49E-22	2.25E-10					
Am-242m	1.63E-26	2.46E-14					
Am-243	2.37E-26	3.57E-14					
Cm-242	1.34E-26	2.03E-14					
Cm-243	3.86E-26	5.83E-14					
Cm-244	2.40E-24	3.62E-12					
Cm-245	4.07E-28	6.13E-16					
Cm-246	2.67E-29	4.03E-17					
Cm-247		9.56E-24					
H-3	1.52E-05	2.90E-06					
Be-10	3.21E-30	4.85E-18					
C-14	1.35E-28	2.03E-16					
Co-60	8.64E-24	1.30E-11					
Ni-59	1.98E-25	2.99E-13					
Ni-63	5.25E-23	7.91E-11					
Se-79	4.91E-25	7.40E-13					
Rb-87	3.14E-29	4.74E-17					
Sr-90	4.24E-20	6.39E-08					
Y-90	4.24E-20	6.39E-08					
Zr-93	2.37E-24	3.58E-12					
Nb-93m	1.83E-24	2.76E-12					
Nb-94	1.28E-24	1.93E-12					
Tc-98	2.76E-30	4.17E-18					
Tc-99	1.96E-23	2.96E-11					

Table C-4. Revised baseline mass balance, Tank WM-180 waste (Continued).

Stream #	109	110	201	202	203	204	205
Stream Name	LET&D Offgas Vapor	Acid Grout Solid	OPC Grout Additive	BFS Grout Additive	Ca(OH)2 Total Additive	Ca(OH)2 Grout Additive	Ca(OH)2 Neutraliz. Additive
Radiological Composition	Ci/wscm	Ci/kg	Ci/kg	Ci/kg	Ci/kg	Ci/kg	Ci/kg
Ru-106	1.05E-24	1.58E-12					
Rh-102	9.23E-28	1.39E-15					
Rh-106	1.05E-24	1.58E-12					
Pd-107	1.77E-26	2.67E-14					
Cd-113m	3.56E-24	5.37E-12					
In-115		1.63E-22					
Sn-121m	7.16E-26	1.08E-13					
Sn-126	4.61E-25	6.96E-13					
Sb-125	1.72E-23	2.59E-11					
Sb-126	6.16E-26	9.29E-14					
Te-123		6.19E-25					
Te-125m	3.37E-24	5.09E-12					
I-129	5.59E-09	2.96E-16					
Cs-134	1.12E-23	1.68E-11					
Cs-135	9.61E-25	1.45E-12					
Cs-137	5.63E-20	8.49E-08					
Ba-137m	5.33E-20	8.03E-08					
La-138		3.08E-22					
Ce-142	3.20E-29	4.83E-17					
Ce-144	7.05E-25	1.06E-12					
Pr-144	7.05E-25	1.06E-12					
Nd-144		2.60E-21					
Pm-146	5.45E-26	8.22E-14					
Pm-147	1.91E-22	2.88E-10					
Sm-146		4.46E-19					
Sm-147	7.89E-30	1.19E-17					
Sm-148		6.12E-23					
Sm-149		5.43E-24					
Sm-151	3.77E-22	5.69E-10					
Eu-152	2.73E-24	4.12E-12					
Eu-154	9.79E-23	1.48E-10					
Eu-155	1.78E-22	2.69E-10					
Gd-152		2.30E-24					
Ho-166m	4.93E-29	7.44E-17					
Other Stream Data:							
TRU, nCi/gm		3.89E-03					
Heat Generation, W/m3		1.82E-06					
Mass Flow, kg/hr	2.25E+02	9.91E+01	3.90E+01	1.30E+01	1.24E+01	3.93E-01	1.20E+01

* Standard conditions = 68°F and 1 atmosphere

Table C-5. Revised baseline mass balance, Tank WM-187 waste.

PFD Sheet #	PFD-1	PFD-2	PFD-2	PFD-2	PFD-2	PFD-2	PFD-2	PFD-3
Stream #	101	102	103	104	105	106	107	108
Stream Name	SBW Feed	Evaporator Bottoms	Evaporator Overheads Vapor	Mist Eliminator Vapor	VOG Offgas Vapor	POG + VOG Offgas Vapor	LET&D Feed Liquid	LET&D Acid Liquid
Rate or Volume Flow (actual)	85.8	21.5	2.68E+04	2.75E+04	1.17E+04	1.37E+04	66.7	10.9
Volume Flow (standard, wet)*			1.16E+04	1.16E+04	7.34E+03	8.57E+03		
Volume Flow (standard, dry)*			3.80E+02	3.80E+02	7.13E+03	8.35E+03		
Rate Units	gal/hr	gal/hr	ft3/hr	ft3/hr	ft3/hr	ft3/hr	gal/hr	gal/hr
Temperature, °C	25.0	120.2	120.2	120.0	107.5	109.4	35.0	35.0
Temperature, °F	77.0	248.4	248.4	248.0	225.6	228.8	95.0	95.0
Pressure, psia	12.3	8.6	8.6	8.4	12.0	12.0	12.0	12.2
Specific Gravity	1.27	1.75	0.00035	0.00034	0.00075	0.00074	1.06	1.17
Chemical Composition	Mol/Liter	Mol/Liter	lb/wscf	lb/wscf	lb/wscf	lb/wscf	Mol/Liter	Mol/Liter
H+	1.47E+00	3.66E-01	8.55E-05	8.55E-05	3.93E-12	1.16E-08	1.77E+00	1.09E+01
OH-		7.36E-09						
Al+3	3.61E-01	1.44E+00	5.99E-08	5.99E-10			4.64E-07	2.85E-06
Sb+5	2.78E-05	1.11E-04	2.08E-11	2.08E-13			3.58E-11	2.20E-10
As+5	1.77E-04	7.06E-04	8.14E-11	8.14E-13			2.27E-10	1.40E-09
Ba+2	7.12E-05	2.84E-04	6.01E-11	6.01E-13			9.15E-11	5.62E-10
Be+2	1.67E-05	6.66E-05	9.24E-13	9.24E-15			2.14E-11	1.32E-10
B+3	1.10E-02	4.40E-02	7.33E-10	7.33E-12			1.42E-08	8.71E-08
Cd+2	1.87E-03	7.47E-03	1.29E-09	1.29E-11			2.41E-09	1.48E-08
Ca+2	3.47E-02	1.39E-01	8.56E-09	8.56E-11			4.47E-08	2.74E-07
Cr+3	4.71E-03	1.88E-02	1.51E-09	1.51E-11			6.06E-09	3.72E-08
Co+2	1.94E-03	7.74E-03	7.03E-10	7.03E-12			2.49E-09	1.53E-08
Cs+	8.42E-05	3.36E-04	6.88E-11	6.88E-13			1.08E-10	6.65E-10
Cu+2	5.12E-04	2.04E-03	2.00E-10	2.00E-12			6.59E-10	4.05E-09
Fe+3	2.53E-02	1.01E-01	8.69E-09	8.69E-11			3.25E-08	2.00E-07
Pb+2	6.73E-04	2.69E-03	8.58E-10	8.58E-12			8.66E-10	5.32E-09
Hg+2	3.40E-03	1.26E-02	3.03E-06	3.03E-06	1.14E-11	4.21E-10	3.16E-04	1.93E-03
Mn+4	1.87E-02	7.45E-02	6.30E-09	6.30E-11			2.40E-08	1.47E-07
Ni+2	1.41E-03	5.63E-03	5.09E-10	5.09E-12			1.81E-09	1.11E-08
K+	3.13E-01	1.25E+00	7.53E-08	7.53E-10			4.03E-07	2.47E-06
Se+4	4.61E-04	1.84E-03	2.24E-10	2.24E-12			5.93E-10	3.64E-09
Ag+	7.08E-04	2.82E-03	4.69E-10	4.69E-12			9.10E-10	5.59E-09
Na+	1.76E+00	7.04E+00	2.49E-07	2.49E-09			2.27E-06	1.39E-05
Tl+3	6.31E-06	2.52E-05	7.93E-12	7.93E-14			8.12E-12	4.99E-11
U+4	2.90E-04	1.16E-03	4.25E-10	4.25E-12			3.73E-10	2.29E-09
V+3	6.14E-05	2.45E-04	1.92E-11	1.92E-13			7.90E-11	4.85E-10
Zn+2	7.21E-04	2.88E-03	2.90E-10	2.90E-12			9.27E-10	5.70E-09
Zr+4	6.66E-02	2.66E-01	3.73E-08	3.73E-10			8.56E-08	5.26E-07
Cl-	1.80E-02	6.02E-02	6.39E-06	6.38E-06	4.04E-12	8.71E-10	3.77E-03	3.85E-03
F-	5.61E-02	2.24E-01	4.71E-08	4.06E-08		5.52E-12	4.47E-05	2.74E-04
SO4-2	4.99E-02	1.99E-01	2.95E-08	2.95E-10			6.42E-08	3.94E-07
NO3-	4.62E+00	1.29E+01	5.25E-03	5.25E-03	2.42E-10	7.14E-07	1.77E+00	1.09E+01
PO4-3	1.75E-01	6.96E-01	1.02E-07	1.02E-09			2.24E-07	1.38E-06
Am+4	6.56E-08	2.62E-07	9.80E-14	9.80E-16			8.43E-14	5.18E-13
Br-	2.21E-07	7.01E-07	2.23E-10	2.23E-10	1.41E-16	3.04E-14	5.84E-08	5.97E-08
Ce+4	4.07E-05	1.62E-04	3.50E-11	3.50E-13			5.23E-11	3.21E-10
Eu+3	3.68E-07	1.47E-06	3.44E-13	3.44E-15			4.73E-13	2.90E-12
Gd+3	1.37E-04	5.46E-04	1.32E-10	1.32E-12			1.76E-10	1.08E-09
Ge+4	6.37E-09	2.54E-08	2.85E-15	2.85E-17			8.19E-15	5.03E-14
In+3	1.07E-06	4.26E-06	7.54E-13	7.54E-15			1.37E-12	8.43E-12
I-	3.12E-06	1.09E-05	2.94E-09	2.94E-09	1.86E-15	4.01E-13	4.84E-07	4.96E-07
La+3	6.66E-06	2.66E-05	5.69E-12	5.69E-14			8.56E-12	5.26E-11
Li+	6.26E-04	2.50E-03	2.67E-11	2.67E-13			8.05E-10	4.94E-09
Mg+2	1.54E-02	6.14E-02	2.30E-09	2.30E-11			1.98E-08	1.22E-07
Mo+6	1.23E-03	4.91E-03	7.26E-10	7.26E-12			1.58E-09	9.73E-09

Table C-5. Revised baseline mass balance, Tank WM-187 waste (Continued).

Stream #	101	102	103	104	105	106	107	108
Stream Name	SBW Feed	Evaporator Bottoms	Evaporator Overheads Vapor	Mist Eliminator Vapor	VOG Offgas Vapor	POG + VOG Offgas Vapor	LET&D Feed Liquid	LET&D Acid Liquid
Chemical Composition	Mol/Liter	Mol/Liter	lb/wscf	lb/wscf	lb/wscf	lb/wscf	Mol/Liter	Mol/Liter
Nd+3	2.15E-05	8.57E-05	1.90E-11	1.90E-13			2.76E-11	1.70E-10
Np+4	3.28E-06	1.31E-05	4.78E-12	4.78E-14			4.22E-12	2.59E-11
Nb+5	1.86E-03	7.41E-03	1.06E-09	1.06E-11			2.39E-09	1.47E-08
Pd+4	3.01E-03	1.20E-02	1.97E-09	1.97E-11			3.87E-09	2.38E-08
Pu+4	8.75E-06	3.49E-05	1.31E-11	1.31E-13			1.13E-11	6.91E-11
Pr+4	6.05E-06	2.42E-05	5.25E-12	5.24E-14			7.78E-12	4.78E-11
Rh+4	2.61E-06	1.04E-05	1.65E-12	1.65E-14			3.36E-12	2.06E-11
Rb+	4.02E-06	1.60E-05	2.11E-12	2.11E-14			5.17E-12	3.18E-11
Ru+3	1.36E-03	5.43E-03	8.46E-10	8.46E-12			1.75E-09	1.08E-08
Sm+3	4.03E-06	1.61E-05	3.72E-12	3.72E-14			5.18E-12	3.18E-11
Si+4	1.59E-01	6.33E-01	2.74E-08	2.74E-10			2.04E-07	1.25E-06
Sr+2	8.80E-05	3.51E-04	4.74E-11	4.74E-13			1.13E-10	6.95E-10
Tc+7	6.42E-06	2.56E-05	3.83E-12	3.83E-14			8.25E-12	5.07E-11
Te+4	3.48E-06	1.39E-05	2.73E-12	2.73E-14			4.48E-12	2.75E-11
Tb+4	1.53E-09	6.12E-09	1.50E-15	1.50E-17			1.97E-15	1.21E-14
Th+4	1.85E-05	7.37E-05	2.63E-11	2.63E-13			2.37E-11	1.46E-10
Sn+4	3.23E-03	1.29E-02	2.36E-09	2.36E-11			4.15E-09	2.55E-08
Ti+4	1.62E-03	6.46E-03	4.77E-10	4.77E-12			2.08E-09	1.28E-08
Y+3	4.96E-06	1.98E-05	2.71E-12	2.71E-14			6.38E-12	3.92E-11
O-2 (oxides)	2.70E-01	1.08E+00	2.66E-08	2.66E-10			3.47E-07	2.13E-06
H2O	4.71E+01	2.68E+01	4.54E-02	4.54E-02	1.36E-03	1.17E-03	5.27E+01	2.66E+01
O2		1.78E-10	1.69E-07	1.69E-07	1.69E-02	1.70E-02	7.84E-05	
N2		2.16E-10	2.81E-07	2.81E-07	5.58E-02	5.60E-02	1.18E-04	
C (organic)	1.96E-01	7.72E-01	1.77E-06	1.76E-06	2.34E-12	2.41E-10	3.06E-03	1.88E-02
H (organic)	1.96E-01	7.72E-01	1.49E-07	1.48E-07	1.96E-13	2.02E-11	3.06E-03	1.88E-02
SiO2, BFS, or OPC Additives								
Gas Stream Bulk Composition (wet basis)	mol.% or ppmv	mol.% or ppmv	mol.% or ppmv	mol.% or ppmv	mol.% or ppmv	mol.% or ppmv	mol.% or ppmv	mol.% or ppmv
H2O, mol.%			96.74	96.74	2.91	2.50		
O2, mol.%			0.0002	0.0002	20.39	20.47		
N2, mol.%			0.0004	0.0004	76.71	77.02		
CO2, mol.%								
HNO3, mol. %			3.26	3.26	1.5E-07	4.4E-04		
CO, ppmv								
NO, ppmv								
NO2, ppmv								
C (organic), ppmv			57	56	7.5E-05	7.7E-03		
H (organic), ppmv			57	56	7.5E-05	7.7E-03		
PM (mg/wscm)			7	0.07				
Gas Stream Bulk Composition (dry basis)	mol.% or ppmv	mol.% or ppmv	mol.% or ppmv	mol.% or ppmv	mol.% or ppmv	mol.% or ppmv	mol.% or ppmv	mol.% or ppmv
O2, mol.%			0.01	0.01	21.00	21.00		
N2, mol.%			0.01	0.01	79.00	79.00		
CO2, mol.%								
HNO3, mol. %			99.84	99.88	1.5E-07	4.6E-04		
CO, ppmv								
NO, ppmv								
NO2, ppmv								
C (organic), ppmv			1,737	1,724	7.7E-05	7.9E-03		
H (organic), ppmv			1,737	1,724	7.7E-05	7.9E-03		
PM (mg/dscm)			212	2				

Table C-5. Revised baseline mass balance, Tank WM-187 waste (Continued).

Stream #	101	102	103	104	105	106	107	108
Stream Name	SBW Feed	Evaporator Bottoms	Evaporator Overheads Vapor	Mist Eliminator Vapor	VOG Offgas Vapor	POG + VOG Offgas Vapor	LET&D Feed Liquid	LET&D Acid Liquid
Canister Rate, canisters/day		2.44						
Total Canisters Generated		182						
Drum Rate, drums/day								
Total Drums Generated								
Radiological Composition	Ci/L	Ci/L	Ci/wscm	Ci/wscm	Ci/wscm	Ci/wscm	Ci/L	Ci/L
Ra-226	6.30E-12	2.52E-11	6.21E-16	6.21E-18	1.97E-25	1.70E-25	8.10E-18	4.98E-17
Ac-227	2.97E-11	1.18E-10	2.92E-15	2.92E-17	9.28E-25	8.03E-25	3.82E-17	2.34E-16
Th-228	2.46E-09	9.83E-09	2.43E-13	2.43E-15	7.70E-23	6.66E-23	3.17E-15	1.95E-14
Th-230	1.03E-09	4.10E-09	1.01E-13	1.01E-15	3.21E-23	2.78E-23	1.32E-15	8.11E-15
Th-232	5.45E-16	2.18E-15	5.37E-20	5.37E-22	1.70E-29	1.47E-29	7.01E-22	4.31E-21
Pa-231	6.88E-11	2.74E-10	6.77E-15	6.77E-17	2.15E-24	1.86E-24	8.84E-17	5.43E-16
Pa-233	2.26E-06	9.00E-06	2.22E-10	2.22E-12	7.05E-20	6.10E-20	2.90E-12	1.78E-11
U-232	2.35E-09	9.36E-09	2.31E-13	2.31E-15	7.33E-23	6.34E-23	3.02E-15	1.85E-14
U-233	7.56E-11	3.02E-10	7.45E-15	7.45E-17	2.36E-24	2.04E-24	9.72E-17	5.97E-16
U-234	1.24E-06	4.93E-06	1.22E-10	1.22E-12	3.86E-20	3.34E-20	1.59E-12	9.76E-12
U-235	6.49E-08	2.59E-07	6.39E-12	6.39E-14	2.03E-21	1.76E-21	8.35E-14	5.13E-13
U-236	6.04E-08	2.41E-07	5.95E-12	5.95E-14	1.89E-21	1.63E-21	7.77E-14	4.77E-13
U-237	4.95E-09	1.98E-08	4.88E-13	4.88E-15	1.55E-22	1.34E-22	6.37E-15	3.91E-14
U-238	2.12E-08	8.46E-08	2.09E-12	2.09E-14	6.63E-22	5.73E-22	2.73E-14	1.68E-13
Np-236	2.43E-12	9.70E-12	2.39E-16	2.39E-18	7.60E-26	6.57E-26	3.12E-18	1.92E-17
Np-237	5.64E-07	2.25E-06	5.56E-11	5.56E-13	1.76E-20	1.53E-20	7.25E-13	4.46E-12
Pu-236	3.70E-09	1.48E-08	3.65E-13	3.65E-15	1.16E-22	1.00E-22	4.76E-15	2.93E-14
Pu-238	1.13E-03	4.53E-03	1.12E-07	1.12E-09	3.55E-17	3.07E-17	1.46E-09	8.96E-09
Pu-239	1.25E-04	4.98E-04	1.23E-08	1.23E-10	3.90E-18	3.37E-18	1.60E-10	9.85E-10
Pu-240	1.39E-05	5.54E-05	1.37E-09	1.37E-11	4.34E-19	3.75E-19	1.78E-11	1.10E-10
Pu-241	8.71E-04	3.47E-03	8.57E-08	8.57E-10	2.72E-17	2.35E-17	1.12E-09	6.88E-09
Pu-242	1.09E-08	4.35E-08	1.07E-12	1.07E-14	3.41E-22	2.95E-22	1.40E-14	8.61E-14
Pu-244	6.59E-16	2.63E-15	6.49E-20	6.49E-22	2.06E-29	1.78E-29	8.48E-22	5.21E-21
Am-241	6.74E-05	2.69E-04	6.64E-09	6.64E-11	2.11E-18	1.82E-18	8.66E-11	5.32E-10
Am-242m	1.19E-08	4.74E-08	1.17E-12	1.17E-14	3.71E-22	3.21E-22	1.53E-14	9.38E-14
Am-243	2.36E-08	9.43E-08	2.33E-12	2.33E-14	7.39E-22	6.39E-22	3.04E-14	1.87E-13
Cm-242	2.36E-08	9.41E-08	2.32E-12	2.32E-14	7.37E-22	6.38E-22	3.03E-14	1.86E-13
Cm-243	3.60E-08	1.44E-07	3.54E-12	3.54E-14	1.12E-21	9.73E-22	4.63E-14	2.84E-13
Cm-244	1.63E-06	6.51E-06	1.61E-10	1.61E-12	5.10E-20	4.41E-20	2.10E-12	1.29E-11
Cm-245	3.79E-10	1.51E-09	3.74E-14	3.74E-16	1.19E-23	1.03E-23	4.88E-16	3.00E-15
Cm-246	2.48E-11	9.91E-11	2.45E-15	2.45E-17	7.76E-25	6.72E-25	3.19E-17	1.96E-16
Cm-247	1.09E-17	4.36E-17	1.08E-21	1.08E-23			1.40E-23	8.63E-23
H-3	9.86E-06	5.51E-06	8.30E-06	8.30E-06	7.80E-08	6.79E-08	1.08E-05	5.46E-06
Be-10	2.31E-12	9.21E-12	2.27E-16	2.27E-18	7.22E-26	6.24E-26	2.97E-18	1.82E-17
C-14	1.58E-10	6.29E-10	1.55E-14	1.55E-16	4.92E-24	4.26E-24	2.03E-16	1.24E-15
Co-60	1.65E-05	6.59E-05	1.63E-09	1.63E-11	5.16E-19	4.46E-19	2.12E-11	1.30E-10
Ni-59	2.06E-06	8.22E-06	2.03E-10	2.03E-12	6.43E-20	5.57E-20	2.65E-12	1.63E-11
Ni-63	4.29E-05	1.71E-04	4.22E-09	4.22E-11	1.34E-18	1.16E-18	5.51E-11	3.39E-10
Se-79	5.71E-07	2.28E-06	5.62E-11	5.62E-13	1.78E-20	1.54E-20	7.34E-13	4.51E-12
Rb-87	2.26E-11	9.00E-11	2.22E-15	2.22E-17	7.05E-25	6.10E-25	2.90E-17	1.78E-16
Sr-90	3.04E-02	1.21E-01	2.99E-06	2.99E-08	9.49E-16	8.21E-16	3.90E-08	2.40E-07
Y-90	3.04E-02	1.21E-01	2.99E-06	2.99E-08	9.49E-16	8.21E-16	3.90E-08	2.40E-07
Zr-93	1.70E-06	6.80E-06	1.68E-10	1.68E-12	5.33E-20	4.61E-20	2.19E-12	1.35E-11
Nb-93m	1.31E-06	5.24E-06	1.29E-10	1.29E-12	4.10E-20	3.55E-20	1.69E-12	1.04E-11
Nb-94	1.48E-06	5.92E-06	1.46E-10	1.46E-12	4.63E-20	4.01E-20	1.91E-12	1.17E-11
Tc-98	1.99E-12	7.92E-12	1.95E-16	1.95E-18	6.20E-26	5.37E-26	2.55E-18	1.57E-17
Tc-99	1.69E-05	6.75E-05	1.67E-09	1.67E-11	5.28E-19	4.57E-19	2.17E-11	1.34E-10

Table C-5. Revised baseline mass balance, Tank WM-187 waste (Continued).

Stream #	101	102	103	104	105	106	107	108
Stream Name	SBW Feed	Evaporator Bottoms	Evaporator Overheads Vapor	Mist Eliminator Vapor	VOG Offgas Vapor	POG + VOG Offgas Vapor	LET&D Feed Liquid	LET&D Acid Liquid
Radiological Composition	Ci/L	Ci/L	Ci/wscm	Ci/wscm	Ci/wscm	Ci/wscm	Ci/L	Ci/L
Ru-106	1.22E-06	4.88E-06	1.20E-10	1.20E-12	3.82E-20	3.31E-20	1.57E-12	9.66E-12
Rh-102	6.63E-10	2.65E-09	6.53E-14	6.53E-16	2.07E-23	1.79E-23	8.53E-16	5.24E-15
Rh-106	1.22E-06	4.88E-06	1.20E-10	1.20E-12	3.82E-20	3.31E-20	1.57E-12	9.66E-12
Pd-107	1.27E-08	5.07E-08	1.25E-12	1.25E-14	3.97E-22	3.44E-22	1.63E-14	1.00E-13
Cd-113m	2.56E-06	1.02E-05	2.52E-10	2.52E-12	7.99E-20	6.91E-20	3.29E-12	2.02E-11
In-115	7.75E-17	3.09E-16	7.63E-21	7.63E-23	2.42E-30	2.09E-30	9.96E-23	6.12E-22
Sn-121m	5.15E-08	2.05E-07	5.07E-12	5.07E-14	1.61E-21	1.39E-21	6.61E-14	4.06E-13
Sn-126	5.38E-07	2.15E-06	5.30E-11	5.30E-13	1.68E-20	1.45E-20	6.92E-13	4.25E-12
Sb-125	7.14E-04	2.85E-03	7.04E-08	7.03E-10	2.23E-17	1.93E-17	9.18E-10	5.64E-09
Sb-126	4.43E-08	1.77E-07	4.36E-12	4.36E-14	1.38E-21	1.20E-21	5.69E-14	3.50E-13
Te-123	2.95E-19	1.18E-18	2.90E-23	2.90E-25			3.79E-25	2.33E-24
Te-125m	2.42E-06	9.67E-06	2.39E-10	2.39E-12	7.57E-20	6.55E-20	3.12E-12	1.91E-11
I-129	6.94E-08	2.32E-07	1.11E-08	1.11E-08	7.04E-15	1.51E-12	1.45E-08	1.49E-08
Cs-134	7.29E-05	2.91E-04	7.18E-09	7.18E-11	2.28E-18	1.97E-18	9.37E-11	5.76E-10
Cs-135	1.08E-06	4.29E-06	1.06E-10	1.06E-12	3.36E-20	2.91E-20	1.38E-12	8.49E-12
Cs-137	4.44E-02	1.77E-01	4.37E-06	4.37E-08	1.39E-15	1.20E-15	5.70E-08	3.50E-07
Ba-137m	4.20E-02	1.67E-01	4.13E-06	4.13E-08	1.31E-15	1.13E-15	5.40E-08	3.31E-07
La-138	1.47E-16	5.86E-16	1.45E-20	1.45E-22	4.59E-30	3.97E-30	1.89E-22	1.16E-21
Ce-142	2.30E-11	9.18E-11	2.27E-15	2.27E-17	7.19E-25	6.22E-25	2.96E-17	1.82E-16
Ce-144	8.27E-07	3.30E-06	8.14E-11	8.14E-13	2.58E-20	2.24E-20	1.06E-12	6.53E-12
Pr-144	8.27E-07	3.30E-06	8.14E-11	8.14E-13	2.58E-20	2.24E-20	1.06E-12	6.53E-12
Nd-144	1.24E-15	4.94E-15	1.22E-19	1.22E-21	3.87E-29	3.34E-29	1.59E-21	9.77E-21
Pm-146	4.00E-08	1.60E-07	3.94E-12	3.94E-14	1.25E-21	1.08E-21	5.14E-14	3.16E-13
Pm-147	2.22E-04	8.87E-04	2.19E-08	2.19E-10	6.95E-18	6.01E-18	2.86E-10	1.76E-09
Sm-146	2.12E-13	8.47E-13	2.09E-17	2.09E-19	6.63E-27	5.74E-27	2.73E-19	1.68E-18
Sm-147	5.67E-12	2.26E-11	5.58E-16	5.58E-18	1.77E-25	1.53E-25	7.29E-18	4.48E-17
Sm-148	2.91E-17	1.16E-16	2.87E-21	2.87E-23			3.74E-23	2.30E-22
Sm-149	2.59E-18	1.03E-17	2.55E-22	2.55E-24			3.32E-24	2.04E-23
Sm-151	4.40E-04	1.76E-03	4.34E-08	4.34E-10	1.38E-17	1.19E-17	5.66E-10	3.48E-09
Eu-152	2.57E-06	1.03E-05	2.53E-10	2.53E-12	8.04E-20	6.96E-20	3.31E-12	2.03E-11
Eu-154	9.75E-05	3.89E-04	9.60E-09	9.60E-11	3.05E-18	2.64E-18	1.25E-10	7.70E-10
Eu-155	1.03E-04	4.11E-04	1.01E-08	1.01E-10	3.22E-18	2.78E-18	1.32E-10	8.13E-10
Gd-152	1.09E-18	4.37E-18	1.08E-22	1.08E-24			1.41E-24	8.64E-24
Ho-166m	3.54E-11	1.41E-10	3.49E-15	3.49E-17	1.11E-24	9.58E-25	4.55E-17	2.80E-16
Other Stream Data:								
TRU, nCi/gm	1.08E+03	3.12E+03					1.66E-03	9.27E-03
Heat Generation, W/m3	4.62E-01	1.84E+00					9.66E-07	3.84E-06
Mass Flow, kg/hr	4.07E+02	1.42E+02	2.68E+02	2.68E+02	2.47E+02	2.88E+02	2.68E+02	4.79E+01

Table C-5. Revised baseline mass balance, Tank WM-187 waste (Continued).

PFD Sheet #	PFD-3	PFD-4	PFD-4	PFD-4	PFD-4	PFD-4	PFD-4
Stream #	109	110	201	202	203	204	205
Stream Name	LET&D Offgas Vapor	Acid Grout Solid	OPC Grout Additive	BFS Grout Additive	Ca(OH)2 Total Additive	Ca(OH)2 Grout Additive	Ca(OH)2 Neutraliz. Additive
Rate or Volume Flow (actual)	1.65E+04	301.8	119	39.6	37.7	1.20	36.5
Volume Flow (standard, wet)*	1.03E+04						
Volume Flow (standard, dry)*	7.11E-01						
Rate Units	ft3/hr	lb/hr	lb/hr	lb/hr	lb/hr	lb/hr	lb/hr
Temperature, °C	119.1	64.3	25.0	25.0	25.0	25.0	25.0
Temperature, °F	246.3	147.8	77.0	77.0	77.0	77.0	77.0
Pressure, psia	12.3	12.2	12.3	12.3	12.3	12.3	12.3
Specific Gravity	0.00047	2.06	1.2	1.2	0.48	2.24	0.48
Chemical Composition	lb/wscf	Wt. %	Wt. %	Wt. %	Wt. %	Wt. %	Wt. %
H+	1.70E-07	8.23E-06					
OH-		1.81E-01			4.59E+01	4.59E+01	4.59E+01
Al+3		2.31E-06					
Sb+5		8.04E-10					
As+5		3.14E-09					
Ba+2		2.32E-09					
Be+2		3.57E-11					
B+3		2.83E-08					
Cd+2		4.99E-08					
Ca+2		6.76E+00			5.41E+01	5.41E+01	5.41E+01
Cr+3		5.81E-08					
Co+2		2.71E-08					
Cs+		2.65E-09					
Cu+2		7.73E-09					
Fe+3		3.35E-07					
Pb+2		3.31E-08					
Hg+2		1.16E-02					
Mn+4		2.43E-07					
Ni+2		1.96E-08					
K+		2.90E-06					
Se+4		8.64E-09					
Ag+		1.81E-08					
Na+		9.62E-06					
Tl+3		3.06E-10					
U+4		1.64E-08					
V+3		7.42E-10					
Zn+2		1.12E-08					
Zr+4		1.44E-06					
Cl-	5.99E-06	4.10E-03					
F-		1.57E-04					
SO4-2		1.14E-06					
NO3-	4.59E-09	2.03E+01					
PO4-3		3.93E-06					
Am+4		3.78E-12					
Br-	2.09E-10	1.43E-07					
Ce+4		1.35E-09					
Eu+3		1.33E-11					
Gd+3		5.10E-09					
Ge+4		1.10E-13					
In+3		2.91E-11					
I-	2.76E-09	1.89E-06					
La+3		2.19E-10					
Li+		1.03E-09					
Mg+2		8.88E-08					
Mo+6		2.80E-08					

Table C-5. Revised baseline mass balance, Tank WM-187 waste (Continued).

Stream #	109	110	201	202	203	204	205
Stream Name	LET&D Offgas Vapor	Acid Grout Solid	OPC Grout Additive	BFS Grout Additive	Ca(OH)2 Total Additive	Ca(OH)2 Grout Additive	Ca(OH)2 Neutraliz. Additive
Chemical Composition	lb/wscf	Wt. %	Wt. %	Wt. %	Wt. %	Wt. %	Wt. %
Nd+3		7.35E-10					
Np+4		1.85E-10					
Nb+5		4.09E-08					
Pd+4		7.61E-08					
Pu+4		5.07E-10					
Pr+4		2.02E-10					
Rh+4		6.38E-11					
Rb+		8.15E-11					
Ru+3		3.26E-08					
Sm+3		1.44E-10					
Si+4		1.06E-06					
Sr+2		1.83E-09					
Tc+7		1.48E-10					
Te+4		1.05E-10					
Tb+4		5.78E-14					
Th+4		1.02E-09					
Sn+4		9.09E-08					
Ti+4		1.84E-08					
Y+3		1.05E-10					
O-2 (oxides)		1.03E-06					
H2O	4.70E-02	2.03E+01					
O2	1.35E-07						
N2	1.78E-07						
C (organic)		6.79E-03					
H (organic)		5.70E-04					
SiO2, BFS, or OPC Additives		5.25E+01	1.00E+02	1.00E+02			
Gas Stream Bulk Composition (wet basis)	mol.% or ppmv	mol.% or ppmv	mol.% or ppmv	mol.% or ppmv	mol.% or ppmv	mol.% or ppmv	mol.% or ppmv
H2O, mol.%	99.99						
O2, mol.%	0.00						
N2, mol.%	0.00						
CO2, mol.%							
HNO3, mol. %	0.01						
CO, ppmv							
NO, ppmv							
NO2, ppmv							
C (organic), ppmv							
H (organic), ppmv							
PM (mg/wscm)							
Gas Stream Bulk Composition (dry basis)	mol.% or ppmv	mol.% or ppmv	mol.% or ppmv	mol.% or ppmv	mol.% or ppmv	mol.% or ppmv	mol.% or ppmv
O2, mol.%	2.35						
N2, mol.%	3.54						
CO2, mol.%							
HNO3, mol. %	94.12						
CO, ppmv							
NO, ppmv							
NO2, ppmv							
C (organic), ppmv							
H (organic), ppmv							
PM (mg/dscm)							

Table C-5. Revised baseline mass balance, Tank WM-187 waste (Continued).

Stream #	109	110	201	202	203	204	205
Stream Name	LET&D Offgas Vapor	Acid Grout Solid	OPC Grout Additive	BFS Grout Additive	Ca(OH)2 Total Additive	Ca(OH)2 Grout Additive	Ca(OH)2 Neutraliz. Additive
Chemical Composition	lb/wscf	Wt. %	Wt. %	Wt. %	Wt. %	Wt. %	Wt. %
Nd+3		7.35E-10					
Np+4		1.85E-10					
Nb+5		4.09E-08					
Pd+4		7.61E-08					
Pu+4		5.07E-10					
Pr+4		2.02E-10					
Rh+4		6.38E-11					
Rb+		8.15E-11					
Ru+3		3.26E-08					
Sm+3		1.44E-10					
Si+4		1.06E-06					
Sr+2		1.83E-09					
Tc+7		1.48E-10					
Te+4		1.05E-10					
Tb+4		5.78E-14					
Th+4		1.02E-09					
Sn+4		9.09E-08					
Ti+4		1.84E-08					
Y+3		1.05E-10					
O-2 (oxides)		1.03E-06					
H2O	4.70E-02	2.03E+01					
O2	1.35E-07						
N2	1.78E-07						
C (organic)		6.79E-03					
H (organic)		5.70E-04					
SiO2, BFS, or OPC Additives		5.25E+01	1.00E+02	1.00E+02			
Gas Stream Bulk Composition (wet basis)	mol.% or ppmv	mol.% or ppmv	mol.% or ppmv	mol.% or ppmv	mol.% or ppmv	mol.% or ppmv	mol.% or ppmv
H2O, mol.%	99.99						
O2, mol.%	0.00						
N2, mol.%	0.00						
CO2, mol.%							
HNO3, mol. %	0.01						
CO, ppmv							
NO, ppmv							
NO2, ppmv							
C (organic), ppmv							
H (organic), ppmv							
PM (mg/wscm)							
Gas Stream Bulk Composition (dry basis)	mol.% or ppmv	mol.% or ppmv	mol.% or ppmv	mol.% or ppmv	mol.% or ppmv	mol.% or ppmv	mol.% or ppmv
O2, mol.%	2.35						
N2, mol.%	3.54						
CO2, mol.%							
HNO3, mol. %	94.12						
CO, ppmv							
NO, ppmv							
NO2, ppmv							
C (organic), ppmv							
H (organic), ppmv							
PM (mg/dscm)							

Table C-5. Revised baseline mass balance, Tank WM-187 waste (Continued).

Stream #	109	110	201	202	203	204	205
Stream Name	LET&D Offgas Vapor	Acid Grout Solid	OPC Grout Additive	BFS Grout Additive	Ca(OH)2 Total Additive	Ca(OH)2 Grout Additive	Ca(OH)2 Neutraliz. Additive
Radiological Composition	Ci/wscm	Ci/kg	Ci/kg	Ci/kg	Ci/kg	Ci/kg	Ci/kg
Ru-106	2.72E-24	2.90E-12					
Rh-102	1.47E-27	1.57E-15					
Rh-106	2.72E-24	2.90E-12					
Pd-107	2.82E-26	3.02E-14					
Cd-113m	5.68E-24	6.06E-12					
In-115		1.84E-22					
Sn-121m	1.14E-25	1.22E-13					
Sn-126	1.20E-24	1.28E-12					
Sb-125	1.59E-21	1.69E-09					
Sb-126	9.83E-26	1.05E-13					
Te-123		7.00E-25					
Te-125m	5.38E-24	5.75E-12					
I-129	1.04E-08	4.48E-09					
Cs-134	1.62E-22	1.73E-10					
Cs-135	2.39E-24	2.55E-12					
Cs-137	9.86E-20	1.05E-07					
Ba-137m	9.32E-20	9.96E-08					
La-138		3.49E-22					
Ce-142	5.11E-29	5.46E-17					
Ce-144	1.84E-24	1.96E-12					
Pr-144	1.84E-24	1.96E-12					
Nd-144		2.93E-21					
Pm-146	8.88E-26	9.48E-14					
Pm-147	4.94E-22	5.27E-10					
Sm-146		5.04E-19					
Sm-147	1.26E-29	1.34E-17					
Sm-148		6.91E-23					
Sm-149		6.13E-24					
Sm-151	9.78E-22	1.04E-09					
Eu-152	5.72E-24	6.10E-12					
Eu-154	2.17E-22	2.31E-10					
Eu-155	2.29E-22	2.44E-10					
Gd-152		2.60E-24					
Ho-166m	7.87E-29	8.40E-17					
Other Stream Data:							
TRU, nCi/gm		3.25E-03					
Heat Generation, W/m3		1.99E-06					
Mass Flow, kg/hr	2.20E+02	1.37E+02	5.39E+01	1.80E+01	1.71E+01	5.42E-01	1.66E+01

* Standard conditions = 68oF and 1 atmosphere

Table C-6. Revised baseline mass balance, Tank WM-188 waste.

PFD Sheet #	PFD-1	PFD-2	PFD-2	PFD-2	PFD-2	PFD-2	PFD-2
Stream #	101	102	103	104	105	106	107
Stream Name	SBW Feed	Evaporator Bottoms	Evaporator Overheads Vapor	Mist Eliminator Vapor	VOG Offgas Vapor	POG + VOG Offgas Vapor	LET&D Feed Liquid
Rate or Volume Flow (actual)	85.8	21.4	2.59E+04	2.68E+04	1.17E+04	1.37E+04	65.7
Volume Flow (standard, wet)*			1.14E+04	1.14E+04	7.34E+03	8.57E+03	
Volume Flow (standard, dry)*			5.48E+02	5.48E+02	7.13E+03	8.36E+03	
Rate Units	gal/hr	gal/hr	ft3/hr	ft3/hr	ft3/hr	ft3/hr	gal/hr
Temperature, °C	25.0	116.7	116.7	120.0	107.5	109.4	35.0
Temperature, °F	77.0	242.0	242.0	248.0	225.6	228.8	95.0
Pressure, psia	12.3	8.6	8.6	8.4	12.0	12.0	12.0
Specific Gravity	1.26	1.75	0.00037	0.00036	0.00075	0.00074	1.09
Chemical Composition	Mol/Liter	Mol/Liter	lb/wscf	lb/wscf	lb/wscf	lb/wscf	Mol/Liter
H+	2.18E+00	7.40E-01	1.26E-04	1.26E-04	5.81E-12	1.68E-08	2.60E+00
OH-							
Al+3	5.07E-01	2.03E+00	8.61E-08	8.61E-10			6.61E-07
Sb+5	1.58E-05	6.34E-05	1.22E-11	1.22E-13			2.07E-11
As+5	8.88E-05	3.55E-04	4.19E-11	4.19E-13			1.16E-10
Ba+2	7.24E-05	2.90E-04	6.26E-11	6.26E-13			9.45E-11
Be+2	1.83E-05	7.31E-05	1.04E-12	1.04E-14			2.38E-11
B+3	1.59E-02	6.35E-02	1.08E-09	1.08E-11			2.07E-08
Cd+2	2.42E-03	9.70E-03	1.72E-09	1.72E-11			3.16E-09
Ca+2	4.83E-02	1.93E-01	1.22E-08	1.22E-10			6.30E-08
Cr+3	4.48E-03	1.79E-02	1.47E-09	1.47E-11			5.85E-09
Co+2	3.97E-05	1.59E-04	1.47E-11	1.47E-13			5.18E-11
Cs+	5.75E-05	2.30E-04	4.82E-11	4.82E-13			7.51E-11
Cu+2	6.78E-04	2.71E-03	2.71E-10	2.71E-12			8.85E-10
Fe+3	2.49E-02	9.98E-02	8.77E-09	8.77E-11			3.25E-08
Pb+2	7.98E-04	3.19E-03	1.04E-09	1.04E-11			1.04E-09
Hg+2	5.11E-03	1.93E-02	3.70E-06	3.70E-06	1.31E-11	5.02E-10	3.82E-04
Mn+4	1.43E-02	5.73E-02	4.96E-09	4.96E-11			1.87E-08
Ni+2	1.78E-03	7.11E-03	6.57E-10	6.57E-12			2.32E-09
K+	1.82E-01	7.29E-01	4.49E-08	4.49E-10			2.38E-07
Se+4	2.34E-04	9.36E-04	1.16E-10	1.16E-12			3.05E-10
Ag+	3.64E-04	1.46E-03	2.47E-10	2.47E-12			4.75E-10
Na+	1.35E+00	5.41E+00	1.96E-07	1.96E-09			1.76E-06
Tl+3	4.42E-06	1.77E-05	5.70E-12	5.70E-14			5.77E-12
U+4	3.50E-04	1.40E-03	5.25E-10	5.25E-12			4.57E-10
V+3	3.62E-05	1.45E-04	1.16E-11	1.16E-13			4.72E-11
Zn+2	7.85E-04	3.14E-03	3.23E-10	3.23E-12			1.02E-09
Zr+4	3.65E-02	1.46E-01	2.09E-08	2.09E-10			4.76E-08
Cl-	2.39E-02	7.56E-02	1.11E-05	1.11E-05	4.63E-12	1.48E-09	6.49E-03
F-	3.45E-02	1.38E-01	2.80E-08	2.39E-08		3.17E-12	2.61E-05
SO4-2	4.05E-02	1.62E-01	2.45E-08	2.45E-10			5.29E-08
NO3-	5.35E+00	1.34E+01	7.77E-03	7.76E-03	3.57E-10	1.03E-06	2.59E+00
PO4-3	9.61E-02	3.84E-01	5.75E-08	5.75E-10			1.25E-07
Am+4	6.68E-08	2.67E-07	1.02E-13	1.02E-15			8.72E-14
Br-	2.87E-07	8.88E-07	3.30E-10	3.30E-10	1.38E-16	4.39E-14	8.55E-08
Ce+4	3.31E-05	1.32E-04	2.92E-11	2.92E-13			4.32E-11
Eu+3	4.77E-07	1.91E-06	4.57E-13	4.57E-15			6.23E-13
Gd+3	1.41E-04	5.63E-04	1.39E-10	1.39E-12			1.84E-10
Ge+4	8.29E-09	3.32E-08	3.79E-15	3.79E-17			1.08E-14
In+3	1.46E-06	5.83E-06	1.05E-12	1.05E-14			1.90E-12
I-	3.07E-06	1.01E-05	4.35E-09	4.35E-09	1.82E-15	5.78E-13	7.10E-07
La+3	8.66E-06	3.47E-05	7.58E-12	7.58E-14			1.13E-11
Li+	4.52E-04	1.81E-03	1.98E-11	1.98E-13			5.90E-10
Mg+2	1.78E-02	7.10E-02	2.72E-09	2.72E-11			2.32E-08
Mo+6	7.29E-04	2.92E-03	4.40E-10	4.40E-12			9.51E-10

Table C-6. Revised baseline mass balance, Tank WM-188 waste (Continued).

Stream #	101	102	103	104	105	106	107
Stream Name	SBW Feed	Evaporator Bottoms	Evaporator Overheads Vapor	Mist Eliminator Vapor	VOG Offgas Vapor	POG + VOG Offgas Vapor	LET&D Feed Liquid
Chemical Composition	Mol/Liter	Mol/Liter	lb/wscf	lb/wscf	lb/wscf	lb/wscf	Mol/Liter
Nd+3	2.79E-05	1.12E-04	2.54E-11	2.54E-13			3.64E-11
Np+4	2.55E-06	1.02E-05	3.81E-12	3.81E-14			3.33E-12
Nb+5	1.05E-03	4.19E-03	6.12E-10	6.12E-12			1.37E-09
Pd+4	1.70E-03	6.79E-03	1.14E-09	1.14E-11			2.22E-09
Pu+4	6.59E-06	2.64E-05	1.01E-11	1.01E-13			8.60E-12
Pr+4	7.87E-06	3.15E-05	6.99E-12	6.99E-14			1.03E-11
Rh+4	3.40E-06	1.36E-05	2.20E-12	2.20E-14			4.43E-12
Rb+	5.23E-06	2.09E-05	2.81E-12	2.81E-14			6.82E-12
Ru+3	7.86E-04	3.14E-03	5.00E-10	5.00E-12			1.03E-09
Sm+3	5.20E-06	2.08E-05	4.93E-12	4.93E-14			6.79E-12
Si+4	8.92E-02	3.57E-01	1.58E-08	1.58E-10			1.16E-07
Sr+2	7.77E-05	3.11E-04	4.29E-11	4.29E-13			1.01E-10
Tc+7	1.01E-05	4.05E-05	6.19E-12	6.19E-14			1.32E-11
Te+4	3.46E-06	1.38E-05	2.78E-12	2.78E-14			4.51E-12
Tb+4	1.99E-09	7.98E-09	2.00E-15	2.00E-17			2.60E-15
Th+4	2.29E-05	9.18E-05	3.35E-11	3.35E-13			2.99E-11
Sn+4	1.73E-03	6.91E-03	1.29E-09	1.29E-11			2.25E-09
Ti+4	8.83E-04	3.53E-03	2.66E-10	2.66E-12			1.15E-09
Y+3	6.46E-06	2.58E-05	3.62E-12	3.62E-14			8.43E-12
O-2 (oxides)	1.41E-01	5.63E-01	1.42E-08	1.42E-10			1.84E-07
H2O	4.63E+01	3.20E+01	4.47E-02	4.47E-02	1.36E-03	1.17E-03	5.14E+01
O2		1.62E-10	1.54E-07	1.54E-07	1.69E-02	1.70E-02	6.56E-05
N2		1.95E-10	2.57E-07	2.57E-07	5.58E-02	5.60E-02	9.51E-05
C (organic)	6.89E-02	2.73E-01	5.03E-07	4.99E-07	8.19E-13	6.69E-11	8.62E-04
H (organic)	6.89E-02	2.73E-01	4.22E-08	4.19E-08	6.88E-14	5.62E-12	8.62E-04
SiO2, BFS, or OPC Additives							
Gas Stream Bulk Composition (wet basis)	mol.% or ppmv	mol.% or ppmv	mol.% or ppmv	mol.% or ppmv	mol.% or ppmv	mol.% or ppmv	mol.% or ppmv
H2O, mol.%			95.18	95.18	2.91	2.50	
O2, mol.%			0.0002	0.0002	20.39	20.47	
N2, mol.%			0.0004	0.0004	76.70	77.02	
CO2, mol.%							
HNO3, mol. %			4.82	4.82	2.2E-07	6.4E-04	
CO, ppmv							
NO, ppmv							
NO2, ppmv							
C (organic), ppmv			16	16	2.6E-05	2.1E-03	
H (organic), ppmv			16	16	2.6E-05	2.1E-03	
PM (mg/wscm)			4	0.04			
Gas Stream Bulk Composition (dry basis)	mol.% or ppmv	mol.% or ppmv	mol.% or ppmv	mol.% or ppmv	mol.% or ppmv	mol.% or ppmv	mol.% or ppmv
O2, mol.%			0.00	0.00	21.00	21.00	
N2, mol.%			0.01	0.01	79.00	79.00	
CO2, mol.%							
HNO3, mol. %			99.93	99.96	2.3E-07	6.6E-04	
CO, ppmv							
NO, ppmv							
NO2, ppmv							
C (organic), ppmv			334	331	2.7E-05	2.2E-03	
H (organic), ppmv			334	331	2.7E-05	2.2E-03	
PM (mg/dscm)			84	1			

Table C-6. Revised baseline mass balance, Tank WM-188 waste (Continued).

Stream #	101	102	103	104	105	106	107
Stream Name	SBW Feed	Evaporator Bottoms	Evaporator Overheads Vapor	Mist Eliminator Vapor	VOG Offgas Vapor	POG + VOG Offgas Vapor	LET&D Feed Liquid
Canister Rate, canisters/day		2.43					
Total Canisters Generated		354					
Drum Rate, drums/day							
Total Drums Generated							
Radiological Composition	Ci/L	Ci/L	Ci/wscm	Ci/wscm	Ci/wscm	Ci/wscm	Ci/L
Ra-226	8.48E-12	3.39E-11	8.56E-16	8.55E-18	2.65E-25	2.29E-25	1.11E-17
Ac-227	3.99E-11	1.60E-10	4.03E-15	4.03E-17	1.25E-24	1.08E-24	5.21E-17
Th-228	3.31E-09	1.33E-08	3.34E-13	3.34E-15	1.04E-22	8.96E-23	4.32E-15
Th-230	1.06E-09	4.23E-09	1.07E-13	1.07E-15	3.30E-23	2.86E-23	1.38E-15
Th-232	7.33E-16	2.93E-15	7.40E-20	7.40E-22	2.29E-29	1.98E-29	9.57E-22
Pa-231	9.25E-11	3.70E-10	9.33E-15	9.33E-17	2.89E-24	2.50E-24	1.21E-16
Pa-233	3.03E-06	1.21E-05	3.06E-10	3.06E-12	9.48E-20	8.20E-20	3.96E-12
U-232	2.49E-09	9.96E-09	2.51E-13	2.51E-15	7.77E-23	6.73E-23	3.25E-15
U-233	9.02E-11	3.61E-10	9.10E-15	9.10E-17	2.82E-24	2.44E-24	1.18E-16
U-234	1.11E-06	4.45E-06	1.12E-10	1.12E-12	3.47E-20	3.00E-20	1.45E-12
U-235	8.17E-08	3.27E-07	8.24E-12	8.24E-14	2.55E-21	2.21E-21	1.07E-13
U-236	4.79E-08	1.92E-07	4.84E-12	4.84E-14	1.50E-21	1.30E-21	6.26E-14
U-237	6.66E-09	2.67E-08	6.72E-13	6.72E-15	2.08E-22	1.80E-22	8.69E-15
U-238	1.46E-08	5.83E-08	1.47E-12	1.47E-14	4.55E-22	3.94E-22	1.90E-14
Np-236	3.19E-12	1.28E-11	3.22E-16	3.22E-18	9.97E-26	8.63E-26	4.16E-18
Np-237	4.33E-07	1.73E-06	4.37E-11	4.37E-13	1.35E-20	1.17E-20	5.66E-13
Pu-236	3.63E-09	1.45E-08	3.66E-13	3.66E-15	1.13E-22	9.82E-23	4.74E-15
Pu-238	8.27E-04	3.31E-03	8.35E-08	8.34E-10	2.58E-17	2.24E-17	1.08E-09
Pu-239	9.26E-05	3.70E-04	9.34E-09	9.34E-11	2.89E-18	2.50E-18	1.21E-10
Pu-240	1.35E-05	5.41E-05	1.36E-09	1.36E-11	4.23E-19	3.66E-19	1.77E-11
Pu-241	6.01E-04	2.41E-03	6.07E-08	6.07E-10	1.88E-17	1.63E-17	7.85E-10
Pu-242	1.06E-08	4.24E-08	1.07E-12	1.07E-14	3.31E-22	2.86E-22	1.38E-14
Pu-244	8.08E-16	3.23E-15	8.16E-20	8.15E-22	2.53E-29	2.18E-29	1.05E-21
Am-241	5.83E-05	2.33E-04	5.88E-09	5.88E-11	1.82E-18	1.58E-18	7.61E-11
Am-242m	1.61E-08	6.46E-08	1.63E-12	1.63E-14	5.05E-22	4.37E-22	2.11E-14
Am-243	2.63E-08	1.05E-07	2.65E-12	2.65E-14	8.21E-22	7.11E-22	3.43E-14
Cm-242	3.50E-08	1.40E-07	3.53E-12	3.53E-14	1.09E-21	9.46E-22	4.56E-14
Cm-243	3.65E-08	1.46E-07	3.69E-12	3.69E-14	1.14E-21	9.88E-22	4.77E-14
Cm-244	1.27E-06	5.10E-06	1.29E-10	1.29E-12	3.98E-20	3.44E-20	1.66E-12
Cm-245	3.85E-10	1.54E-09	3.88E-14	3.88E-16	1.20E-23	1.04E-23	5.02E-16
Cm-246	2.53E-11	1.01E-10	2.55E-15	2.55E-17	7.89E-25	6.83E-25	3.30E-17
Cm-247	5.52E-18	2.21E-17	5.57E-22	5.57E-24			7.20E-24
H-3	1.18E-05	7.94E-06	9.86E-06	9.86E-06	7.68E-08	6.71E-08	1.28E-05
Be-10	3.11E-12	1.24E-11	3.13E-16	3.13E-18	9.70E-26	8.40E-26	4.05E-18
C-14	1.59E-10	6.37E-10	1.61E-14	1.61E-16	4.97E-24	4.30E-24	2.08E-16
Co-60	8.97E-06	3.59E-05	9.05E-10	9.05E-12	2.80E-19	2.43E-19	1.17E-11
Ni-59	1.10E-06	4.41E-06	1.11E-10	1.11E-12	3.44E-20	2.98E-20	1.44E-12
Ni-63	4.22E-05	1.69E-04	4.26E-09	4.26E-11	1.32E-18	1.14E-18	5.51E-11
Se-79	5.78E-07	2.31E-06	5.83E-11	5.83E-13	1.81E-20	1.56E-20	7.54E-13
Rb-87	3.03E-11	1.21E-10	3.06E-15	3.06E-17	9.48E-25	8.20E-25	3.96E-17
Sr-90	3.98E-02	1.59E-01	4.02E-06	4.02E-08	1.24E-15	1.08E-15	5.20E-08
Y-90	3.98E-02	1.59E-01	4.02E-06	4.02E-08	1.24E-15	1.08E-15	5.20E-08
Zr-93	2.29E-06	9.18E-06	2.31E-10	2.31E-12	7.17E-20	6.20E-20	2.99E-12
Nb-93m	1.77E-06	7.07E-06	1.78E-10	1.78E-12	5.52E-20	4.78E-20	2.31E-12
Nb-94	1.50E-06	6.01E-06	1.52E-10	1.52E-12	4.70E-20	4.06E-20	1.96E-12
Tc-98	2.67E-12	1.07E-11	2.69E-16	2.69E-18	8.34E-26	7.22E-26	3.48E-18
Tc-99	2.09E-05	8.37E-05	2.11E-09	2.11E-11	6.53E-19	5.65E-19	2.73E-11

Table C-6. Revised baseline mass balance, Tank WM-188 waste (Continued).

Stream #	101	102	103	104	105	106	107
Stream Name	SBW Feed	Evaporator Bottoms	Evaporator Overheads Vapor	Mist Eliminator Vapor	VOG Offgas Vapor	POG + VOG Offgas Vapor	LET&D Feed Liquid
Radiological Composition	Ci/L	Ci/L	Ci/wscm	Ci/wscm	Ci/wscm	Ci/wscm	Ci/L
Ru-106	1.23E-06	4.94E-06	1.25E-10	1.25E-12	3.86E-20	3.34E-20	1.61E-12
Rh-102	8.92E-10	3.57E-09	9.00E-14	9.00E-16	2.79E-23	2.41E-23	1.16E-15
Rh-106	1.23E-06	4.94E-06	1.25E-10	1.25E-12	3.86E-20	3.34E-20	1.61E-12
Pd-107	1.71E-08	6.84E-08	1.73E-12	1.73E-14	5.34E-22	4.62E-22	2.23E-14
Cd-113m	3.44E-06	1.38E-05	3.47E-10	3.47E-12	1.07E-19	9.29E-20	4.49E-12
In-115	1.04E-16	4.17E-16	1.05E-20	1.05E-22	3.26E-30	2.82E-30	1.36E-22
Sn-121m	6.92E-08	2.77E-07	6.98E-12	6.98E-14	2.16E-21	1.87E-21	9.03E-14
Sn-126	5.44E-07	2.18E-06	5.49E-11	5.49E-13	1.70E-20	1.47E-20	7.10E-13
Sb-125	3.69E-04	1.48E-03	3.72E-08	3.72E-10	1.15E-17	9.97E-18	4.81E-10
Sb-126	5.95E-08	2.38E-07	6.01E-12	6.01E-14	1.86E-21	1.61E-21	7.77E-14
Te-123	3.97E-19	1.59E-18	4.00E-23	4.00E-25			5.18E-25
Te-125m	3.26E-06	1.30E-05	3.29E-10	3.29E-12	1.02E-19	8.81E-20	4.25E-12
I-129	7.06E-08	2.24E-07	1.48E-08	1.48E-08	6.19E-15	1.97E-12	1.92E-08
Cs-134	3.69E-05	1.48E-04	3.72E-09	3.72E-11	1.15E-18	9.97E-19	4.81E-11
Cs-135	1.11E-06	4.45E-06	1.12E-10	1.12E-12	3.47E-20	3.00E-20	1.45E-12
Cs-137	2.28E-02	9.12E-02	2.30E-06	2.30E-08	7.12E-16	6.16E-16	2.97E-08
Ba-137m	2.16E-02	8.63E-02	2.18E-06	2.18E-08	6.74E-16	5.83E-16	2.81E-08
La-138	1.98E-16	7.91E-16	1.99E-20	1.99E-22	6.17E-30	5.34E-30	2.58E-22
Ce-142	3.09E-11	1.24E-10	3.12E-15	3.12E-17	9.67E-25	8.37E-25	4.04E-17
Ce-144	8.33E-07	3.33E-06	8.41E-11	8.40E-13	2.60E-20	2.25E-20	1.09E-12
Pr-144m							
Pr-144	8.33E-07	3.33E-06	8.41E-11	8.40E-13	2.60E-20	2.25E-20	1.09E-12
Nd-144	1.66E-15	6.66E-15	1.68E-19	1.68E-21	5.20E-29	4.50E-29	2.17E-21
Pm-146	5.27E-08	2.11E-07	5.32E-12	5.31E-14	1.65E-21	1.42E-21	6.87E-14
Pm-147	2.25E-04	9.01E-04	2.27E-08	2.27E-10	7.03E-18	6.08E-18	2.94E-10
Sm-146	2.85E-13	1.14E-12	2.88E-17	2.88E-19	8.92E-27	7.72E-27	3.73E-19
Sm-147	7.62E-12	3.05E-11	7.69E-16	7.69E-18	2.38E-25	2.06E-25	9.95E-18
Sm-148	3.92E-17	1.57E-16	3.95E-21	3.95E-23	1.22E-30	1.06E-30	5.11E-23
Sm-149	3.48E-18	1.39E-17	3.51E-22	3.51E-24			4.54E-24
Sm-151	4.45E-04	1.78E-03	4.49E-08	4.49E-10	1.39E-17	1.20E-17	5.81E-10
Eu-150							
Eu-152	2.94E-06	1.18E-05	2.97E-10	2.97E-12	9.20E-20	7.96E-20	3.84E-12
Eu-154	5.00E-05	2.00E-04	5.05E-09	5.04E-11	1.56E-18	1.35E-18	6.53E-11
Eu-155	4.31E-05	1.73E-04	4.35E-09	4.35E-11	1.35E-18	1.17E-18	5.63E-11
Gd-152	1.47E-18	5.89E-18	1.48E-22	1.48E-24			1.92E-24
Ho-166m	4.76E-11	1.91E-10	4.81E-15	4.81E-17	1.49E-24	1.29E-24	6.22E-17
Other Stream Data:							
TRU, nCi/gm	8.00E+02	2.31E+03					1.21E-03
Heat Generation, W/m3	4.10E-01	1.64E+00					9.74E-07
Mass Flow, kg/hr	4.07E+02	1.42E+02	2.71E+02	2.71E+02	2.47E+02	2.88E+02	2.71E+02

Table C-6. Revised baseline mass balance, Tank WM-188 waste (Continued).

PFD Sheet #	PFD-3	PFD-3	PFD-4	PFD-4	PFD-4	PFD-4	PFD-4	PFD-4
Stream #	108	109	110	201	202	203	204	205
Stream Name	LET&D Acid Liquid	LET&D Offgas Vapor	Acid Grout Solid	OPC Grout Additive	BFS Grout Additive	Ca(OH)2 Total Additive	Ca(OH)2 Grout Additive	Ca(OH)2 Neutraliz. Additive
Rate or Volume Flow (actual)	15.7	1.51E+04	435	171	57.1	54.4	1.71	52.7
Volume Flow (standard, wet)*		9.47E+03						
Volume Flow (standard, dry)*		1.24E+00						
Rate Units	gal/hr	ft3/hr	lb/hr	lb/hr	lb/hr	lb/hr	lb/hr	lb/hr
Temperature, °C	35.0	119.1	64.2	25.0	25.0	25.0	25.0	25.0
Temperature, °F	95.0	246.3	147.5	77.0	77.0	77.0	77.0	77.0
Pressure, psia	12.2	12.3	12.2	12.3	12.3	12.3	12.3	12.3
Specific Gravity	1.16	0.00047	2.06	1.2	1.2	0.48	0.48	0.48
Chemical Composition	Mol/Liter	lb/wscf	Wt. %	Wt. %	Wt. %	Wt. %	Wt. %	Wt. %
H+	1.09E+01	3.35E-07	3.24E-06					
OH-			1.78E-01			4.59E+01	4.59E+01	4.59E+01
Al+3	2.77E-06		2.25E-06					
Sb+5	8.67E-11		3.17E-10					
As+5	4.86E-10		1.09E-09					
Ba+2	3.96E-10		1.63E-09					
Be+2	1.00E-10		2.71E-11					
B+3	8.69E-08		2.82E-08					
Cd+2	1.33E-08		4.48E-08					
Ca+2	2.64E-07		6.76E+00			5.41E+01	5.41E+01	5.41E+01
Cr+3	2.45E-08		3.83E-08					
Co+2	2.17E-10		3.84E-10					
Cs+	3.15E-10		1.26E-09					
Cu+2	3.71E-09		7.08E-09					
Fe+3	1.36E-07		2.29E-07					
Pb+2	4.37E-09		2.72E-08					
Hg+2	1.57E-03		9.66E-03					
Mn+4	7.84E-08		1.29E-07					
Ni+2	9.73E-09		1.71E-08					
K+	9.97E-07		1.17E-06					
Se+4	1.28E-09		3.04E-09					
Ag+	1.99E-09		6.46E-09					
Na+	7.40E-06		5.11E-06					
Tl+3	2.42E-11		1.49E-10					
U+4	1.92E-09		1.37E-08					
V+3	1.98E-10		3.03E-10					
Zn+2	4.30E-09		8.44E-09					
Zr+4	2.00E-07		5.47E-07					
Cl-	3.14E-03	1.18E-05	2.90E-02					
F-	1.09E-04		6.24E-05					
SO4-2	2.22E-07		6.40E-07					
NO3-	1.09E+01	1.17E-08	2.03E+01					
PO4-3	5.26E-07		1.50E-06					
Am+4	3.66E-13		2.67E-12					
Br-	4.15E-08	3.50E-10	8.61E-07					
Ce+4	1.81E-10		7.63E-10					
Eu+3	2.61E-12		1.19E-11					
Gd+3	7.71E-10		3.64E-09					
Ge+4	4.54E-14		9.90E-14					
In+3	7.98E-12		2.75E-11					
I-	3.44E-07	4.61E-09	1.14E-05					
La+3	4.74E-11		1.98E-10					
Li+	2.48E-09		5.16E-10					
Mg+2	9.72E-08		7.10E-08					
Mo+6	3.99E-09		1.15E-08					

Table C-6. Revised baseline mass balance, Tank WM-188 waste (Continued).

Stream #	108	109	110	201	202	203	204	205
Stream Name	LET&D Acid Liquid	LET&D Offgas Vapor	Acid Grout Solid	OPC Grout Additive	BFS Grout Additive	Ca(OH)2 Total Additive	Ca(OH)2 Grout Additive	Ca(OH)2 Neutraliz. Additive
Chemical Composition	Mol/Liter	lb/wscf	Wt. %	Wt. %	Wt. %	Wt. %	Wt. %	Wt. %
Nd+3	1.53E-10		6.62E-10					
Np+4	1.40E-11		9.95E-11					
Nb+5	5.73E-09		1.60E-08					
Pd+4	9.29E-09		2.97E-08					
Pu+4	3.61E-11		2.64E-10					
Pr+4	4.31E-11		1.82E-10					
Rh+4	1.86E-11		5.75E-11					
Rb+	2.86E-11		7.35E-11					
Ru+3	4.30E-09		1.31E-08					
Sm+3	2.85E-11		1.29E-10					
Si+4	4.88E-07		4.12E-07					
Sr+2	4.25E-10		1.12E-09					
Tc+7	5.55E-11		1.62E-10					
Te+4	1.89E-11		7.25E-11					
Tb+4	1.09E-14		5.21E-14					
Th+4	1.26E-10		8.76E-10					
Sn+4	9.45E-09		3.37E-08					
Ti+4	4.83E-09		6.95E-09					
Y+3	3.53E-11		9.44E-11					
O-2 (oxides)	7.70E-07		3.70E-07					
H2O	2.66E+01	4.70E-02	2.03E+01					
O2		1.22E-07						
N2		1.54E-07						
C (organic)	3.61E-03		1.30E-03					
H (organic)	3.61E-03		1.09E-04					
SiO2, BFS, or OPC Additives			5.25E+01	1.00E+02	1.00E+02			
Gas Stream Bulk Composition (wet basis)	mol.% or ppmv	mol.% or ppmv	mol.% or ppmv	mol.% or ppmv	mol.% or ppmv	mol.% or ppmv	mol.% or ppmv	mol.% or ppmv
H2O, mol.%		99.99						
O2, mol.%		1.5E-04						
N2, mol.%		2.1E-04						
CO2, mol.%								
HNO3, mol. %		0.01						
CO, ppmv								
NO, ppmv								
NO2, ppmv								
C (organic), ppmv								
H (organic), ppmv								
PM (mg/wscm)								
Gas Stream Bulk Composition (dry basis)	mol.% or ppmv	mol.% or ppmv	mol.% or ppmv	mol.% or ppmv	mol.% or ppmv	mol.% or ppmv	mol.% or ppmv	mol.% or ppmv
O2, mol.%		1.11						
N2, mol.%		1.61						
CO2, mol.%								
HNO3, mol. %		97.28						
CO, ppmv								
NO, ppmv								
NO2, ppmv								
C (organic), ppmv								
H (organic), ppmv								
PM (mg/dscm)								

Table C-6. Revised baseline mass balance, Tank WM-188 waste (Continued).

Stream #	108	109	110	201	202	203	204	205
Stream Name	LET&D Acid Liquid	LET&D Offgas Vapor	Acid Grout Solid	OPC Grout Additive	BFS Grout Additive	Ca(OH)2 Total Additive	Ca(OH)2 Grout Additive	Ca(OH)2 Neutraliz. Additive
Canister Rate, canisters/day								
Total Canisters Generated								
Drum Rate, drums/day			13.74					
Total Drums Generated			1,997					
Radiological Composition	Ci/L	Ci/wscm	Ci/kg	Ci/kg	Ci/kg	Ci/kg	Ci/kg	Ci/kg
Ra-226	4.64E-17	2.05E-29	1.39E-17					
Ac-227	2.19E-16	9.67E-29	6.57E-17					
Th-228	1.81E-14	8.02E-27	5.45E-15					
Th-230	5.78E-15	2.56E-27	1.74E-15					
Th-232	4.01E-21		1.21E-21					
Pa-231	5.06E-16	2.24E-28	1.52E-16					
Pa-233	1.66E-11	7.35E-24	4.99E-12					
U-232	1.36E-14	6.03E-27	4.09E-15					
U-233	4.94E-16	2.18E-28	1.48E-16					
U-234	6.08E-12	2.69E-24	1.83E-12					
U-235	4.47E-13	1.98E-25	1.34E-13					
U-236	2.62E-13	1.16E-25	7.88E-14					
U-237	3.65E-14	1.61E-26	1.10E-14					
U-238	7.97E-14	3.53E-26	2.39E-14					
Np-236	1.75E-17	7.73E-30	5.25E-18					
Np-237	2.37E-12	1.05E-24	7.13E-13					
Pu-236	1.99E-14	8.79E-27	5.97E-15					
Pu-238	4.53E-09	2.00E-21	1.36E-09					
Pu-239	5.07E-10	2.24E-22	1.52E-10					
Pu-240	7.40E-11	3.28E-23	2.22E-11					
Pu-241	3.29E-09	1.46E-21	9.89E-10					
Pu-242	5.80E-14	2.57E-26	1.74E-14					
Pu-244	4.42E-21		1.33E-21					
Am-241	3.19E-10	1.41E-22	9.59E-11					
Am-242m	8.84E-14	3.91E-26	2.66E-14					
Am-243	1.44E-13	6.37E-26	4.32E-14					
Cm-242	1.91E-13	8.47E-26	5.75E-14					
Cm-243	2.00E-13	8.85E-26	6.01E-14					
Cm-244	6.97E-12	3.09E-24	2.10E-12					
Cm-245	2.10E-15	9.31E-28	6.32E-16					
Cm-246	1.38E-16	6.12E-29	4.15E-17					
Cm-247	3.02E-23		9.08E-24					
H-3	6.60E-06	1.04E-05	1.98E-06					
Be-10	1.70E-17	7.52E-30	5.11E-18					
C-14	8.71E-16	3.85E-28	2.62E-16					
Co-60	4.91E-11	2.17E-23	1.48E-11					
Ni-59	6.03E-12	2.67E-24	1.81E-12					
Ni-63	2.31E-10	1.02E-22	6.94E-11					
Se-79	3.16E-12	1.40E-24	9.50E-13					
Rb-87	1.66E-16	7.35E-29	4.99E-17					
Sr-90	2.18E-07	9.65E-20	6.55E-08					
Y-90	2.18E-07	9.65E-20	6.55E-08					
Zr-93	1.26E-11	5.55E-24	3.77E-12					
Nb-93m	9.67E-12	4.28E-24	2.91E-12					
Nb-94	8.23E-12	3.64E-24	2.47E-12					
Tc-98	1.46E-17	6.47E-30	4.39E-18					
Tc-99	1.14E-10	5.06E-23	3.44E-11					

Table C-6. Revised baseline mass balance, Tank WM-188 waste (Continued).

Stream #	108	109	110	201	202	203	204	205
Stream Name	LET&D Acid Liquid	LET&D Offgas Vapor	Acid Grout Solid	OPC Grout Additive	BFS Grout Additive	Ca(OH)2 Total Additive	Ca(OH)2 Grout Additive	Ca(OH)2 Neutraliz. Additive
Radiological Composition	Ci/L	Ci/wscm	Ci/kg	Ci/kg	Ci/kg	Ci/kg	Ci/kg	Ci/kg
Ru-106	6.76E-12	2.99E-24	2.03E-12					
Rh-102	4.88E-15	2.16E-27	1.47E-15					
Rh-106	6.76E-12	2.99E-24	2.03E-12					
Pd-107	9.36E-14	4.14E-26	2.81E-14					
Cd-113m	1.88E-11	8.33E-24	5.65E-12					
In-115	5.70E-22		1.71E-22					
Sn-121m	3.79E-13	1.68E-25	1.14E-13					
Sn-126	2.98E-12	1.32E-24	8.94E-13					
Sb-125	2.02E-09	8.93E-22	6.06E-10					
Sb-126	3.26E-13	1.44E-25	9.79E-14					
Te-123	2.17E-24		6.52E-25					
Te-125m	1.78E-11	7.90E-24	5.36E-12					
I-129	9.39E-09	1.57E-08	2.82E-09					
Cs-134	2.02E-10	8.93E-23	6.06E-11					
Cs-135	6.08E-12	2.69E-24	1.83E-12					
Cs-137	1.25E-07	5.52E-20	3.75E-08					
Ba-137m	1.18E-07	5.22E-20	3.55E-08					
La-138	1.08E-21		3.25E-22					
Ce-142	1.69E-16	7.49E-29	5.09E-17					
Ce-144	4.56E-12	2.02E-24	1.37E-12					
Pr-144m								
Pr-144	4.56E-12	2.02E-24	1.37E-12					
Nd-144	9.11E-21		2.74E-21					
Pm-146	2.88E-13	1.28E-25	8.66E-14					
Pm-147	1.23E-09	5.45E-22	3.70E-10					
Sm-146	1.56E-18		4.70E-19					
Sm-147	4.17E-17	1.85E-29	1.25E-17					
Sm-148	2.14E-22		6.44E-23					
Sm-149	1.90E-23		5.72E-24					
Sm-151	2.43E-09	1.08E-21	7.32E-10					
Eu-150								
Eu-152	1.61E-11	7.13E-24	4.84E-12					
Eu-154	2.74E-10	1.21E-22	8.22E-11					
Eu-155	2.36E-10	1.04E-22	7.10E-11					
Gd-152	8.05E-24		2.42E-24					
Ho-166m	2.61E-16	1.15E-28	7.84E-17					
Other Stream Data:								
TRU, nCi/gm	4.75E-03		1.66E-03					
Heat Generation, W/m3	2.47E-06		1.28E-06					
Mass Flow, kg/hr	6.91E+01	2.02E+02	1.97E+02	7.77E+01	2.59E+01	2.47E+01	7.77E-01	2.39E+01

* Standard conditions = 68oF and 1 atmosphere

Table C-7. Revised baseline mass balance, Tank WM-189 waste.

PFD Sheet #	PFD-1	PFD-2	PFD-2	PFD-2	PFD-2	PFD-2	PFD-2	PFD-3
Stream #	101	102	103	104	105	106	107	108
Stream Name	SBW Feed	Evaporator Bottoms	Evaporator Overheads Vapor	Mist Eliminator Vapor	VOG Offgas Vapor	POG + VOG Offgas Vapor	LET&D Feed Liquid	LET&D Acid Liquid
Rate or Volume Flow (actual)	85.8	24.2	2.44E+04	2.49E+04	1.17E+04	1.37E+04	61.5	17.7
Volume Flow (standard, wet)*			1.06E+04	1.06E+04	7.33E+03	8.56E+03		
Volume Flow (standard, dry)*			6.19E+02	6.18E+02	7.13E+03	8.36E+03		
Rate Units	gal/hr	gal/hr	ft3/hr	ft3/hr	ft3/hr	ft3/hr	gal/hr	gal/hr
Temperature, °C	25.0	120.9	121.0	120.0	107.5	109.4	35.0	35.0
Temperature, °F	77.0	249.7	249.7	248.0	225.6	228.8	95.0	95.0
Pressure, psia	12.3	8.6	8.6	8.4	12.0	12.0	12.0	12.2
Specific Gravity	1.30	1.75	0.00037	0.00037	0.00075	0.00074	1.11	1.16
Chemical Composition	Mol/Liter	Mol/Liter	lb/wscf	lb/wscf	lb/wscf	lb/wscf	Mol/Liter	Mol/Liter
H+	2.43E+00	6.27E-01	1.54E-04	1.54E-04	2.86E-09	2.14E-08	3.14E+00	1.09E+01
OH-		9.52E-09						
Al+3	6.08E-01	2.16E+00	1.11E-07	1.11E-09			8.47E-07	2.94E-06
Sb+5	1.81E-05	6.41E-05	1.49E-11	1.49E-13			2.52E-11	8.75E-11
As+5	9.02E-05	3.20E-04	4.58E-11	4.58E-13			1.26E-10	4.37E-10
Ba+2	6.85E-05	2.43E-04	6.38E-11	6.38E-13			9.56E-11	3.32E-10
Be+2	2.23E-05	7.90E-05	1.36E-12	1.36E-14			3.11E-11	1.08E-10
B+3	1.83E-02	6.49E-02	1.34E-09	1.34E-11			2.55E-08	8.86E-08
Cd+2	3.27E-03	1.16E-02	2.49E-09	2.49E-11			4.55E-09	1.58E-08
Ca+2	6.13E-02	2.17E-01	1.67E-08	1.67E-10			8.55E-08	2.97E-07
Cr+3	5.13E-03	1.82E-02	1.81E-09	1.81E-11			7.16E-09	2.49E-08
Co+2	4.28E-05	1.52E-04	1.71E-11	1.71E-13			5.97E-11	2.07E-10
Cs+	6.10E-05	2.16E-04	5.50E-11	5.50E-13			8.51E-11	2.96E-10
Cu+2	8.80E-04	3.12E-03	3.79E-10	3.79E-12			1.23E-09	4.26E-09
Fe+3	2.97E-02	1.05E-01	1.12E-08	1.12E-10			4.14E-08	1.44E-07
Pb+2	9.97E-04	3.54E-03	1.40E-09	1.40E-11			1.39E-09	4.83E-09
Hg+2	5.44E-03	1.80E-02	5.09E-06	5.09E-06	2.68E-10	8.58E-10	5.23E-04	1.79E-03
Mn+4	1.65E-02	5.84E-02	6.13E-09	6.13E-11			2.29E-08	7.97E-08
Ni+2	2.09E-03	7.40E-03	8.30E-10	8.30E-12			2.91E-09	1.01E-08
K+	2.02E-01	7.15E-01	5.34E-08	5.34E-10			2.81E-07	9.77E-07
Se+4	2.59E-04	9.18E-04	1.38E-10	1.38E-12			3.61E-10	1.25E-09
Ag+	4.05E-04	1.44E-03	2.96E-10	2.96E-12			5.64E-10	1.96E-09
Na+	1.70E+00	6.03E+00	2.65E-07	2.65E-09			2.37E-06	8.23E-06
Tl+3	4.76E-06	1.69E-05	6.59E-12	6.59E-14			6.64E-12	2.31E-11
U+4	5.63E-04	2.00E-03	9.08E-10	9.07E-12			7.85E-10	2.73E-09
V+3	3.17E-05	1.13E-04	1.10E-11	1.09E-13			4.42E-11	1.54E-10
Zn+2	9.43E-04	3.34E-03	4.18E-10	4.18E-12			1.31E-09	4.57E-09
Zr+4	3.89E-02	1.38E-01	2.40E-08	2.40E-10			5.42E-08	1.88E-07
Cl-	2.05E-02	5.94E-02	8.93E-06	8.93E-06	1.72E-10	1.25E-09	5.18E-03	3.58E-03
F-	3.32E-02	1.18E-01	2.27E-08	1.85E-08	1.55E-12	3.61E-12	2.00E-05	6.94E-05
SO4-2	9.08E-02	3.22E-01	5.91E-08	5.91E-10			1.27E-07	4.40E-07
NO3-	6.22E+00	1.41E+01	9.44E-03	9.44E-03	1.76E-07	1.32E-06	3.13E+00	1.09E+01
PO4-3	1.07E-01	3.81E-01	6.91E-08	6.91E-10			1.50E-07	5.20E-07
Am+4	6.52E-08	2.31E-07	1.07E-13	1.07E-15			9.09E-14	3.16E-13
Br-	2.71E-07	7.65E-07	3.00E-10	3.00E-10	5.78E-15	4.20E-14	7.73E-08	5.34E-08
Ce+4	3.96E-05	1.40E-04	3.76E-11	3.76E-13			5.52E-11	1.92E-10
Eu+3	4.51E-07	1.60E-06	4.64E-13	4.64E-15			6.28E-13	2.18E-12
Gd+3	1.35E-04	4.80E-04	1.44E-10	1.44E-12			1.89E-10	6.55E-10
Ge+4	7.82E-09	2.77E-08	3.85E-15	3.85E-17			1.09E-14	3.79E-14
In+3	1.26E-06	4.45E-06	9.76E-13	9.76E-15			1.75E-12	6.08E-12
I-	3.02E-06	9.06E-06	3.96E-09	3.96E-09	7.63E-14	5.54E-13	6.42E-07	4.43E-07
La+3	8.17E-06	2.90E-05	7.69E-12	7.69E-14			1.14E-11	3.96E-11
Li+	5.42E-04	1.92E-03	2.55E-11	2.55E-13			7.55E-10	2.62E-09
Mg+2	1.94E-02	6.87E-02	3.19E-09	3.19E-11			2.70E-08	9.38E-08
Mo+6	8.37E-04	2.97E-03	5.44E-10	5.44E-12			1.17E-09	4.05E-09

Table C-7. Revised baseline mass balance, Tank WM-189 waste (Continued).

Stream #	101	102	103	104	105	106	107	108
Stream Name	SBW Feed	Evaporator Bottoms	Evaporator Overheads Vapor	Mist Eliminator Vapor	VOG Offgas Vapor	POG + VOG Offgas Vapor	LET&D Feed Liquid	LET&D Acid Liquid
Chemical Composition	Mol/Liter	Mol/Liter	lb/wscf	lb/wscf	lb/wscf	lb/wscf	Mol/Liter	Mol/Liter
Nd+3	2.64E-05	9.35E-05	2.58E-11	2.58E-13			3.68E-11	1.28E-10
Np+4	2.74E-06	9.71E-06	4.40E-12	4.40E-14			3.82E-12	1.33E-11
Nb+5	1.14E-03	4.05E-03	7.18E-10	7.18E-12			1.59E-09	5.53E-09
Pd+4	1.69E-03	5.99E-03	1.22E-09	1.22E-11			2.36E-09	8.18E-09
Pu+4	6.57E-06	2.33E-05	1.09E-11	1.09E-13			9.16E-12	3.18E-11
Pr+4	7.43E-06	2.64E-05	7.09E-12	7.09E-14			1.04E-11	3.60E-11
Rh+4	3.21E-06	1.14E-05	2.24E-12	2.24E-14			4.47E-12	1.55E-11
Rb+	4.93E-06	1.75E-05	2.86E-12	2.86E-14			6.88E-12	2.39E-11
Ru+3	8.85E-04	3.14E-03	6.06E-10	6.06E-12			1.23E-09	4.29E-09
Sm+3	4.91E-06	1.74E-05	5.01E-12	5.01E-14			6.85E-12	2.38E-11
Si+4	9.84E-02	3.49E-01	1.87E-08	1.87E-10			1.37E-07	4.77E-07
Sr+2	1.19E-04	4.22E-04	7.06E-11	7.06E-13			1.66E-10	5.76E-10
Tc+7	5.86E-06	2.08E-05	3.85E-12	3.85E-14			8.18E-12	2.84E-11
Te+4	5.74E-06	2.04E-05	4.96E-12	4.96E-14			8.01E-12	2.78E-11
Tb+4	1.88E-09	6.67E-09	2.03E-15	2.03E-17			2.62E-15	9.11E-15
Th+4	2.85E-05	1.01E-04	4.48E-11	4.48E-13			3.97E-11	1.38E-10
Sn+4	1.92E-03	6.82E-03	1.55E-09	1.55E-11			2.68E-09	9.31E-09
Ti+4	9.93E-04	3.52E-03	3.22E-10	3.22E-12			1.38E-09	4.81E-09
Y+3	6.09E-06	2.16E-05	3.67E-12	3.67E-14			8.50E-12	2.95E-11
O-2 (oxides)	1.57E-01	5.57E-01	1.70E-08	1.70E-10			2.19E-07	7.61E-07
H2O	4.47E+01	2.83E+01	4.42E-02	4.42E-02	1.25E-03	1.08E-03	5.05E+01	2.66E+01
O2		1.42E-10	1.42E-07	1.42E-07	1.70E-02	1.70E-02	5.87E-05	
N2		1.72E-10	2.36E-07	2.36E-07	5.59E-02	5.61E-02	8.43E-05	
C (organic)	4.79E-02	1.68E-01	4.26E-07	4.22E-07	1.52E-12	5.34E-11	7.23E-04	2.51E-03
H (organic)	4.79E-02	1.68E-01	3.57E-08	3.54E-08	1.27E-13	4.48E-12	7.23E-04	2.51E-03
SiO2, BFS, or OPC Additives								
Gas Stream Bulk Composition (wet basis)	mol.% or ppmv	mol.% or ppmv	mol.% or ppmv	mol.% or ppmv	mol.% or ppmv	mol.% or ppmv	mol.% or ppmv	mol.% or ppmv
H2O, mol.%			94.15	94.15	2.68	2.31		
O2, mol.%			0.0002	0.0002	20.44	20.51		
N2, mol.%			0.0003	0.0003	76.88	77.17		
CO2, mol.%								
HNO3, mol. %			5.85	5.85	1.1E-04	8.2E-04		
CO, ppmv								
NO, ppmv								
NO2, ppmv								
C (organic), ppmv			14	13	4.9E-05	1.7E-03		
H (organic), ppmv			14	13	4.9E-05	1.7E-03		
PM (mg/wscm)			6	0.1				
Gas Stream Bulk Composition (dry basis)	mol.% or ppmv	mol.% or ppmv	mol.% or ppmv	mol.% or ppmv	mol.% or ppmv	mol.% or ppmv	mol.% or ppmv	mol.% or ppmv
O2, mol.%			0.003	0.003	21.00	21.00		
N2, mol.%			0.01	0.01	79.00	79.00		
CO2, mol.%								
HNO3, mol. %			99.94	99.96	1.1E-04	8.4E-04		
CO, ppmv								
NO, ppmv								
NO2, ppmv								
C (organic), ppmv			232	230	5.0E-05	1.8E-03		
H (organic), ppmv			232	230	5.0E-05	1.8E-03		
PM (mg/dscm)			95	1				

Table C-7. Revised baseline mass balance, Tank WM-189 waste (Continued).

Stream #	101	102	103	104	105	106	107	108
Stream Name	SBW Feed	Evaporator Bottoms	Evaporator Overheads Vapor	Mist Eliminator Vapor	VOG Offgas Vapor	POG + VOG Offgas Vapor	LET&D Feed Liquid	LET&D Acid Liquid
Canister Rate, canisters/day		2.75						
Total Canisters Generated		382						
Drum Rate, drums/day								
Total Drums Generated								
Radiological Composition	Ci/L	Ci/L	Ci/wscm	Ci/wscm	Ci/wscm	Ci/wscm	Ci/L	Ci/L
Ra-226	7.31E-12	2.59E-11	7.94E-16	7.94E-18	2.29E-25	1.98E-25	1.02E-17	3.54E-17
Ac-227	3.44E-11	1.22E-10	3.74E-15	3.74E-17	1.08E-24	9.32E-25	4.80E-17	1.67E-16
Th-228	2.86E-09	1.01E-08	3.10E-13	3.10E-15	8.94E-23	7.74E-23	3.98E-15	1.38E-14
Th-230	9.63E-10	3.42E-09	1.05E-13	1.05E-15	3.01E-23	2.61E-23	1.34E-15	4.67E-15
Th-232	6.32E-16	2.24E-15	6.86E-20	6.86E-22	1.98E-29	1.71E-29	8.82E-22	3.06E-21
Pa-231	7.98E-11	2.83E-10	8.66E-15	8.66E-17	2.50E-24	2.16E-24	1.11E-16	3.86E-16
Pa-233	2.62E-06	9.28E-06	2.84E-10	2.84E-12	8.19E-20	7.09E-20	3.65E-12	1.27E-11
U-232	2.26E-09	8.00E-09	2.45E-13	2.45E-15	7.06E-23	6.11E-23	3.14E-15	1.09E-14
U-233	7.97E-11	2.83E-10	8.65E-15	8.65E-17	2.49E-24	2.16E-24	1.11E-16	3.86E-16
U-234	1.56E-06	5.55E-06	1.70E-10	1.70E-12	4.89E-20	4.23E-20	2.18E-12	7.57E-12
U-235	6.30E-08	2.24E-07	6.84E-12	6.84E-14	1.97E-21	1.71E-21	8.79E-14	3.05E-13
U-236	7.31E-08	2.59E-07	7.93E-12	7.93E-14	2.29E-21	1.98E-21	1.02E-13	3.54E-13
U-237	5.75E-09	2.04E-08	6.24E-13	6.24E-15	1.80E-22	1.56E-22	8.01E-15	2.78E-14
U-238	3.48E-08	1.23E-07	3.77E-12	3.77E-14	1.09E-21	9.41E-22	4.85E-14	1.68E-13
Np-236	2.76E-12	9.77E-12	2.99E-16	2.99E-18	8.62E-26	7.46E-26	3.84E-18	1.33E-17
Np-237	4.66E-07	1.65E-06	5.05E-11	5.05E-13	1.46E-20	1.26E-20	6.49E-13	2.25E-12
Pu-236	3.68E-09	1.30E-08	3.99E-13	3.99E-15	1.15E-22	9.95E-23	5.13E-15	1.78E-14
Pu-238	8.44E-04	2.99E-03	9.16E-08	9.16E-10	2.64E-17	2.29E-17	1.18E-09	4.09E-09
Pu-239	9.22E-05	3.27E-04	1.00E-08	1.00E-10	2.89E-18	2.50E-18	1.29E-10	4.47E-10
Pu-240	1.37E-05	4.86E-05	1.49E-09	1.49E-11	4.29E-19	3.71E-19	1.91E-11	6.64E-11
Pu-241	7.39E-04	2.62E-03	8.02E-08	8.02E-10	2.31E-17	2.00E-17	1.03E-09	3.58E-09
Pu-242	1.07E-08	3.81E-08	1.16E-12	1.16E-14	3.36E-22	2.91E-22	1.50E-14	5.20E-14
Pu-244	3.17E-16	1.13E-15	3.44E-20	3.44E-22	9.93E-30	8.59E-30	4.43E-22	1.54E-21
Am-241	7.25E-05	2.57E-04	7.87E-09	7.87E-11	2.27E-18	1.96E-18	1.01E-10	3.51E-10
Am-242m	1.36E-08	4.84E-08	1.48E-12	1.48E-14	4.27E-22	3.69E-22	1.90E-14	6.61E-14
Am-243	2.32E-08	8.22E-08	2.52E-12	2.52E-14	7.25E-22	6.28E-22	3.23E-14	1.12E-13
Cm-242	2.72E-08	9.66E-08	2.96E-12	2.96E-14	8.53E-22	7.38E-22	3.80E-14	1.32E-13
Cm-243	3.34E-08	1.18E-07	3.62E-12	3.62E-14	1.04E-21	9.03E-22	4.65E-14	1.62E-13
Cm-244	1.41E-06	5.00E-06	1.53E-10	1.53E-12	4.41E-20	3.82E-20	1.97E-12	6.83E-12
Cm-245	3.51E-10	1.25E-09	3.81E-14	3.81E-16	1.10E-23	9.51E-24	4.90E-16	1.70E-15
Cm-246	2.31E-11	8.18E-11	2.50E-15	2.50E-17	7.22E-25	6.24E-25	3.21E-17	1.12E-16
Cm-247	6.19E-18	2.20E-17	6.72E-22	6.72E-24			8.63E-24	3.00E-23
H-3	9.12E-06	5.76E-06	8.00E-06	8.00E-06	1.83E-07	1.58E-07	1.03E-05	5.41E-06
Be-10	2.68E-12	9.50E-12	2.91E-16	2.91E-18	8.38E-26	7.25E-26	3.74E-18	1.30E-17
C-14	1.46E-10	5.18E-10	1.58E-14	1.58E-16	4.57E-24	3.95E-24	2.04E-16	7.07E-16
Co-60	2.97E-05	1.05E-04	3.23E-09	3.23E-11	9.31E-19	8.05E-19	4.15E-11	1.44E-10
Ni-59	1.23E-06	4.35E-06	1.33E-10	1.33E-12	3.83E-20	3.32E-20	1.71E-12	5.93E-12
Ni-63	3.87E-05	1.37E-04	4.20E-09	4.20E-11	1.21E-18	1.05E-18	5.40E-11	1.88E-10
Se-79	5.30E-07	1.88E-06	5.75E-11	5.75E-13	1.66E-20	1.43E-20	7.39E-13	2.57E-12
Rb-87	2.62E-11	9.28E-11	2.84E-15	2.84E-17	8.19E-25	7.08E-25	3.65E-17	1.27E-16
Sr-90	3.53E-02	1.25E-01	3.83E-06	3.83E-08	1.11E-15	9.56E-16	4.92E-08	1.71E-07
Y-90	3.53E-02	1.25E-01	3.83E-06	3.83E-08	1.11E-15	9.56E-16	4.92E-08	1.71E-07
Zr-93	1.98E-06	7.02E-06	2.15E-10	2.15E-12	6.19E-20	5.36E-20	2.76E-12	9.58E-12
Nb-93m	1.52E-06	5.41E-06	1.65E-10	1.65E-12	4.77E-20	4.13E-20	2.12E-12	7.38E-12
Nb-94	1.38E-06	4.89E-06	1.50E-10	1.50E-12	4.31E-20	3.73E-20	1.92E-12	6.67E-12
Tc-98	2.30E-12	8.17E-12	2.50E-16	2.50E-18	7.21E-26	6.24E-26	3.21E-18	1.12E-17
Tc-99	1.40E-05	4.95E-05	1.52E-09	1.52E-11	4.37E-19	3.78E-19	1.95E-11	6.76E-11

Table C-7. Revised baseline mass balance, Tank WM-189 waste (Continued).

Stream #	101	102	103	104	105	106	107	108
Stream Name	SBW Feed	Evaporator Bottoms	Evaporator Overheads Vapor	Mist Eliminator Vapor	VOG Offgas Vapor	POG + VOG Offgas Vapor	LET&D Feed Liquid	LET&D Acid Liquid
Radiological Composition	Ci/L	Ci/L	Ci/wscm	Ci/wscm	Ci/wscm	Ci/wscm	Ci/L	Ci/L
Ru-106	1.13E-06	4.02E-06	1.23E-10	1.23E-12	3.54E-20	3.07E-20	1.58E-12	5.48E-12
Rh-102	7.70E-10	2.73E-09	8.35E-14	8.35E-16	2.41E-23	2.08E-23	1.07E-15	3.73E-15
Rh-106	1.13E-06	4.02E-06	1.23E-10	1.23E-12	3.54E-20	3.07E-20	1.58E-12	5.48E-12
Pd-107	1.47E-08	5.23E-08	1.60E-12	1.60E-14	4.62E-22	3.99E-22	2.06E-14	7.14E-14
Cd-113m	2.97E-06	1.05E-05	3.22E-10	3.22E-12	9.28E-20	8.03E-20	4.13E-12	1.44E-11
In-115	8.99E-17	3.19E-16	9.76E-21	9.75E-23	2.81E-30	2.43E-30	1.25E-22	4.35E-22
Sn-121m	5.97E-08	2.12E-07	6.48E-12	6.48E-14	1.87E-21	1.62E-21	8.32E-14	2.89E-13
Sn-126	4.99E-07	1.77E-06	5.41E-11	5.41E-13	1.56E-20	1.35E-20	6.95E-13	2.42E-12
Sb-125	4.10E-04	1.45E-03	4.45E-08	4.45E-10	1.28E-17	1.11E-17	5.72E-10	1.99E-09
Sb-126	5.13E-08	1.82E-07	5.57E-12	5.57E-14	1.61E-21	1.39E-21	7.16E-14	2.49E-13
Te-123	3.42E-19	1.21E-18	3.71E-23	3.71E-25			4.77E-25	1.66E-24
Te-125m	2.81E-06	9.97E-06	3.05E-10	3.05E-12	8.80E-20	7.61E-20	3.92E-12	1.36E-11
I-129	6.47E-08	1.88E-07	1.28E-08	1.27E-08	2.46E-13	1.78E-12	1.64E-08	1.14E-08
Cs-134	6.39E-05	2.27E-04	6.94E-09	6.94E-11	2.00E-18	1.73E-18	8.92E-11	3.10E-10
Cs-135	1.01E-06	3.60E-06	1.10E-10	1.10E-12	3.17E-20	2.74E-20	1.41E-12	4.91E-12
Cs-137	5.25E-02	1.86E-01	5.70E-06	5.70E-08	1.64E-15	1.42E-15	7.32E-08	2.54E-07
Ba-137m	4.97E-02	1.76E-01	5.39E-06	5.39E-08	1.55E-15	1.34E-15	6.92E-08	2.40E-07
La-138	1.70E-16	6.05E-16	1.85E-20	1.85E-22	5.33E-30	4.61E-30	2.38E-22	8.26E-22
Ce-142	2.67E-11	9.47E-11	2.90E-15	2.90E-17	8.35E-25	7.23E-25	3.72E-17	1.29E-16
Ce-144	7.65E-07	2.71E-06	8.30E-11	8.30E-13	2.39E-20	2.07E-20	1.07E-12	3.70E-12
Pr-144	7.65E-07	2.71E-06	8.30E-11	8.30E-13	2.39E-20	2.07E-20	1.07E-12	3.70E-12
Nd-144	1.44E-15	5.09E-15	1.56E-19	1.56E-21	4.49E-29	3.89E-29	2.00E-21	6.95E-21
Pm-146	4.54E-08	1.61E-07	4.93E-12	4.93E-14	1.42E-21	1.23E-21	6.33E-14	2.20E-13
Pm-147	2.06E-04	7.32E-04	2.24E-08	2.24E-10	6.46E-18	5.59E-18	2.88E-10	9.99E-10
Sm-146	2.46E-13	8.73E-13	2.67E-17	2.67E-19	7.71E-27	6.67E-27	3.43E-19	1.19E-18
Sm-147	6.58E-12	2.33E-11	7.14E-16	7.14E-18	2.06E-25	1.78E-25	9.17E-18	3.18E-17
Sm-148	3.38E-17	1.20E-16	3.67E-21	3.67E-23	1.06E-30		4.71E-23	1.64E-22
Sm-149	3.00E-18	1.06E-17	3.26E-22	3.26E-24			4.18E-24	1.45E-23
Sm-151	4.08E-04	1.45E-03	4.43E-08	4.43E-10	1.28E-17	1.10E-17	5.69E-10	1.98E-09
Eu-152	2.62E-06	9.31E-06	2.85E-10	2.85E-12	8.22E-20	7.11E-20	3.66E-12	1.27E-11
Eu-154	1.57E-04	5.56E-04	1.70E-08	1.70E-10	4.91E-18	4.25E-18	2.19E-10	7.59E-10
Eu-155	1.47E-04	5.23E-04	1.60E-08	1.60E-10	4.61E-18	3.99E-18	2.06E-10	7.14E-10
Gd-152	1.27E-18	4.50E-18	1.38E-22	1.38E-24	3.97E-32	3.44E-32	1.77E-24	6.15E-24
Ho-166m	4.11E-11	1.46E-10	4.46E-15	4.46E-17	1.29E-24	1.11E-24	5.73E-17	1.99E-16
Other Stream Data:								
TRU, nCi/gm	8.01E+02	2.12E+03					1.32E-03	4.35E-03
Heat Generation, W/m3	5.23E-01	1.85E+00					1.08E-06	2.72E-06
Mass Flow, kg/hr	4.21E+02	1.60E+02	2.58E+02	2.58E+02	2.46E+02	2.88E+02	2.58E+02	7.81E+01

Table C-7. Revised baseline mass balance, Tank WM-189 waste (Continued).

PFD Sheet #	PFD-3	PFD-4	PFD-4	PFD-4	PFD-4	PFD-4	PFD-4
Stream #	109	110	201	202	203	204	205
Stream Name	LET&D Offgas Vapor	Acid Grout Solid	OPC Grout Additive	BFS Grout Additive	Ca(OH)2 Total Additive	Ca(OH)2 Grout Additive	Ca(OH)2 Neutraliz. Additive
Rate or Volume Flow (actual)	1.35E+04	492.0	193.7	64.6	61.5	1.94	59.6
Volume Flow (standard, wet)*	8.43E+03						
Volume Flow (standard, dry)*	8.45E-01						
Rate Units	ft3/hr	lb/hr	lb/hr	lb/hr	lb/hr	lb/hr	lb/hr
Temperature, °C	119.1	64.2	25.0	25.0	25.0	25.0	25.0
Temperature, °F	246.3	147.5	77.0	77.0	77.0	77.0	77.0
Pressure, psia	12.3	12.2	12.3	12.3	12.3	12.3	12.3
Specific Gravity	0.00047	2.06	1.2	1.2	0.48	0.48	0.48
Chemical Composition	lb/wscf	Wt. %	Wt. %	Wt. %	Wt. %	Wt. %	Wt. %
H+	2.55E-07	2.02E-06					
OH-		1.79E-01			4.59E+01	4.59E+01	4.59E+01
Al+3		2.39E-06					
Sb+5		3.20E-10					
As+5		9.84E-10					
Ba+2		1.37E-09					
Be+2		2.92E-11					
B+3		2.88E-08					
Cd+2		5.34E-08					
Ca+2		3.58E-07			5.41E+01	5.41E+01	5.41E+01
Cr+3		3.88E-08					
Co+2		3.67E-10					
Cs+		1.18E-09					
Cu+2		8.14E-09					
Fe+3		2.41E-07					
Pb+2		3.01E-08					
Hg+2		1.09E-02					
Mn+4		1.32E-07					
Ni+2		1.78E-08					
K+		1.15E-06					
Se+4		2.97E-09					
Ag+		6.35E-09					
Na+		5.69E-06					
Tl+3		1.42E-10					
U+4		1.95E-08					
V+3		2.35E-10					
Zn+2		8.97E-09					
Zr+4		5.16E-07					
Cl-	8.95E-06	1.92E-02					
F-		3.96E-05					
SO4-2		1.27E-06					
NO3-	1.85E-08	2.03E+01					
PO4-3		1.48E-06					
Am+4		2.30E-12					
Br-	3.01E-10	6.45E-07					
Ce+4		8.07E-10					
Eu+3		9.96E-12					
Gd+3		3.09E-09					
Ge+4		8.26E-14					
In+3		2.10E-11					
I-	3.97E-09	8.50E-06					
La+3		1.65E-10					
Li+		5.47E-10					
Mg+2		6.85E-08					
Mo+6		1.17E-08					

Table C-7. Revised baseline mass balance, Tank WM-189 waste (Continued).

Stream #	109	110	201	202	203	204	205
Stream Name	LET&D Offgas Vapor	Acid Grout Solid	OPC Grout Additive	BFS Grout Additive	Ca(OH)2 Total Additive	Ca(OH)2 Grout Additive	Ca(OH)2 Neutraliz. Additive
Chemical Composition	lb/wscf	Wt. %	Wt. %	Wt. %	Wt. %	Wt. %	Wt. %
Nd+3		5.53E-10					
Np+4		9.44E-11					
Nb+5		1.54E-08					
Pd+4		2.62E-08					
Pu+4		2.33E-10					
Pr+4		1.52E-10					
Rh+4		4.80E-11					
Rb+		6.14E-11					
Ru+3		1.30E-08					
Sm+3		1.07E-10					
Si+4		4.02E-07					
Sr+2		1.52E-09					
Tc+7		8.28E-11					
Te+4		1.07E-10					
Tb+4		4.35E-14					
Th+4		9.62E-10					
Sn+4		3.32E-08					
Ti+4		6.92E-09					
Y+3		7.88E-11					
O-2 (oxides)		3.66E-07					
H2O	4.70E-02	2.03E+01					
O2	1.14E-07						
N2	1.44E-07						
C (organic)		9.06E-04					
H (organic)		7.60E-05					
SiO2, BFS, or OPC Additives		5.25E+01	1.33E+02	4.00E+02			
Gas Stream Bulk Composition (wet basis)	mol.% or ppmv	mol.% or ppmv	mol.% or ppmv	mol.% or ppmv	mol.% or ppmv	mol.% or ppmv	mol.% or ppmv
H2O, mol.%	99.99						
O2, mol.%	1.4E-04						
N2, mol.%	2.0E-04						
CO2, mol.%							
HNO3, mol. %	0.01						
CO, ppmv							
NO, ppmv							
NO2, ppmv							
C (organic), ppmv							
H (organic), ppmv							
PM (mg/wscm)							
Gas Stream Bulk Composition (dry basis)	mol.% or ppmv	mol.% or ppmv	mol.% or ppmv	mol.% or ppmv	mol.% or ppmv	mol.% or ppmv	mol.% or ppmv
O2, mol.%	1.37						
N2, mol.%	1.96						
CO2, mol.%							
HNO3, mol. %	96.66						
CO, ppmv							
NO, ppmv							
NO2, ppmv							
C (organic), ppmv							
H (organic), ppmv							
PM (mg/dscm)							

Table C-7. Revised baseline mass balance, Tank WM-189 waste (Continued).

Stream #	109	110	201	202	203	204	205
Stream Name	LET&D Offgas Vapor	Acid Grout Solid	OPC Grout Additive	BFS Grout Additive	Ca(OH)2 Total Additive	Ca(OH)2 Grout Additive	Ca(OH)2 Neutraliz. Additive
Canister Rate, canisters/day							
Total Canisters Generated							
Drum Rate, drums/day		15.53					
Total Drums Generated		2,161					
Radiological Composition	Ci/wscm	Ci/kg	Ci/kg	Ci/kg	Ci/kg	Ci/kg	Ci/kg
Ra-226	1.99E-29	1.06E-17					
Ac-227	9.37E-29	5.01E-17					
Th-228	7.78E-27	4.16E-15					
Th-230	2.62E-27	1.40E-15					
Th-232		9.20E-22					
Pa-231	2.17E-28	1.16E-16					
Pa-233	7.12E-24	3.81E-12					
U-232	6.14E-27	3.28E-15					
U-233	2.17E-28	1.16E-16					
U-234	4.26E-24	2.28E-12					
U-235	1.72E-25	9.17E-14					
U-236	1.99E-25	1.06E-13					
U-237	1.56E-26	8.36E-15					
U-238	9.46E-26	5.06E-14					
Np-236	7.50E-30	4.01E-18					
Np-237	1.27E-24	6.77E-13					
Pu-236	1.00E-26	5.35E-15					
Pu-238	2.30E-21	1.23E-09					
Pu-239	2.51E-22	1.34E-10					
Pu-240	3.73E-23	1.99E-11					
Pu-241	2.01E-21	1.08E-09					
Pu-242	2.92E-26	1.56E-14					
Pu-244		4.62E-22					
Am-241	1.97E-22	1.06E-10					
Am-242m	3.71E-26	1.99E-14					
Am-243	6.31E-26	3.37E-14					
Cm-242	7.41E-26	3.96E-14					
Cm-243	9.08E-26	4.86E-14					
Cm-244	3.84E-24	2.05E-12					
Cm-245	9.56E-28	5.11E-16					
Cm-246	6.27E-29	3.36E-17					
Cm-247		9.01E-24					
H-3	8.51E-06	1.63E-06					
Be-10	7.29E-30	3.90E-18					
C-14	3.97E-28	2.12E-16					
Co-60	8.09E-23	4.33E-11					
Ni-59	3.33E-24	1.78E-12					
Ni-63	1.05E-22	5.64E-11					
Se-79	1.44E-24	7.71E-13					
Rb-87	7.12E-29	3.81E-17					
Sr-90	9.61E-20	5.14E-08					
Y-90	9.61E-20	5.14E-08					
Zr-93	5.38E-24	2.88E-12					
Nb-93m	4.15E-24	2.22E-12					
Nb-94	3.75E-24	2.00E-12					
Tc-98	6.27E-30	3.35E-18					
Tc-99	3.80E-23	2.03E-11					

Table C-7. Revised baseline mass balance, Tank WM-189 waste (Continued).

Stream #	109	110	201	202	203	204	205
Stream Name	LET&D Offgas Vapor	Acid Grout Solid	OPC Grout Additive	BFS Grout Additive	Ca(OH)2 Total Additive	Ca(OH)2 Grout Additive	Ca(OH)2 Neutraliz. Additive
Radiological Composition	Ci/wscm	Ci/kg	Ci/kg	Ci/kg	Ci/kg	Ci/kg	Ci/kg
Ru-106	3.08E-24	1.65E-12					
Rh-102	2.09E-27	1.12E-15					
Rh-106	3.08E-24	1.65E-12					
Pd-107	4.01E-26	2.15E-14					
Cd-113m	8.07E-24	4.31E-12					
In-115		1.31E-22					
Sn-121m	1.62E-25	8.69E-14					
Sn-126	1.36E-24	7.26E-13					
Sb-125	1.12E-21	5.97E-10					
Sb-126	1.40E-25	7.47E-14					
Te-123		4.98E-25					
Te-125m	7.65E-24	4.09E-12					
I-129	1.28E-08	3.42E-09					
Cs-134	1.74E-22	9.30E-11					
Cs-135	2.76E-24	1.48E-12					
Cs-137	1.43E-19	7.64E-08					
Ba-137m	1.35E-19	7.23E-08					
La-138		2.48E-22					
Ce-142	7.26E-29	3.88E-17					
Ce-144	2.08E-24	1.11E-12					
Pr-144	2.08E-24	1.11E-12					
Nd-144		2.09E-21					
Pm-146	1.24E-25	6.61E-14					
Pm-147	5.62E-22	3.00E-10					
Sm-146		3.58E-19					
Sm-147	1.79E-29	9.57E-18					
Sm-148		4.92E-23					
Sm-149		4.37E-24					
Sm-151	1.11E-21	5.94E-10					
Eu-152	7.14E-24	3.82E-12					
Eu-154	4.27E-22	2.28E-10					
Eu-155	4.01E-22	2.14E-10					
Gd-152	3.45E-36	1.85E-24					
Ho-166m	1.12E-28	5.98E-17					
Other Stream Data:							
TRU, nCi/gm		1.52E-03					
Heat Generation, W/m3		1.41E-06					
Mass Flow, kg/hr	1.80E+02	2.23E+02	8.79E+01	2.93E+01	2.79E+01	8.79E-01	2.70E+01

* Standard conditions = 68oF and 1 atmosphere

Table C-8. Alkaline scrub balance, Tank WM-180 waste.

WM-180 PFD Sheet #	PFD-2A	PFD-2A	PFD-2A	PFD-2A	PFD-2A	PFD-2A	PFD-2A	PFD-2A	PFD-2A
Stream #	101	102	103	104	105	106	107	108	201
Stream Name	SBW Feed	Evaporator Bottoms	Evaporator Overheads Vapor	Mist Eliminator Vapor	Alkaline Scrubber Vapor	POG + VOG Offgas Vapor	VOG Offgas Vapor	Scrubber Recycle to Feed	20 wt.% MgO Additive
Rate or Volume Flow (actual)	85.8	26.6	36,397	36,842	34,297	38,784	11,747	14.8	72.2
Volume Flow (standard, wet)*			14,010	14,010	13,293	20,694	7,387		
Volume Flow (standard, dry)*			275.4	275.2	0.53	7,124	7,137		
Rate Units	gal/hr	gal/hr	ft3/hr	ft3/hr	ft3/hr	ft3/hr	ft3/hr	gal/hr	lb/hr
Temperature, °C	25.0	120	120	114	88	175	108	88.1	25.0
Temperature, °F	77.0	247	247	237	190	348	226	191	77.0
Pressure, psia	12.3	7.6	7.6	7.4	7.0	12.0	12.0	30.0	12.3
Specific Gravity	1.23	1.75	0.0003	0.0003	0.00029	0.00048	0.00074	1.28	1.20
Chemical Composition	Mol/Liter	Mol/Liter	lb/wscf	lb/wscf	lb/wscf	lb/wscf	lb/wscf	Mol/Liter	Wt. %
H+	1.07E+00	2.11E-01	5.15E-05	5.15E-05	1.09E-09	1.56E-09	2.40E-09	1.31E-04	2.64E-12
OH-			1.00E-14		1.06E-11	1.30E-13		6.25E-05	1.69E+01
Al+3	5.83E-01	1.88E+00	8.04E-08	1.23E-11	1.44E-14			5.25E-08	
Sb+5	1.39E-06	4.49E-06	8.65E-13	8.65E-15	1.01E-17			8.17E-12	
As+3	4.47E-04	1.44E-03	1.71E-10	1.71E-12	2.00E-15			2.62E-09	
Ba+2	5.00E-05	1.61E-04	3.51E-11	7.18E-15	8.38E-18			6.00E-12	
Be+2	7.82E-06	2.52E-05	3.60E-13	4.01E-16	4.68E-19			5.11E-12	
B+3	1.04E-02	3.36E-02	5.74E-10	1.08E-13	1.26E-16			1.15E-09	
Cd+2	7.16E-04	2.31E-03	4.11E-10	3.74E-14	4.36E-17			3.82E-11	
Ca+2	3.69E-02	1.19E-01	7.57E-09	9.08E-13	1.06E-15			2.60E-09	
Cr+3	3.36E-03	1.09E-02	8.93E-10	1.44E-13	1.68E-16			3.18E-10	
Co+2	1.83E-05	5.91E-05	5.51E-12	3.17E-15	3.70E-18			6.17E-12	
Cs+	2.61E-05	8.43E-05	1.51E-11	1.15E-13	1.34E-16			9.95E-11	
Cu+2	6.32E-04	2.04E-03	2.05E-10	2.87E-14	3.35E-17			5.19E-11	
Fe+3	1.92E-02	6.21E-02	5.49E-09	4.25E-12	4.96E-15			8.74E-09	
Pb+2	1.26E-03	4.08E-03	1.34E-09	1.11E-13	1.29E-16			6.13E-11	
Hg+2	1.46E-03	4.72E-03	9.49E-07	9.48E-07	1.22E-08	3.44E-11	7.43E-11	5.53E-04	
Mn+4	1.27E-02	4.11E-02	3.57E-09	3.57E-11	4.17E-14			7.47E-08	
Ni+2	1.39E-03	4.48E-03	4.16E-10	5.83E-14	6.80E-17			1.14E-10	
K+	1.76E-01	5.69E-01	3.52E-08	3.10E-12	3.62E-15			9.12E-09	
Se+4	7.67E-05	2.48E-04	3.10E-11	3.10E-13	3.62E-16			4.51E-10	
Ag+	6.24E-06	2.02E-05	2.50E-12	1.20E-14	1.40E-17			1.28E-11	
Na+	1.96E+00	6.33E+00	1.41E-07	1.72E-10	2.01E-13			8.61E-07	
Tl+3	2.75E-05	8.87E-05	2.87E-11	2.87E-13	3.35E-16			1.61E-10	
U+4	3.61E-04	1.17E-03	4.39E-10	4.39E-12	5.16E-15			2.13E-09	
V+3	8.76E-04	2.83E-03	2.28E-10	2.28E-12	2.66E-15			5.14E-09	
Zn+2	9.51E-04	3.07E-03	3.18E-10	4.14E-14	4.83E-17			7.27E-11	
Zr+4	1.32E-03	4.27E-03	6.17E-10	6.17E-12	7.20E-15			7.77E-09	
Cl-	2.86E-02	9.26E-02	1.55E-05	1.55E-05	2.22E-08	2.43E-10	1.37E-10	5.01E-02	
F-	4.02E-02	1.30E-01	1.72E-08	1.72E-08	1.02E-09	6.55E-10	8.16E-12	9.85E-05	
SO4-2	4.96E-02	1.60E-01	2.44E-08	2.44E-10	2.84E-13			2.91E-07	
NO3-	4.94E+00	1.59E+01	3.14E-03	3.14E-03	3.73E-06	9.32E-08	1.48E-07	5.82E+00	
PO4-3	1.95E-02	6.30E-02	9.46E-09	9.46E-11	1.10E-13			1.14E-07	
Am+4	3.16E-08	1.02E-07	3.89E-14	3.89E-16	4.57E-19			1.86E-13	
Br-	1.55E-07	5.04E-07	1.90E-10	1.90E-10	2.74E-13	2.99E-15	1.68E-15	2.74E-07	
Ce+4	4.36E-05	1.41E-04	3.12E-11	3.12E-13	3.67E-16			2.56E-10	
Eu+3	2.58E-07	8.32E-07	2.00E-13	3.04E-19	3.54E-22			2.30E-16	
Gd+3	1.61E-04	5.19E-04	1.29E-10	1.71E-14	2.00E-17			1.25E-11	
Ge+4	4.48E-09	1.45E-08	1.66E-15	1.66E-17	1.95E-20			2.64E-14	
In+3	7.05E-07	2.28E-06	4.14E-13						
I-	1.35E-06	4.37E-06	2.51E-09	2.51E-09	3.61E-12	3.94E-14	2.22E-14	2.27E-06	
La+3	4.68E-06	1.51E-05	3.32E-12						
Li+	4.58E-04	1.48E-03	1.12E-11	4.25E-14	4.96E-17			7.04E-10	
Mg+2	1.08E-02	1.67E+00	6.42E-08		7.25E-07	9.32E-14		2.94E+00	1.21E+01
Mo+6	1.88E-04	6.06E-04	9.20E-11	9.20E-13	1.07E-15			1.10E-09	

Table C-8. Alkaline scrub balance, Tank WM-180 waste. (Continued).

Stream #	101	102	103	104	105	106	107	108	201
Chemical Composition	Mol/Liter	Mol/Liter	lb/wscf	lb/wscf	lb/wscf	lb/wscf	lb/wscf	Mol/Liter	Wt. %
Nd+3	1.51E-05	4.88E-05	1.11E-11						
Np+4	8.73E-06	2.82E-05	1.06E-11	1.06E-13	1.24E-16			5.13E-11	
Nb+5	4.46E-04	1.44E-03	2.12E-10	2.12E-12	2.47E-15			2.62E-09	
Pd+4	3.13E-05	1.01E-04	1.70E-11	1.70E-13	1.99E-16			1.84E-10	
Pu+4	1.01E-05	3.25E-05	1.23E-11	1.23E-13	1.44E-16			5.92E-11	
Pr+4	4.26E-06	1.37E-05	3.07E-12	3.07E-14	3.60E-17			2.50E-11	
Rh+4	1.84E-06	5.93E-06	9.66E-13	9.66E-15	1.14E-17			1.08E-11	
Rb+	2.94E-06	9.49E-06	7.84E-13	8.74E-16	1.02E-18			1.17E-12	
Ru+3	1.26E-04	4.08E-04	6.52E-11	7.58E-14	8.84E-17			8.61E-11	
Sm+3	2.80E-06	9.05E-06	2.15E-12	1.57E-17	1.83E-20			1.20E-14	
Si+4	3.08E-03	9.94E-03	4.42E-10	4.42E-12	5.15E-15			1.81E-08	
Sr+2	1.08E-04	3.48E-04	4.82E-11	4.64E-15	5.42E-18			6.09E-12	
Tc+7	5.30E-06	1.71E-05	2.63E-12						
Te+4	1.47E-06	4.75E-06	9.59E-13	9.59E-15	1.13E-17			8.65E-12	
Tb+4	1.08E-09	3.48E-09	8.75E-16	8.75E-18	1.03E-20			6.34E-15	
Th+4	1.05E-10	3.39E-10	1.25E-16	1.25E-18	1.46E-21			6.18E-16	
Sn+4	7.38E-05	2.38E-04	4.48E-11	4.48E-13	5.23E-16			4.33E-10	
Ti+4	1.34E-04	4.34E-04	3.29E-11	3.29E-13	3.85E-16			7.90E-10	
Y+3	3.49E-06	1.13E-05	1.59E-12	2.28E-20	2.66E-23			2.94E-17	
O-2 (oxides)	5.11E-02	1.65E-01	4.18E-09	4.18E-11	4.88E-14			3.00E-07	
H2O	5.05E+01	2.50E+01	4.60E-02	4.60E-02	4.69E-02	3.07E-02	1.58E-03	4.70E+01	7.11E+01
O2			1.42E-07	1.42E-07	1.50E-07	6.01E-03	1.69E-02	1.94E-10	
N2			2.40E-07	2.40E-07	2.53E-07	1.98E-02	5.55E-02	2.22E-10	
C (organic)	1.78E-02	5.74E-02	1.64E-07	1.64E-07	5.01E-10	3.22E-10	7.15E-13	1.54E-03	
H (organic)	1.78E-02	5.74E-02	1.37E-08	1.37E-08	4.21E-11	2.70E-11	6.00E-14	1.54E-03	
Gas Stream Bulk Composition (wet basis)	mol.% or ppmv	mol.% or ppmv	mol.% or ppmv	mol.% or ppmv	mol.% or ppmv	mol.% or ppmv	mol.% or ppmv	mol.% or ppmv	mol.% or ppmv
H2O, mol.%			98.03	98.04	100.00	65.57	3.39		
O2, mol.%			0.0002	0.0002	0.0002	7.23	20.29		
N2, mol.%			0.0003	0.0003	0.0003	27.20	76.32		
CO2, mol.%									
HNO3, mol. %			1.96	1.96	0.00004	0.00006	0.00009		
CO, ppmv									
HCl, ppmv			167	167	0.24	0.003	0.001		
C (organic), ppmv			5	5	0.016	0.010	0.00002		
H (organic), ppmv			5	5	0.016	0.010	0.00002		
PM (mg/wscm)			1	0.01	0.000015				
Hg (ug/wscm)			1.5E+04	1.5E+04	196	1	1		
Gas Stream Bulk Composition (dry basis)	mol.% or ppmv	mol.% or ppmv	mol.% or ppmv	mol.% or ppmv	mol.% or ppmv	mol.% or ppmv	mol.% or ppmv	mol.% or ppmv	mol.% or ppmv
O2, mol.%			0.009	0.009	4.48	21.00	21.00		
N2, mol.%			0.017	0.017	8.64	79.00	79.00		
CO2, mol.%									
HNO3, mol. %			99.89	99.95	1.03	0.0002	0.0001		
CO, ppmv									
HCl, ppmv			8.5E+03	8.5E+03	6.0E+03	0.008	0.002		
C (organic), ppmv			2.7E+02	2.7E+02	4.0E+02	0.03	0.00002		
H (organic), ppmv			266	267	400	0.03	0.00002		
PM (mg/dscm)			66	1	0.38				
Hg (ug/wscm)			2.0E+06	2.0E+06	1.3E+07	3	2		
Total Mass Flow, kg/hr	4.22E+02	1.76E+02	3.13E+02	3.13E+02	2.83E+02	5.31E+02	2.48E+02	7.17E+01	3.27E+01
Canister Rate, canisters/day		3.02							
Total Canisters Generated		425							

Table C-8. Alkaline scrub balance, Tank WM-180 waste. (Continued).

Stream #	101	102	103	104	105	106	107	108	201
Radiological Composition	Ci/L	Ci/L	Ci/wscm	Ci/wscm	Ci/wscm	Ci/wscm	Ci/wscm	Ci/L	
Ra-226	4.03E-12	1.30E-11	3.30E-16	3.30E-18	3.79E-21	4.95E-26	1.25E-25	2.33E-17	
Ac-227	1.90E-11	6.13E-11	1.55E-15	1.55E-17	1.79E-20	2.33E-25	5.89E-25	1.10E-16	
Th-228	1.57E-09	5.08E-09	1.29E-13	1.29E-15	1.48E-18	1.94E-23	4.89E-23	9.12E-15	
Th-230	4.29E-10	1.39E-09	3.51E-14	3.51E-16	4.04E-19	5.28E-24	1.33E-23	2.49E-15	
Th-232	3.48E-16	1.13E-15	2.85E-20	2.85E-22	3.28E-25	4.28E-30	1.08E-29	2.02E-21	
Pa-231	4.40E-11	1.42E-10	3.60E-15	3.60E-17	4.14E-20	5.40E-25	1.37E-24	2.55E-16	
Pa-233	1.44E-06	4.66E-06	1.18E-10	1.18E-12	1.36E-15	1.77E-20	4.48E-20	8.36E-12	
U-232	1.03E-09	3.34E-09	8.47E-14	8.47E-16	9.73E-19	1.27E-23	3.21E-23	5.99E-15	
U-233	4.03E-11	1.30E-10	3.30E-15	3.30E-17	3.79E-20	4.96E-25	1.25E-24	2.34E-16	
U-234	1.04E-06	3.35E-06	8.48E-11	8.48E-13	9.75E-16	1.27E-20	3.22E-20	6.00E-12	
U-235	3.78E-08	1.22E-07	3.10E-12	3.10E-14	3.56E-17	4.65E-22	1.18E-21	2.19E-13	
U-236	5.62E-08	1.81E-07	4.60E-12	4.60E-14	5.29E-17	6.91E-22	1.74E-21	3.25E-13	
U-237	3.17E-09	1.02E-08	2.59E-13	2.59E-15	2.98E-18	3.89E-23	9.83E-23	1.83E-14	
U-238	2.24E-08	7.22E-08	1.83E-12	1.83E-14	2.11E-17	2.75E-22	6.95E-22	1.30E-13	
Np-236	1.88E-12	6.06E-12	1.54E-16	1.54E-18	1.77E-21	2.31E-26	5.83E-26	1.09E-17	
Np-237	1.46E-06	4.71E-06	1.19E-10	1.19E-12	1.37E-15	1.79E-20	4.53E-20	8.45E-12	
Pu-236	2.08E-09	6.70E-09	1.70E-13	1.70E-15	1.95E-18	2.55E-23	6.45E-23	1.20E-14	
Pu-238	9.47E-04	3.06E-03	7.75E-08	7.75E-10	8.91E-13	1.16E-17	2.94E-17	5.49E-09	
Pu-239	1.44E-04	4.64E-04	1.18E-08	1.18E-10	1.35E-13	1.77E-18	4.46E-18	8.32E-10	
Pu-240	7.80E-06	2.52E-05	6.38E-10	6.38E-12	7.34E-15	9.58E-20	2.42E-19	4.52E-11	
Pu-241	5.70E-04	1.84E-03	4.67E-08	4.67E-10	5.37E-13	7.01E-18	1.77E-17	3.30E-09	
Pu-242	6.01E-09	1.94E-08	4.92E-13	4.92E-15	5.66E-18	7.39E-23	1.87E-22	3.48E-14	
Pu-244	5.15E-16	1.66E-15	4.21E-20	4.22E-22	4.85E-25	6.33E-30	1.60E-29	2.98E-21	
Am-241	6.86E-05	2.21E-04	5.61E-09	5.61E-11	6.45E-14	8.43E-19	2.13E-18	3.97E-10	
Am-242m	7.48E-09	2.42E-08	6.13E-13	6.13E-15	7.04E-18	9.20E-23	2.32E-22	4.34E-14	
Am-243	1.09E-08	3.51E-08	8.89E-13	8.89E-15	1.02E-17	1.34E-22	3.37E-22	6.29E-14	
Cm-242	6.17E-09	1.99E-08	5.05E-13	5.05E-15	5.81E-18	7.59E-23	1.92E-22	3.58E-14	
Cm-243	1.78E-08	5.73E-08	1.45E-12	1.45E-14	1.67E-17	2.18E-22	5.51E-22	1.03E-13	
Cm-244	1.10E-06	3.56E-06	9.03E-11	9.03E-13	1.04E-15	1.36E-20	3.43E-20	6.39E-12	
Cm-245	1.87E-10	6.03E-10	1.53E-14	1.53E-16	1.76E-19	2.30E-24	5.80E-24	1.08E-15	
Cm-246	1.23E-11	3.96E-11	1.00E-15	1.00E-17	1.15E-20	1.51E-25	3.81E-25	7.11E-17	
H-3	1.72E-05	8.38E-06	1.37E-05	1.37E-05	1.24E-05	8.10E-06	4.71E-07	1.38E-05	
Be-10	1.48E-12	4.77E-12	1.21E-16	1.21E-18	1.39E-21	1.81E-26	4.58E-26	8.55E-18	
C-14	6.19E-11	2.00E-10	5.07E-15	5.07E-17	5.83E-20	7.61E-25	1.92E-24	3.59E-16	
Co-60	3.97E-06	1.28E-05	3.25E-10	3.25E-12	3.73E-15	4.88E-20	1.23E-19	2.30E-11	
Ni-59	9.14E-08	2.95E-07	7.48E-12	7.48E-14	8.60E-17	1.12E-21	2.84E-21	5.29E-13	
Ni-63	2.41E-05	7.78E-05	1.97E-09	1.97E-11	2.27E-14	2.96E-19	7.48E-19	1.40E-10	
Se-79	2.25E-07	7.27E-07	1.84E-11	1.84E-13	2.12E-16	2.77E-21	7.00E-21	1.31E-12	
Rb-87	1.44E-11	4.66E-11	1.18E-15	1.18E-17	1.36E-20	1.77E-25	4.48E-25	8.35E-17	
Sr-90	1.95E-02	6.29E-02	1.59E-06	1.59E-08	1.83E-11	2.39E-16	6.05E-16	1.13E-07	
Y-90	1.95E-02	6.29E-02	1.59E-06	1.59E-08	1.83E-11	2.39E-16	6.05E-16	1.13E-07	
Zr-93	1.09E-06	3.52E-06	8.92E-11	8.92E-13	1.03E-15	1.34E-20	3.38E-20	6.32E-12	
Nb-93m	8.40E-07	2.71E-06	6.87E-11	6.87E-13	7.90E-16	1.03E-20	2.61E-20	4.87E-12	
Nb-94	5.87E-07	1.90E-06	4.81E-11	4.81E-13	5.53E-16	7.22E-21	1.82E-20	3.40E-12	
Tc-98	1.27E-12	4.10E-12	1.04E-16	1.04E-18	1.19E-21	1.56E-26	3.94E-26	7.35E-18	
Tc-99	9.01E-06	2.91E-05	7.37E-10	7.37E-12	8.48E-15	1.11E-19	2.80E-19	5.22E-11	
Ru-106	4.80E-07	1.55E-06	3.93E-11	3.93E-13	4.52E-16	5.90E-21	1.49E-20	2.78E-12	
Rh-102	4.24E-10	1.37E-09	3.47E-14	3.47E-16	3.99E-19	5.21E-24	1.32E-23	2.46E-15	
Rh-106	4.80E-07	1.55E-06	3.93E-11	3.93E-13	4.52E-16	5.90E-21	1.49E-20	2.78E-12	
Pd-107	8.13E-09	2.62E-08	6.65E-13	6.65E-15	7.65E-18	9.99E-23	2.52E-22	4.71E-14	
Cd-113m	1.63E-06	5.28E-06	1.34E-10	1.34E-12	1.54E-15	2.01E-20	5.07E-20	9.47E-12	
Sn-121m	3.29E-08	1.06E-07	2.69E-12	2.69E-14	3.10E-17	4.04E-22	1.02E-21	1.91E-13	
Sn-126	2.12E-07	6.84E-07	1.73E-11	1.73E-13	1.99E-16	2.61E-21	6.58E-21	1.23E-12	
Sb-125	7.89E-06	2.55E-05	6.46E-10	6.46E-12	7.43E-15	9.71E-20	2.45E-19	4.57E-11	
Sb-126	2.83E-08	9.14E-08	2.32E-12	2.32E-14	2.66E-17	3.48E-22	8.79E-22	1.64E-13	

Table C-8. Alkaline scrub balance, Tank WM-180 waste. (Continued).

Stream #	101	102	103	104	105	106	107	108	201
Radiological Composition	Ci/L	Ci/L	Ci/wscm	Ci/wscm	Ci/wscm	Ci/wscm	Ci/wscm	Ci/L	
Te-125m	1.55E-06	5.00E-06	1.27E-10	1.27E-12	1.46E-15	1.90E-20	4.81E-20	8.98E-12	
I-129	2.40E-08	7.82E-08	5.90E-09	5.90E-09	8.65E-12	9.42E-14	5.22E-14	4.32E-08	
Cs-134	5.12E-06	1.65E-05	4.19E-10	4.19E-12	4.82E-15	6.30E-20	1.59E-19	2.97E-11	
Cs-135	4.41E-07	1.42E-06	3.61E-11	3.61E-13	4.15E-16	5.42E-21	1.37E-20	2.56E-12	
Cs-137	2.59E-02	8.35E-02	2.12E-06	2.12E-08	2.43E-11	3.18E-16	8.03E-16	1.50E-07	
Ba-137m	2.45E-02	7.90E-02	2.00E-06	2.00E-08	2.30E-11	3.01E-16	7.59E-16	1.42E-07	
La-138	9.39E-17	3.03E-16	7.69E-21	7.69E-23	8.84E-26	1.15E-30	2.92E-30	5.44E-22	
Ce-142	1.47E-11	4.75E-11	1.20E-15	1.20E-17	1.38E-20	1.81E-25	4.57E-25	8.52E-17	
Ce-144	3.24E-07	1.04E-06	2.65E-11	2.65E-13	3.04E-16	3.98E-21	1.00E-20	1.87E-12	
Pr-144	3.24E-07	1.04E-06	2.65E-11	2.65E-13	3.04E-16	3.98E-21	1.00E-20	1.87E-12	
Nd-144	7.91E-16	2.55E-15	6.47E-20	6.47E-22	7.44E-25	9.72E-30	2.46E-29	4.58E-21	
Pm-146	2.50E-08	8.08E-08	2.05E-12	2.05E-14	2.36E-17	3.08E-22	7.77E-22	1.45E-13	
Pm-147	8.78E-05	2.84E-04	7.19E-09	7.19E-11	8.26E-14	1.08E-18	2.73E-18	5.09E-10	
Sm-146	1.36E-13	4.38E-13	1.11E-17	1.11E-19	1.28E-22	1.67E-27	4.21E-27	7.86E-19	
Sm-147	3.62E-12	1.17E-11	2.97E-16	2.97E-18	3.41E-21	4.45E-26	1.13E-25	2.10E-17	
Sm-151	1.73E-04	5.59E-04	1.42E-08	1.42E-10	1.63E-13	2.13E-18	5.38E-18	1.00E-09	
Eu-152	1.25E-06	4.05E-06	1.03E-10	1.03E-12	1.18E-15	1.54E-20	3.89E-20	7.26E-12	
Eu-154	4.50E-05	1.45E-04	3.68E-09	3.68E-11	4.23E-14	5.53E-19	1.40E-18	2.61E-10	
Eu-155	8.18E-05	2.64E-04	6.70E-09	6.70E-11	7.70E-14	1.01E-18	2.54E-18	4.74E-10	
Ho-166m	2.26E-11	7.31E-11	1.85E-15	1.85E-17	2.13E-20	2.78E-25	7.03E-25	1.31E-16	

Table C-9. Alkaline scrub balance, Tank WM-187 waste.

WM-187 PFD Sheet #	PFD-2A	PFD-2A	PFD-2A	PFD-2A	PFD-2A	PFD-2A	PFD-2A	PFD-2A	PFD-2A
Stream #	101	102	103	104	105	106	107	108	201
Stream Name	SBW Feed	Evaporator Bottoms	Evaporator Overheads Vapor	Mist Eliminator Vapor	Alkaline Scrubber Vapor	POG + VOG Offgas Vapor	VOG Offgas Vapor	Scrubber Recycle to Feed	20 wt.% MgO Additive
Rate or Volume Flow (actual)	85.8	26.4	35,835	36,269	31,503	36,574	11,770	19.5	101.3
Volume Flow (standard, wet)*			13,574	13,574	12,188	19,601	7,401		
Volume Flow (standard, dry)*			386.9	386.8	0.55	7,113	7,125		
Rate Units	gal/hr	gal/hr	ft3/hr	ft3/hr	ft3/hr	ft3/hr	ft3/hr	gal/hr	lb/hr
Temperature, °C	25.0	126	126	120.2	88.7	173	108	88.8	25.0
Temperature, °F	77.0	259	259	248	192	344	226	192	77.0
Pressure, psia	12.3	7.6	7.6	7.4	7.0	12.0	12.0	30.0	12.3
Specific Gravity	1.26	1.75	0.00030	0.00030	0.00029	0.00049	0.00074	1.30	1.20
Chemical Composition	Mol/Liter	Mol/Liter	lb/wscf	lb/wscf	lb/wscf	lb/wscf	lb/wscf	Mol/Liter	Wt. %
H+	1.47E+00	2.18E-01	7.46E-05	7.46E-05	1.28E-09	1.80E-08	4.56E-08	1.40E-04	2.64E-12
OH-			2.70E-14		1.35E-11	1.45E-13		7.13E-05	1.69E+01
Al+3	3.61E-01	1.18E+00	5.14E-08	4.70E-11	4.36E-14			1.45E-07	
Sb+5	2.78E-05	9.06E-05	1.79E-11	1.79E-13	1.66E-16			1.23E-10	
As+3	1.77E-04	5.76E-04	6.99E-11	6.99E-13	6.49E-16			7.78E-10	
Ba+2	7.12E-05	2.32E-04	5.16E-11	2.39E-13	2.21E-16			1.45E-10	
Be+2	1.67E-05	5.43E-05	7.93E-13	4.04E-15	3.75E-18			3.74E-11	
B+3	1.10E-02	3.59E-02	6.29E-10	4.51E-13	4.18E-16			3.48E-09	
Cd+2	1.87E-03	6.09E-03	1.11E-09	6.28E-13	5.82E-16			4.66E-10	
Ca+2	3.47E-02	1.13E-01	7.34E-09	4.02E-12	3.73E-15			8.36E-09	
Cr+3	4.71E-03	1.53E-02	1.29E-09	1.88E-12	1.74E-15			3.01E-09	
Co+2	1.94E-03	6.32E-03	6.03E-10	1.94E-14	1.80E-17			2.75E-11	
Cs+	8.43E-05	2.74E-04	5.29E-11	4.70E-13	4.35E-16			2.95E-10	
Cu+2	5.12E-04	1.67E-03	1.72E-10	6.25E-13	5.80E-16			8.20E-10	
Fe+3	2.53E-02	8.24E-02	7.46E-09	3.76E-11	3.49E-14			5.62E-08	
Pb+2	6.73E-04	2.19E-03	7.36E-10	6.58E-13	6.11E-16			2.65E-10	
Hg+2	3.40E-03	1.11E-02	1.11E-06	1.11E-06	1.11E-08	1.73E-10	3.66E-10	4.58E-04	
Mn+4	1.87E-02	6.08E-02	5.41E-09	5.41E-11	5.02E-14			8.21E-08	
Ni+2	1.41E-03	4.59E-03	4.37E-10	7.60E-13	7.05E-16			1.08E-09	
K+	3.13E-01	1.02E+00	6.46E-08	4.35E-11	4.04E-14			9.28E-08	
Se+4	4.61E-04	1.50E-03	1.92E-10	1.92E-12	1.78E-15			2.03E-09	
Ag+	7.08E-04	2.30E-03	4.02E-10	4.01E-12	3.72E-15			3.10E-09	
Na+	1.77E+00	5.77E+00	1.12E-07	1.27E-10	1.18E-13			4.60E-07	
Tl+3	6.31E-06	2.06E-05	6.81E-12	6.81E-14	6.31E-17			2.78E-11	
U+4	2.90E-04	9.45E-04	3.64E-10	3.64E-12	3.38E-15			1.28E-09	
V+3	6.14E-05	2.00E-04	1.65E-11	1.65E-13	1.54E-16			2.72E-10	
Zn+2	7.21E-04	2.35E-03	2.49E-10	3.77E-13	3.50E-16			4.81E-10	
Zr+4	6.66E-02	2.17E-01	3.20E-08	3.20E-10	2.97E-13			2.93E-07	
Cl-	1.80E-02	5.87E-02	1.15E-05	1.15E-05	1.14E-08	5.41E-10	1.10E-09	2.69E-02	
F-	5.61E-02	1.83E-01	2.19E-08	1.86E-08	9.87E-10	6.30E-10	4.42E-11	7.77E-05	
SO4-2	4.99E-02	1.62E-01	2.53E-08	2.53E-10	2.35E-13			2.19E-07	
NO3-	4.57E+00	1.44E+01	4.57E-03	4.57E-03	4.31E-06	1.10E-06	2.80E-06	6.15E+00	
PO4-3	1.75E-01	5.68E-01	8.74E-08	8.74E-10	8.11E-13			7.67E-07	
Am+4	6.58E-08	2.14E-07	8.37E-14	8.37E-16	7.76E-19			2.89E-13	
Br-	2.21E-07	7.19E-07	4.00E-10	4.00E-10	3.99E-13	1.89E-14	3.85E-14	4.17E-07	
Ce+4	4.07E-05	1.32E-04	3.01E-11	3.01E-13	2.79E-16			1.79E-10	
Eu+3	3.68E-07	1.20E-06	2.95E-13	9.84E-18	9.13E-21			5.40E-15	
Gd+3	1.37E-04	4.45E-04	1.13E-10	2.74E-13	2.54E-16			1.45E-10	
Ge+4	6.37E-09	2.07E-08	2.44E-15	2.44E-17	2.26E-20			2.80E-14	
In+3	1.07E-06	3.48E-06	6.47E-13						
I-	3.12E-06	1.01E-05	5.28E-09	5.27E-09	5.26E-12	2.49E-13	5.07E-13	3.47E-06	
La+3	6.66E-06	2.17E-05	4.88E-12						
Li+	6.27E-04	2.04E-03	1.87E-11	1.46E-13	1.35E-16			1.75E-09	
Mg+2	1.42E-02	2.33E+00	9.17E-08		8.34E-07	1.04E-13		3.09E+00	1.21E+01
Mo+6	1.23E-03	4.01E-03	6.23E-10	6.23E-12	5.78E-15			5.42E-09	

Table C-9. Alkaline scrub balance, Tank WM-187 waste. (Continued).

Stream #	101	102	103	104	105	106	107	108	201
Chemical Composition	Mol/Liter	Mol/Liter	lb/wscf	lb/wscf	lb/wscf	lb/wscf	lb/wscf	Mol/Liter	Wt. %
Nd+3	2.15E-05	6.99E-05	1.63E-11						
Np+4	3.28E-06	1.07E-05	4.10E-12	4.10E-14	3.81E-17			1.44E-11	
Nb+5	1.86E-03	6.05E-03	9.10E-10	9.10E-12	8.44E-15			8.17E-09	
Pd+4	3.01E-03	9.81E-03	1.69E-09	1.69E-11	1.57E-14			1.33E-08	
Pu+4	8.87E-06	2.89E-05	1.12E-11	1.12E-13	1.04E-16			3.90E-11	
Pr+4	6.06E-06	1.97E-05	4.50E-12	4.50E-14	4.17E-17			2.66E-11	
Rh+4	2.61E-06	8.50E-06	1.42E-12	1.42E-14	1.31E-17			1.15E-11	
Rb+	4.04E-06	1.32E-05	9.28E-13	6.85E-16	6.35E-19			6.68E-13	
Ru+3	1.36E-03	4.43E-03	7.26E-10	6.70E-12	6.21E-15			5.52E-09	
Sm+3	4.03E-06	1.31E-05	3.19E-12	3.65E-16	3.39E-19			2.02E-13	
Si+4	1.59E-01	5.17E-01	2.35E-08	2.35E-10	2.18E-13			6.98E-07	
Sr+2	8.80E-05	2.86E-04	4.07E-11	4.94E-14	4.58E-17			4.70E-11	
Tc+7	6.42E-06	2.09E-05	3.28E-12						
Te+4	3.48E-06	1.13E-05	2.34E-12	2.34E-14	2.17E-17			1.53E-11	
Tb+4	1.53E-09	4.99E-09	1.29E-15	1.29E-17	1.19E-20			6.74E-15	
Th+4	1.85E-05	6.01E-05	2.26E-11	2.26E-13	2.10E-16			8.12E-11	
Sn+4	3.23E-03	1.05E-02	2.02E-09	2.02E-11	1.87E-14			1.42E-08	
Ti+4	1.62E-03	5.27E-03	4.09E-10	4.09E-12	3.79E-15			7.12E-09	
Y+3	4.96E-06	1.62E-05	2.33E-12	6.24E-20	5.78E-23			5.85E-17	
O-2 (oxides)	3.25E-01	1.06E+00	2.75E-08	2.75E-10	2.55E-13			1.43E-06	
H2O	4.50E+01	2.16E+01	4.56E-02	4.56E-02	4.69E-02	2.98E-02	1.74E-03	4.66E+01	7.11E+01
O2			1.29E-07	1.29E-07	1.44E-07	6.34E-03	1.68E-02	1.81E-10	
N2			2.19E-07	2.19E-07	2.44E-07	2.09E-02	5.53E-02	2.08E-10	
C (organic)	1.96E-01	6.38E-01	3.15E-06	3.15E-06	7.67E-09	4.79E-09	6.37E-11	2.19E-02	
H (organic)	1.96E-01	6.38E-01	2.64E-07	2.64E-07	6.44E-10	4.02E-10	5.34E-12	2.19E-02	
Gas Stream Bulk Composition (wet basis)	mol.% or ppmv	mol.% or ppmv	mol.% or ppmv	mol.% or ppmv	mol.% or ppmv	mol.% or ppmv	mol.% or ppmv	mol.% or ppmv	mol.% or ppmv
H2O, mol.%			97.15	97.15	100.00	63.71	3.72		
O2, mol.%			0.0002	0.0002	0.0002	7.62	20.22		
N2, mol.%			0.0003	0.0003	0.0003	28.67	76.06		
CO2, mol.%									
HNO3, mol. %			2.84	2.84	0.00005	0.0007	0.002		
CO, ppmv									
HCl, ppmv			124	124	0.12	0.006	0.012		
C (organic), ppmv			101	101	0.25	0.15	0.002		
H (organic), ppmv			101	101	0.25	0.15	0.002		
PM (mg/wscm)			6	0.06	0.0001				
Hg (ug/wscm)			3.1E+03	3.1E+03	32	2	6		
Gas Stream Bulk Composition (dry basis)	mol.% or ppmv	mol.% or ppmv	mol.% or ppmv	mol.% or ppmv	mol.% or ppmv	mol.% or ppmv	mol.% or ppmv	mol.% or ppmv	mol.% or ppmv
O2, mol.%			0.005	0.005	3.82	21.00	21.00		
N2, mol.%			0.011	0.011	7.40	79.00	79.00		
CO2, mol.%									
HNO3, mol. %			99.77	99.81	1.08	0.002	0.002		
CO, ppmv									
HCl, ppmv			4.4E+03	4.4E+03	2.7E+03	0.02	0.01		
C (organic), ppmv			3.5E+03	3.5E+03	5.4E+03	0.42	0.002		
H (organic), ppmv			3,535	3,536	5,433	0.42	0.002		
PM (mg/dscm)			216	2	1				
Hg (ug/wscm)			2.9E+05	2.9E+05	1.8E+06	11	10		
Total Mass Flow, kg/hr	3.94E+02	1.75E+02	3.09E+02	3.09E+02	2.60E+02	5.07E+02	2.48E+02	9.57E+01	4.59E+01
Canister Rate, canisters/day		2.99							
Total Canisters Generated		224							

Table C-9. Alkaline scrub balance, Tank WM-187 waste. (Continued).

Stream #	101	102	103	104	105	106	107	108	201
Radiological Composition	Ci/L	Ci/L	Ci/wscm	Ci/wscm	Ci/wscm	Ci/wscm	Ci/wscm	Ci/L	
Ra-226	6.10E-12	1.99E-11	5.15E-16	5.15E-18	4.78E-21	7.73E-26	1.89E-25	2.68E-17	
Ac-227	2.87E-11	9.35E-11	2.43E-15	2.43E-17	2.25E-20	3.64E-25	8.90E-25	1.26E-16	
Th-228	2.38E-09	7.76E-09	2.01E-13	2.01E-15	1.87E-18	3.02E-23	7.39E-23	1.05E-14	
Th-230	1.01E-09	3.27E-09	8.50E-14	8.50E-16	7.88E-19	1.28E-23	3.12E-23	4.42E-15	
Th-232	5.27E-16	1.72E-15	4.46E-20	4.46E-22	4.13E-25	6.69E-30	1.63E-29	2.32E-21	
Pa-231	6.65E-11	2.17E-10	5.62E-15	5.62E-17	5.21E-20	8.43E-25	2.06E-24	2.93E-16	
Pa-233	2.18E-06	7.10E-06	1.84E-10	1.84E-12	1.71E-15	2.77E-20	6.77E-20	9.60E-12	
U-232	2.30E-09	7.48E-09	1.94E-13	1.94E-15	1.80E-18	2.91E-23	7.12E-23	1.01E-14	
U-233	7.36E-11	2.40E-10	6.22E-15	6.22E-17	5.77E-20	9.33E-25	2.28E-24	3.24E-16	
U-234	1.20E-06	3.92E-06	1.02E-10	1.02E-12	9.43E-16	1.53E-20	3.73E-20	5.29E-12	
U-235	6.32E-08	2.06E-07	5.34E-12	5.34E-14	4.95E-17	8.02E-22	1.96E-21	2.78E-13	
U-236	5.90E-08	1.92E-07	4.99E-12	4.99E-14	4.63E-17	7.48E-22	1.83E-21	2.60E-13	
U-237	4.79E-09	1.56E-08	4.05E-13	4.05E-15	3.76E-18	6.08E-23	1.49E-22	2.11E-14	
U-238	2.06E-08	6.69E-08	1.74E-12	1.74E-14	1.61E-17	2.61E-22	6.37E-22	9.04E-14	
Np-236	2.35E-12	7.65E-12	1.99E-16	1.99E-18	1.84E-21	2.98E-26	7.29E-26	1.03E-17	
Np-237	5.48E-07	1.78E-06	4.63E-11	4.63E-13	4.30E-16	6.95E-21	1.70E-20	2.41E-12	
Pu-236	3.63E-09	1.18E-08	3.07E-13	3.07E-15	2.84E-18	4.60E-23	1.13E-22	1.60E-14	
Pu-238	1.12E-03	3.65E-03	9.48E-08	9.48E-10	8.79E-13	1.42E-17	3.48E-17	4.94E-09	
Pu-239	1.23E-04	4.01E-04	1.04E-08	1.04E-10	9.66E-14	1.56E-18	3.82E-18	5.42E-10	
Pu-240	1.36E-05	4.43E-05	1.15E-09	1.15E-11	1.07E-14	1.72E-19	4.22E-19	5.98E-11	
Pu-241	8.61E-04	2.80E-03	7.28E-08	7.28E-10	6.75E-13	1.09E-17	2.67E-17	3.79E-09	
Pu-242	1.07E-08	3.48E-08	9.03E-13	9.03E-15	8.37E-18	1.35E-22	3.31E-22	4.70E-14	
Pu-244	6.49E-16	2.11E-15	5.49E-20	5.49E-22	5.09E-25	8.23E-30	2.01E-29	2.86E-21	
Am-241	6.58E-05	2.14E-04	5.56E-09	5.56E-11	5.16E-14	8.35E-19	2.04E-18	2.90E-10	
Am-242m	1.15E-08	3.74E-08	9.71E-13	9.71E-15	9.01E-18	1.46E-22	3.56E-22	5.05E-14	
Am-243	2.31E-08	7.52E-08	1.95E-12	1.95E-14	1.81E-17	2.93E-22	7.16E-22	1.02E-13	
Cm-242	2.28E-08	7.43E-08	1.93E-12	1.93E-14	1.79E-17	2.89E-22	7.07E-22	1.00E-13	
Cm-243	3.53E-08	1.15E-07	2.98E-12	2.98E-14	2.76E-17	4.47E-22	1.09E-21	1.55E-13	
Cm-244	1.61E-06	5.24E-06	1.36E-10	1.36E-12	1.26E-15	2.04E-20	4.99E-20	7.07E-12	
Cm-245	3.72E-10	1.21E-09	3.14E-14	3.14E-16	2.91E-19	4.71E-24	1.15E-23	1.64E-15	
Cm-246	2.43E-11	7.93E-11	2.06E-15	2.06E-17	1.91E-20	3.09E-25	7.55E-25	1.07E-16	
H-3	9.54E-06	4.44E-06	8.34E-06	8.34E-06	7.59E-06	4.84E-06	3.18E-07	8.34E-06	
Be-10	2.23E-12	7.27E-12	1.89E-16	1.89E-18	1.75E-21	2.83E-26	6.93E-26	9.83E-18	
C-14	1.55E-10	5.03E-10	1.31E-14	1.31E-16	1.21E-19	1.96E-24	4.79E-24	6.80E-16	
Co-60	1.61E-05	5.23E-05	1.36E-09	1.36E-11	1.26E-14	2.04E-19	4.98E-19	7.06E-11	
Ni-59	2.06E-06	6.70E-06	1.74E-10	1.74E-12	1.61E-15	2.61E-20	6.38E-20	9.06E-12	
Ni-63	4.20E-05	1.37E-04	3.55E-09	3.55E-11	3.29E-14	5.33E-19	1.30E-18	1.85E-10	
Se-79	5.60E-07	1.82E-06	4.73E-11	4.73E-13	4.39E-16	7.10E-21	1.74E-20	2.46E-12	
Rb-87	2.18E-11	7.10E-11	1.84E-15	1.84E-17	1.71E-20	2.77E-25	6.76E-25	9.60E-17	
Sr-90	2.94E-02	9.57E-02	2.48E-06	2.48E-08	2.30E-11	3.73E-16	9.11E-16	1.29E-07	
Y-90	2.94E-02	9.57E-02	2.48E-06	2.48E-08	2.30E-11	3.73E-16	9.11E-16	1.29E-07	
Zr-93	1.65E-06	5.37E-06	1.39E-10	1.39E-12	1.29E-15	2.09E-20	5.11E-20	7.26E-12	
Nb-93m	1.27E-06	4.14E-06	1.07E-10	1.07E-12	9.96E-16	1.61E-20	3.94E-20	5.59E-12	
Nb-94	1.45E-06	4.73E-06	1.23E-10	1.23E-12	1.14E-15	1.84E-20	4.51E-20	6.39E-12	
Tc-98	1.92E-12	6.25E-12	1.62E-16	1.62E-18	1.51E-21	2.44E-26	5.95E-26	8.45E-18	
Tc-99	1.66E-05	5.39E-05	1.40E-09	1.40E-11	1.30E-14	2.10E-19	5.13E-19	7.28E-11	
Ru-106	1.20E-06	3.91E-06	1.01E-10	1.01E-12	9.40E-16	1.52E-20	3.72E-20	5.28E-12	
Rh-102	6.42E-10	2.09E-09	5.42E-14	5.42E-16	5.03E-19	8.14E-24	1.99E-23	2.82E-15	
Rh-106	1.20E-06	3.91E-06	1.01E-10	1.01E-12	9.40E-16	1.52E-20	3.72E-20	5.28E-12	
Pd-107	1.23E-08	4.00E-08	1.04E-12	1.04E-14	9.64E-18	1.56E-22	3.81E-22	5.41E-14	
Cd-113m	2.47E-06	8.05E-06	2.09E-10	2.09E-12	1.94E-15	3.13E-20	7.66E-20	1.09E-11	
Sn-121m	4.98E-08	1.62E-07	4.21E-12	4.21E-14	3.90E-17	6.31E-22	1.54E-21	2.19E-13	
Sn-126	5.28E-07	1.72E-06	4.46E-11	4.46E-13	4.14E-16	6.69E-21	1.64E-20	2.32E-12	
Sb-125	7.14E-04	2.32E-03	6.03E-08	6.03E-10	5.59E-13	9.05E-18	2.21E-17	3.14E-09	
Sb-126	4.28E-08	1.39E-07	3.62E-12	3.62E-14	3.36E-17	5.43E-22	1.33E-21	1.88E-13	

Table C-9. Alkaline scrub balance, Tank WM-187 waste. (Continued).

Stream #	101	102	103	104	105	106	107	108	201
Radiological Composition	Ci/L	Ci/L	Ci/wscm	Ci/wscm	Ci/wscm	Ci/wscm	Ci/wscm	Ci/L	
Te-125m	2.35E-06	7.63E-06	1.98E-10	1.98E-12	1.84E-15	2.97E-20	7.27E-20	1.03E-11	
I-129	6.81E-08	2.18E-07	1.92E-08	1.92E-08	1.83E-11	8.98E-13	1.85E-12	9.54E-08	
Cs-134	7.24E-05	2.36E-04	6.12E-09	6.12E-11	5.67E-14	9.18E-19	2.24E-18	3.18E-10	
Cs-135	1.05E-06	3.43E-06	8.90E-11	8.91E-13	8.26E-16	1.34E-20	3.27E-20	4.63E-12	
Cs-137	4.37E-02	1.42E-01	3.69E-06	3.69E-08	3.42E-11	5.54E-16	1.35E-15	1.92E-07	
Ba-137m	4.13E-02	1.35E-01	3.49E-06	3.49E-08	3.24E-11	5.24E-16	1.28E-15	1.82E-07	
La-138	1.42E-16	4.63E-16	1.20E-20	1.20E-22	1.11E-25	1.80E-30	4.41E-30	6.25E-22	
Ce-142	2.23E-11	7.25E-11	1.88E-15	1.88E-17	1.74E-20	2.82E-25	6.90E-25	9.79E-17	
Ce-144	8.11E-07	2.64E-06	6.85E-11	6.85E-13	6.36E-16	1.03E-20	2.51E-20	3.57E-12	
Pr-144	8.11E-07	2.64E-06	6.85E-11	6.85E-13	6.36E-16	1.03E-20	2.51E-20	3.57E-12	
Nd-144	1.20E-15	3.90E-15	1.01E-19	1.01E-21	9.38E-25	1.52E-29	3.71E-29	5.26E-21	
Pm-146	3.87E-08	1.26E-07	3.27E-12	3.27E-14	3.03E-17	4.90E-22	1.20E-21	1.70E-13	
Pm-147	2.18E-04	7.10E-04	1.84E-08	1.84E-10	1.71E-13	2.76E-18	6.76E-18	9.59E-10	
Sm-146	2.05E-13	6.69E-13	1.74E-17	1.74E-19	1.61E-22	2.60E-27	6.37E-27	9.03E-19	
Sm-147	5.48E-12	1.79E-11	4.63E-16	4.63E-18	4.30E-21	6.95E-26	1.70E-25	2.41E-17	
Sm-151	4.32E-04	1.41E-03	3.65E-08	3.65E-10	3.39E-13	5.48E-18	1.34E-17	1.90E-09	
Eu-152	2.51E-06	8.17E-06	2.12E-10	2.12E-12	1.97E-15	3.18E-20	7.78E-20	1.10E-11	
Eu-154	9.52E-05	3.10E-04	8.04E-09	8.04E-11	7.46E-14	1.21E-18	2.95E-18	4.19E-10	
Eu-155	1.01E-04	3.29E-04	8.53E-09	8.53E-11	7.91E-14	1.28E-18	3.13E-18	4.44E-10	
Ho-166m	3.43E-11	1.12E-10	2.90E-15	2.90E-17	2.69E-20	4.35E-25	1.06E-24	1.51E-16	

Table C-10. Alkaline scrub balance, Tank WM-188 waste.

WM-188 PFD Sheet #	PFD-2A	PFD-2A	PFD-2A	PFD-2A	PFD-2A	PFD-2A	PFD-2A	PFD-2A	PFD-2A
Stream #	101	102	103	104	105	106	107	108	201
Stream Name	SBW Feed	Evaporator Bottoms	Evaporator Overheads Vapor	Mist Eliminator Vapor	Alkaline Scrubber Vapor	POG + VOG Offgas Vapor	VOG Offgas Vapor	Scrubber Recycle to Feed	20 wt.% MgO Additive
Rate or Volume Flow (actual)	85.8	30.2	39,564	40,100	33,918	38,489	11,768	28.7	144.8
Volume Flow (standard, wet)*			15,224	15,224	13,137	20,550	7,400		
Volume Flow (standard, dry)*			552.5	552.3	0.66	7,118	7,130		
Rate Units	gal/hr	gal/hr	ft3/hr	ft3/hr	ft3/hr	ft3/hr	ft3/hr	gal/hr	lb/hr
Temperature, °C	25.0	120	120	114.6	88.3	175	108	88.4	25.0
Temperature, °F	77.0	248	248	238	191	347	226	191	77.0
Pressure, psia	12.3	7.6	7.6	7.4	7.0	12.0	12.0	30.0	12.3
Specific Gravity	1.24	1.75	0.0003	0.0003	0.00029	0.00048	0.00074	1.29	1.20
Chemical Composition	Mol/Liter	Mol/Liter	lb/wscf	lb/wscf	lb/wscf	lb/wscf	lb/wscf	Mol/Liter	Wt. %
H+	2.18E+00	4.81E-01	9.52E-05	9.52E-05	5.52E-09	3.66E-09	3.55E-10	6.70E-04	2.64E-12
OH-			1.31E-14		2.91E-12	1.63E-13		1.34E-05	1.69E+01
Al+3	5.07E-01	1.44E+00	6.43E-08	2.45E-11	1.94E-14			5.76E-08	
Sb+5	1.58E-05	4.50E-05	9.07E-12	9.07E-14	7.20E-17			4.73E-11	
As+3	8.88E-05	2.52E-04	3.13E-11	3.13E-13	2.48E-16			2.65E-10	
Ba+2	7.24E-05	2.05E-04	4.67E-11	1.13E-13	8.99E-17			5.24E-11	
Be+2	1.83E-05	5.19E-05	7.74E-13	2.29E-15	1.82E-18			1.61E-11	
B+3	1.59E-02	4.50E-02	8.07E-10	3.01E-13	2.39E-16			1.77E-09	
Cd+2	2.42E-03	6.88E-03	1.28E-09	3.32E-13	2.63E-16			1.88E-10	
Ca+2	4.83E-02	1.37E-01	9.10E-09	2.37E-12	1.88E-15			3.76E-09	
Cr+3	4.48E-03	1.27E-02	1.10E-09	9.86E-13	7.82E-16			1.20E-09	
Co+2	3.97E-05	1.13E-04	1.10E-11	1.03E-14	8.21E-18			1.11E-11	
Cs+	5.76E-05	1.64E-04	3.29E-11	2.19E-13	1.74E-16			1.05E-10	
Cu+2	6.78E-04	1.92E-03	2.03E-10	2.92E-13	2.31E-16			2.91E-10	
Fe+3	2.49E-02	7.08E-02	6.55E-09	1.78E-11	1.41E-14			2.02E-08	
Pb+2	7.98E-04	2.27E-03	7.77E-10	3.35E-13	2.66E-16			1.03E-10	
Hg+2	5.11E-03	1.45E-02	1.04E-06	1.04E-06	7.97E-09	4.18E-11	1.02E-10	3.24E-04	
Mn+4	1.43E-02	4.07E-02	3.70E-09	3.70E-11	2.94E-14			4.28E-08	
Ni+2	1.78E-03	5.04E-03	4.90E-10	4.25E-13	3.37E-16			4.60E-10	
K+	1.82E-01	5.17E-01	3.35E-08	2.24E-11	1.77E-14			3.63E-08	
Se+4	2.34E-04	6.64E-04	8.69E-11	8.69E-13	6.89E-16			6.99E-10	
Ag+	3.64E-04	1.03E-03	1.84E-10	1.83E-12	1.45E-15			1.08E-09	
Na+	1.36E+00	3.85E+00	1.16E-07	8.75E-11	6.94E-14			2.42E-07	
Tl+3	4.42E-06	1.26E-05	4.25E-12	4.25E-14	3.37E-17			1.32E-11	
U+4	3.50E-04	9.93E-04	3.92E-10	3.92E-12	3.11E-15			1.05E-09	
V+3	3.62E-05	1.03E-04	8.66E-12	8.66E-14	6.87E-17			1.08E-10	
Zn+2	7.85E-04	2.23E-03	2.41E-10	1.86E-13	1.47E-16			1.80E-10	
Zr+4	3.65E-02	1.03E-01	1.56E-08	1.56E-10	1.24E-13			1.09E-07	
Cl-	2.39E-02	6.78E-02	1.54E-05	1.54E-05	1.55E-08	5.99E-10	4.54E-11	2.77E-02	
F-	3.45E-02	9.80E-02	1.12E-08	9.59E-09	4.77E-09	3.05E-09	1.02E-12	2.67E-05	
SO4-2	4.05E-02	1.15E-01	1.83E-08	1.83E-10	1.45E-13			1.21E-07	
NO3-	5.31E+00	1.51E+01	5.83E-03	5.83E-03	4.94E-06	2.14E-07	2.18E-08	5.96E+00	
PO4-3	9.61E-02	2.73E-01	4.29E-08	4.29E-10	3.40E-13			2.87E-07	
Am+4	6.69E-08	1.90E-07	7.59E-14	7.59E-16	6.02E-19			2.00E-13	
Br-	2.87E-07	8.16E-07	4.58E-10	4.58E-10	4.62E-13	1.78E-14	1.35E-15	3.65E-07	
Ce+4	3.31E-05	9.40E-05	2.18E-11	2.18E-13	1.73E-16			9.89E-11	
Eu+3	4.77E-07	1.35E-06	3.41E-13	4.65E-18	3.69E-21			1.94E-15	
Gd+3	1.41E-04	4.00E-04	1.04E-10	1.28E-13	1.02E-16			5.17E-11	
Ge+4	8.29E-09	2.35E-08	2.83E-15	2.83E-17	2.25E-20			2.48E-14	
In+3	1.46E-06	4.14E-06	7.87E-13						
I-	3.07E-06	8.73E-06	6.04E-09	6.04E-09	6.09E-12	2.35E-13	1.78E-14	3.03E-06	
La+3	8.66E-06	2.46E-05	5.66E-12						
Li+	4.53E-04	1.29E-03	1.31E-11	7.06E-14	5.60E-17			6.46E-10	
Mg+2	1.71E-02	2.89E+00	1.17E-07		9.10E-07	1.16E-13		3.00E+00	1.21E+01
Mo+6	7.29E-04	2.07E-03	3.29E-10	3.29E-12	2.61E-15			2.18E-09	

Table C-10. Alkaline scrub balance, Tank WM-188 waste. (Continued).

Stream #	101	102	103	104	105	106	107	108	201
Chemical Composition	Mol/Liter	Mol/Liter	lb/wscf	lb/wscf	lb/wscf	lb/wscf	lb/wscf	Mol/Liter	Wt. %
Nd+3	2.79E-05	7.93E-05	1.89E-11						
Np+4	2.55E-06	7.25E-06	2.85E-12	2.85E-14	2.26E-17			7.62E-12	
Nb+5	1.05E-03	2.97E-03	4.57E-10	4.57E-12	3.63E-15			3.12E-09	
Pd+4	1.70E-03	4.82E-03	8.50E-10	8.50E-12	6.74E-15			5.07E-09	
Pu+4	6.65E-06	1.89E-05	7.47E-12	7.47E-14	5.93E-17			1.99E-11	
Pr+4	7.87E-06	2.24E-05	5.22E-12	5.22E-14	4.14E-17			2.35E-11	
Rh+4	3.40E-06	9.64E-06	1.64E-12	1.64E-14	1.30E-17			1.01E-11	
Rb+	5.24E-06	1.49E-05	1.66E-12	8.47E-16	6.72E-19			6.29E-13	
Ru+3	7.86E-04	2.23E-03	3.74E-10	3.17E-12	2.52E-15			1.99E-09	
Sm+3	5.20E-06	1.48E-05	3.68E-12	1.74E-16	1.38E-19			7.35E-14	
Si+4	8.92E-02	2.53E-01	1.18E-08	1.18E-10	9.35E-14			2.67E-07	
Sr+2	7.77E-05	2.21E-04	3.20E-11	2.54E-14	2.02E-17			1.84E-11	
Tc+7	1.01E-05	2.88E-05	4.62E-12						
Te+4	3.46E-06	9.82E-06	2.07E-12	2.07E-14	1.65E-17			1.03E-11	
Tb+4	1.99E-09	5.66E-09	1.49E-15	1.49E-17	1.18E-20			5.95E-15	
Th+4	2.29E-05	6.51E-05	2.50E-11	2.50E-13	1.99E-16			6.85E-11	
Sn+4	1.73E-03	4.90E-03	9.64E-10	9.64E-12	7.64E-15			5.16E-09	
Ti+4	8.83E-04	2.51E-03	1.99E-10	1.99E-12	1.58E-15			2.64E-09	
Y+3	6.46E-06	1.83E-05	2.70E-12	4.31E-20	3.42E-23			3.08E-17	
O-2 (oxides)	1.83E-01	5.20E-01	1.38E-08	1.38E-10	1.09E-13			5.47E-07	
H2O	4.85E+01	2.79E+01	4.52E-02	4.52E-02	4.69E-02	3.06E-02	1.70E-03	4.68E+01	7.11E+01
O2			1.21E-07	1.21E-07	1.40E-07	6.05E-03	1.68E-02	1.79E-10	
N2			2.05E-07	2.05E-07	2.38E-07	1.99E-02	5.53E-02	2.07E-10	
C (organic)	6.88E-02	1.95E-01	5.40E-07	5.40E-07	1.00E-09	6.42E-10	1.12E-12	2.81E-03	
H (organic)	6.88E-02	1.95E-01	4.53E-08	4.53E-08	8.42E-11	5.38E-11	9.44E-14	2.81E-03	
Gas Stream Bulk Composition (wet basis)	mol.% or ppmv	mol.% or ppmv	mol.% or ppmv	mol.% or ppmv	mol.% or ppmv	mol.% or ppmv	mol.% or ppmv	mol.% or ppmv	mol.% or ppmv
H2O, mol.%			96.37	96.37	100.00	65.36	3.64		
O2, mol.%			0.0001	0.0001	0.0002	7.27	20.23		
N2, mol.%			0.0003	0.0003	0.0003	27.36	76.12		
CO2, mol.%									
HNO3, mol. %			3.63	3.63	0.0002	0.0001	0.00001		
CO, ppmv									
HCl, ppmv			167	167	0.17	0.006	0.0005		
C (organic), ppmv			17	17	0.032	0.021	0.00004		
H (organic), ppmv			17	17	0.032	0.021	0.00004		
PM (mg/wscm)			3	0.03	0.00003				
Hg (ug/wscm)			1.7E+04	1.7E+04	128	0.7	1.6		
Gas Stream Bulk Composition (dry basis)	mol.% or ppmv	mol.% or ppmv	mol.% or ppmv	mol.% or ppmv	mol.% or ppmv	mol.% or ppmv	mol.% or ppmv	mol.% or ppmv	mol.% or ppmv
O2, mol.%			0.004	0.004	3.36	21.00	21.00		
N2, mol.%			0.008	0.008	6.53	79.00	79.00		
CO2, mol.%									
HNO3, mol. %			99.92	99.96	4.21	0.0004	0.00001		
CO, ppmv									
HCl, ppmv			4.6E+03	4.6E+03	3.4E+03	0.02	0.0005		
C (organic), ppmv			4.8E+02	4.8E+02	6.4E+02	0.06	0.00004		
H (organic), ppmv			476	476	642	0.06	0.00004		
PM (mg/dscm)			88	0.88	0.51				
Hg (ug/wscm)			1.2E+06	1.2E+06	6.6E+06	3.6	2.7		
Total Mass Flow, kg/hr	4.19E+02	2.00E+02	3.53E+02	3.53E+02	2.80E+02	5.28E+02	2.48E+02	1.40E+02	6.57E+01
Canister Rate, canisters/day		3.43							
Total Canisters Generated		499							

Table C-10. Alkaline scrub balance, Tank WM-188 waste. (Continued).

Stream #	101	102	103	104	105	106	107	108	201
Radiological Composition	Ci/L	Ci/L	Ci/wscm	Ci/wscm	Ci/wscm	Ci/wscm	Ci/wscm	Ci/L	
Ra-226	8.33E-12	2.36E-11	6.27E-16	6.27E-18	4.83E-21	9.91E-26	2.58E-25	2.40E-17	
Ac-227	3.92E-11	1.11E-10	2.95E-15	2.95E-17	2.27E-20	4.67E-25	1.22E-24	1.13E-16	
Th-228	3.25E-09	9.24E-09	2.45E-13	2.45E-15	1.89E-18	3.87E-23	1.01E-22	9.38E-15	
Th-230	1.04E-09	2.96E-09	7.84E-14	7.84E-16	6.04E-19	1.24E-23	3.23E-23	3.00E-15	
Th-232	7.20E-16	2.04E-15	5.42E-20	5.42E-22	4.18E-25	8.57E-30	2.23E-29	2.08E-21	
Pa-231	9.08E-11	2.58E-10	6.84E-15	6.84E-17	5.27E-20	1.08E-24	2.82E-24	2.62E-16	
Pa-233	2.98E-06	8.46E-06	2.24E-10	2.24E-12	1.73E-15	3.55E-20	9.24E-20	8.59E-12	
U-232	2.45E-09	6.96E-09	1.85E-13	1.85E-15	1.42E-18	2.92E-23	7.60E-23	7.07E-15	
U-233	8.87E-11	2.52E-10	6.68E-15	6.68E-17	5.15E-20	1.06E-24	2.75E-24	2.56E-16	
U-234	1.09E-06	3.10E-06	8.24E-11	8.24E-13	6.34E-16	1.30E-20	3.39E-20	3.15E-12	
U-235	8.04E-08	2.28E-07	6.05E-12	6.05E-14	4.66E-17	9.57E-22	2.49E-21	2.32E-13	
U-236	4.72E-08	1.34E-07	3.56E-12	3.56E-14	2.74E-17	5.62E-22	1.46E-21	1.36E-13	
U-237	6.54E-09	1.86E-08	4.93E-13	4.93E-15	3.79E-18	7.79E-23	2.03E-22	1.89E-14	
U-238	1.43E-08	4.06E-08	1.08E-12	1.08E-14	8.30E-18	1.70E-22	4.44E-22	4.13E-14	
Np-236	3.13E-12	8.90E-12	2.36E-16	2.36E-18	1.82E-21	3.73E-26	9.72E-26	9.04E-18	
Np-237	4.26E-07	1.21E-06	3.21E-11	3.21E-13	2.47E-16	5.08E-21	1.32E-20	1.23E-12	
Pu-236	3.58E-09	1.02E-08	2.70E-13	2.70E-15	2.08E-18	4.26E-23	1.11E-22	1.03E-14	
Pu-238	8.19E-04	2.33E-03	6.17E-08	6.17E-10	4.75E-13	9.75E-18	2.54E-17	2.36E-09	
Pu-239	9.16E-05	2.60E-04	6.90E-09	6.90E-11	5.31E-14	1.09E-18	2.84E-18	2.64E-10	
Pu-240	1.33E-05	3.79E-05	1.00E-09	1.00E-11	7.73E-15	1.59E-19	4.13E-19	3.84E-11	
Pu-241	5.96E-04	1.69E-03	4.49E-08	4.49E-10	3.46E-13	7.09E-18	1.85E-17	1.72E-09	
Pu-242	1.04E-08	2.97E-08	7.87E-13	7.87E-15	6.06E-18	1.24E-22	3.24E-22	3.01E-14	
Pu-244	7.97E-16	2.26E-15	6.00E-20	6.00E-22	4.62E-25	9.49E-30	2.47E-29	2.30E-21	
Am-241	5.74E-05	1.63E-04	4.33E-09	4.33E-11	3.33E-14	6.84E-19	1.78E-18	1.66E-10	
Am-242m	1.59E-08	4.50E-08	1.19E-12	1.19E-14	9.20E-18	1.89E-22	4.92E-22	4.57E-14	
Am-243	2.59E-08	7.35E-08	1.95E-12	1.95E-14	1.50E-17	3.08E-22	8.02E-22	7.46E-14	
Cm-242	3.44E-08	9.75E-08	2.59E-12	2.59E-14	1.99E-17	4.09E-22	1.06E-21	9.91E-14	
Cm-243	3.60E-08	1.02E-07	2.71E-12	2.71E-14	2.09E-17	4.29E-22	1.12E-21	1.04E-13	
Cm-244	1.26E-06	3.58E-06	9.49E-11	9.49E-13	7.31E-16	1.50E-20	3.90E-20	3.63E-12	
Cm-245	3.79E-10	1.08E-09	2.86E-14	2.86E-16	2.20E-19	4.51E-24	1.18E-23	1.09E-15	
Cm-246	2.49E-11	7.07E-11	1.88E-15	1.88E-17	1.44E-20	2.96E-25	7.72E-25	7.18E-17	
H-3	1.16E-05	6.36E-06	9.17E-06	9.17E-06	7.98E-06	5.22E-06	3.46E-07	8.74E-06	
Be-10	3.05E-12	8.66E-12	2.30E-16	2.30E-18	1.77E-21	3.63E-26	9.46E-26	8.80E-18	
C-14	1.57E-10	4.45E-10	1.18E-14	1.18E-16	9.10E-20	1.87E-24	4.86E-24	4.52E-16	
Co-60	8.84E-06	2.51E-05	6.66E-10	6.66E-12	5.13E-15	1.05E-19	2.74E-19	2.55E-11	
Ni-59	1.10E-06	3.13E-06	8.30E-11	8.30E-13	6.39E-16	1.31E-20	3.41E-20	3.18E-12	
Ni-63	4.16E-05	1.18E-04	3.13E-09	3.14E-11	2.41E-14	4.95E-19	1.29E-18	1.20E-10	
Se-79	5.70E-07	1.62E-06	4.29E-11	4.29E-13	3.30E-16	6.78E-21	1.77E-20	1.64E-12	
Rb-87	2.98E-11	8.46E-11	2.24E-15	2.24E-17	1.73E-20	3.55E-25	9.24E-25	8.59E-17	
Sr-90	3.91E-02	1.11E-01	2.95E-06	2.95E-08	2.27E-11	4.66E-16	1.21E-15	1.13E-07	
Y-90	3.91E-02	1.11E-01	2.95E-06	2.95E-08	2.27E-11	4.66E-16	1.21E-15	1.13E-07	
Zr-93	2.25E-06	6.39E-06	1.70E-10	1.70E-12	1.31E-15	2.68E-20	6.98E-20	6.50E-12	
Nb-93m	1.74E-06	4.93E-06	1.31E-10	1.31E-12	1.01E-15	2.07E-20	5.38E-20	5.00E-12	
Nb-94	1.48E-06	4.21E-06	1.12E-10	1.12E-12	8.60E-16	1.76E-20	4.60E-20	4.27E-12	
Tc-98	2.62E-12	7.44E-12	1.98E-16	1.98E-18	1.52E-21	3.12E-26	8.13E-26	7.56E-18	
Tc-99	2.06E-05	5.85E-05	1.55E-09	1.55E-11	1.20E-14	2.45E-19	6.39E-19	5.94E-11	
Ru-106	1.22E-06	3.45E-06	9.17E-11	9.17E-13	7.06E-16	1.45E-20	3.77E-20	3.51E-12	
Rh-102	8.76E-10	2.49E-09	6.60E-14	6.60E-16	5.08E-19	1.04E-23	2.72E-23	2.53E-15	
Rh-106	1.22E-06	3.45E-06	9.17E-11	9.17E-13	7.06E-16	1.45E-20	3.77E-20	3.51E-12	
Pd-107	1.68E-08	4.77E-08	1.27E-12	1.27E-14	9.74E-18	2.00E-22	5.21E-22	4.84E-14	
Cd-113m	3.38E-06	9.59E-06	2.54E-10	2.54E-12	1.96E-15	4.02E-20	1.05E-19	9.74E-12	
Sn-121m	6.80E-08	1.93E-07	5.12E-12	5.12E-14	3.94E-17	8.09E-22	2.11E-21	1.96E-13	
Sn-126	5.36E-07	1.52E-06	4.04E-11	4.04E-13	3.11E-16	6.38E-21	1.66E-20	1.55E-12	
Sb-125	3.68E-04	1.05E-03	2.78E-08	2.78E-10	2.14E-13	4.39E-18	1.14E-17	1.06E-09	
Sb-126	5.85E-08	1.66E-07	4.40E-12	4.40E-14	3.39E-17	6.96E-22	1.81E-21	1.69E-13	

Table C-10. Alkaline scrub balance, Tank WM-188 waste. (Continued).

Stream #	101	102	103	104	105	106	107	108	201
Radiological Composition	Ci/L	Ci/L	Ci/wscm	Ci/wscm	Ci/wscm	Ci/wscm	Ci/wscm	Ci/L	
Te-125m	3.20E-06	9.09E-06	2.41E-10	2.41E-12	1.86E-15	3.81E-20	9.93E-20	9.23E-12	
I-129	6.96E-08	1.97E-07	2.02E-08	2.02E-08	1.96E-11	7.56E-13	5.96E-14	7.68E-08	
Cs-134	3.67E-05	1.04E-04	2.77E-09	2.77E-11	2.13E-14	4.37E-19	1.14E-18	1.06E-10	
Cs-135	1.10E-06	3.11E-06	8.25E-11	8.25E-13	6.35E-16	1.30E-20	3.40E-20	3.16E-12	
Cs-137	2.26E-02	6.42E-02	1.70E-06	1.70E-08	1.31E-11	2.69E-16	7.01E-16	6.52E-08	
Ba-137m	2.14E-02	6.07E-02	1.61E-06	1.61E-08	1.24E-11	2.55E-16	6.63E-16	6.17E-08	
La-138	1.94E-16	5.51E-16	1.46E-20	1.46E-22	1.13E-25	2.31E-30	6.02E-30	5.60E-22	
Ce-142	3.04E-11	8.63E-11	2.29E-15	2.29E-17	1.76E-20	3.62E-25	9.42E-25	8.76E-17	
Ce-144	8.21E-07	2.33E-06	6.19E-11	6.19E-13	4.76E-16	9.78E-21	2.55E-20	2.37E-12	
Pr-144	8.21E-07	2.33E-06	6.19E-11	6.19E-13	4.76E-16	9.78E-21	2.55E-20	2.37E-12	
Nd-144	1.63E-15	4.64E-15	1.23E-19	1.23E-21	9.48E-25	1.95E-29	5.07E-29	4.71E-21	
Pm-146	5.17E-08	1.47E-07	3.90E-12	3.90E-14	3.00E-17	6.16E-22	1.60E-21	1.49E-13	
Pm-147	2.22E-04	6.30E-04	1.67E-08	1.67E-10	1.29E-13	2.64E-18	6.88E-18	6.40E-10	
Sm-146	2.80E-13	7.96E-13	2.11E-17	2.11E-19	1.63E-22	3.34E-27	8.69E-27	8.09E-19	
Sm-147	7.49E-12	2.13E-11	5.64E-16	5.64E-18	4.34E-21	8.91E-26	2.32E-25	2.16E-17	
Sm-151	4.39E-04	1.25E-03	3.30E-08	3.30E-10	2.54E-13	5.22E-18	1.36E-17	1.26E-09	
Eu-152	2.90E-06	8.23E-06	2.18E-10	2.18E-12	1.68E-15	3.45E-20	8.98E-20	8.36E-12	
Eu-154	4.93E-05	1.40E-04	3.72E-09	3.72E-11	2.86E-14	5.87E-19	1.53E-18	1.42E-10	
Eu-155	4.28E-05	1.21E-04	3.22E-09	3.22E-11	2.48E-14	5.09E-19	1.33E-18	1.23E-10	
Ho-166m	4.68E-11	1.33E-10	3.53E-15	3.53E-17	2.71E-20	5.57E-25	1.45E-24	1.35E-16	

Table C-11. Alkaline scrub balance, Tank WM-189 waste.

WM-189 PFD Sheet #	PFD-2A	PFD-2A	PFD-2A	PFD-2A	PFD-2A	PFD-2A	PFD-2A	PFD-2A	PFD-2A
Stream #	101	102	103	104	105	106	107	108	201
Stream Name	SBW Feed	Evaporator Bottoms	Evaporator Overheads Vapor	Mist Eliminator Vapor	Alkaline Scrubber Vapor	POG + VOG Offgas Vapor	VOG Offgas Vapor	Scrubber Recycle to Feed	20 wt.% MgO Additive
Rate or Volume Flow (actual)	85.8	35.3	38,498	39,007	33,434	38,034	11,770	29.2	159.4
Volume Flow (standard, wet)*			14,821	14,821	12,911	20,325	7,401		
Volume Flow (standard, dry)*			607.8	607.7	0.68	7,124	7,136		
Rate Units	gal/hr	gal/hr	ft3/hr	ft3/hr	ft3/hr	ft3/hr	ft3/hr	gal/hr	lb/hr
Temperature, °C	25.0	120	120	114.3	89.4	175	108	89.5	25.0
Temperature, °F	77.0	247	247	238	193	347	226	193	77.0
Pressure, psia	12.3	7.6	7.6	7.4	7.0	12.0	12.0	30.0	12.3
Specific Gravity	1.27	1.75	0.0003	0.0003	0.00029	0.00049	0.00074	1.31	1.20
Chemical Composition	Mol/Liter	Mol/Liter	lb/wscf	lb/wscf	lb/wscf	lb/wscf	lb/wscf	Mol/Liter	Wt. %
H+	2.43E+00	5.28E-01	1.08E-04	1.08E-04	1.66E-09	1.32E-09	7.15E-10	1.06E-04	2.64E-12
OH-			1.26E-14		1.60E-11	1.76E-13		1.14E-04	1.69E+01
Al+3	6.08E-01	1.48E+00	7.92E-08	2.77E-11	2.12E-14			6.24E-08	
Sb+5	1.81E-05	4.40E-05	1.06E-11	1.06E-13	8.17E-17			5.34E-11	
As+3	9.02E-05	2.20E-04	3.27E-11	3.27E-13	2.50E-16			2.65E-10	
Ba+2	6.85E-05	1.67E-04	4.55E-11	1.30E-13	9.92E-17			5.75E-11	
Be+2	2.23E-05	5.42E-05	9.70E-13	2.56E-15	1.96E-18			1.73E-11	
B+3	1.83E-02	4.45E-02	9.55E-10	3.31E-13	2.53E-16			1.86E-09	
Cd+2	3.27E-03	7.95E-03	1.77E-09	3.74E-13	2.86E-16			2.03E-10	
Ca+2	6.13E-02	1.49E-01	1.19E-08	2.64E-12	2.02E-15			4.01E-09	
Cr+3	5.13E-03	1.25E-02	1.29E-09	1.11E-12	8.51E-16			1.30E-09	
Co+2	4.28E-05	1.04E-04	1.22E-11	1.16E-14	8.91E-18			1.20E-11	
Cs+	6.12E-05	1.49E-04	3.60E-11	2.59E-13	1.98E-16			1.19E-10	
Cu+2	8.80E-04	2.14E-03	2.70E-10	3.34E-13	2.56E-16			3.20E-10	
Fe+3	2.97E-02	7.22E-02	8.01E-09	2.04E-11	1.56E-14			2.22E-08	
Pb+2	9.97E-04	2.43E-03	9.98E-10	3.80E-13	2.91E-16			1.12E-10	
Hg+2	5.44E-03	1.32E-02	1.20E-06	1.20E-06	9.34E-09	3.95E-11	9.23E-11	3.65E-04	
Mn+4	1.65E-02	4.00E-02	4.37E-09	4.37E-11	3.34E-14			4.84E-08	
Ni+2	2.09E-03	5.08E-03	5.92E-10	4.76E-13	3.64E-16			4.93E-10	
K+	2.02E-01	4.91E-01	3.81E-08	2.53E-11	1.94E-14			3.94E-08	
Se+4	2.59E-04	6.29E-04	9.87E-11	9.87E-13	7.55E-16			7.61E-10	
Ag+	4.05E-04	9.85E-04	2.11E-10	2.10E-12	1.61E-15			1.19E-09	
Na+	1.71E+00	4.16E+00	1.48E-07	2.13E-10	1.63E-13			5.64E-07	
Tl+3	4.76E-06	1.16E-05	4.70E-12	4.70E-14	3.60E-17			1.40E-11	
U+4	5.63E-04	1.37E-03	6.47E-10	6.47E-12	4.95E-15			1.66E-09	
V+3	3.17E-05	7.72E-05	7.81E-12	7.81E-14	6.04E-17			9.44E-11	
Zn+2	9.43E-04	2.29E-03	2.98E-10	2.11E-13	1.62E-16			1.97E-10	
Zr+4	3.89E-02	9.45E-02	1.71E-08	1.71E-10	1.31E-13			1.14E-07	
Cl-	2.05E-02	4.98E-02	9.90E-06	9.90E-06	1.07E-08	1.24E-10	4.32E-11	1.69E-02	
F-	3.32E-02	8.08E-02	9.10E-09	7.30E-09	1.07E-09	6.78E-10	1.03E-12	2.10E-05	
SO4-2	9.08E-02	2.21E-01	4.21E-08	4.21E-10	3.22E-13			2.67E-07	
NO3-	6.18E+00	1.48E+01	6.60E-03	6.60E-03	5.15E-06	7.86E-08	4.40E-08	6.48E+00	
PO4-3	1.07E-01	2.61E-01	4.93E-08	4.93E-10	3.77E-13			3.16E-07	
Am+4	6.53E-08	1.59E-07	7.60E-14	7.60E-16	5.81E-19			1.92E-13	
Br-	2.71E-07	6.59E-07	3.33E-10	3.33E-10	3.59E-13	4.16E-15	1.45E-15	2.53E-07	
Ce+4	3.96E-05	9.63E-05	2.68E-11	2.68E-13	2.05E-16			1.16E-10	
Eu+3	4.51E-07	1.10E-06	3.31E-13	5.32E-18	4.07E-21			2.13E-15	
Gd+3	1.35E-04	3.29E-04	1.03E-10	1.47E-13	1.12E-16			5.68E-11	
Ge+4	7.82E-09	1.90E-08	2.74E-15	2.74E-17	2.10E-20			2.30E-14	
In+3	1.25E-06	3.05E-06	6.96E-13						
I-	3.02E-06	7.33E-06	4.39E-09	4.39E-09	4.73E-12	5.49E-14	1.92E-14	2.10E-06	
La+3	8.17E-06	1.99E-05	5.48E-12						
Li+	5.44E-04	1.32E-03	1.59E-11	8.72E-14	6.67E-17			7.65E-10	
Mg+2	1.86E-02	2.73E+00	1.32E-07		9.92E-07	1.26E-13		3.25E+00	1.21E+01
Mo+6	8.36E-04	2.04E-03	3.88E-10	3.88E-12	2.97E-15			2.46E-09	

Table C-11. Alkaline scrub balance, Tank WM-189 waste. (Continued).

Stream #	101	102	103	104	105	106	107	108	201
Chemical Composition	Mol/Liter	Mol/Liter	lb/wscf	lb/wscf	lb/wscf	lb/wscf	lb/wscf	Mol/Liter	Wt. %
Nd+3	2.64E-05	6.41E-05	1.84E-11						
Np+4	2.74E-06	6.66E-06	3.13E-12	3.13E-14	2.40E-17			8.05E-12	
Nb+5	1.14E-03	2.78E-03	5.12E-10	5.12E-12	3.92E-15			3.36E-09	
Pd+4	1.69E-03	4.11E-03	8.69E-10	8.69E-12	6.65E-15			4.97E-09	
Pu+4	6.64E-06	1.61E-05	7.66E-12	7.66E-14	5.86E-17			1.95E-11	
Pr+4	7.43E-06	1.81E-05	5.06E-12	5.06E-14	3.87E-17			2.19E-11	
Rh+4	3.21E-06	7.80E-06	1.59E-12	1.59E-14	1.22E-17			9.43E-12	
Rb+	4.96E-06	1.21E-05	1.59E-12	1.97E-15	1.51E-18			1.41E-12	
Ru+3	8.85E-04	2.15E-03	4.32E-10	3.63E-12	2.78E-15			2.19E-09	
Sm+3	4.91E-06	1.20E-05	3.57E-12	1.99E-16	1.52E-19			8.06E-14	
Si+4	9.84E-02	2.39E-01	1.34E-08	1.34E-10	1.02E-13			2.90E-07	
Sr+2	1.19E-04	2.90E-04	5.04E-11	2.87E-14	2.20E-17			2.00E-11	
Tc+7	5.86E-06	1.43E-05	2.75E-12						
Te+4	5.74E-06	1.40E-05	3.54E-12	3.54E-14	2.71E-17			1.69E-11	
Tb+4	1.88E-09	4.58E-09	1.44E-15	1.44E-17	1.10E-20			5.53E-15	
Th+4	2.85E-05	6.93E-05	3.19E-11	3.19E-13	2.44E-16			8.38E-11	
Sn+4	1.92E-03	4.68E-03	1.10E-09	1.10E-11	8.43E-15			5.65E-09	
Ti+4	9.93E-04	2.42E-03	2.30E-10	2.30E-12	1.76E-15			2.92E-09	
Y+3	6.09E-06	1.48E-05	2.62E-12	4.71E-20	3.60E-23			3.23E-17	
O-2 (oxides)	2.06E-01	5.01E-01	1.59E-08	1.59E-10	1.22E-13			6.05E-07	
H2O	4.83E+01	2.76E+01	4.50E-02	4.50E-02	4.69E-02	3.04E-02	1.67E-03	4.62E+01	7.11E+01
O2			1.17E-07	1.17E-07	1.34E-07	6.12E-03	1.68E-02	1.64E-10	
N2			1.99E-07	1.99E-07	2.29E-07	2.02E-02	5.54E-02	1.90E-10	
C (organic)	4.79E-02	1.17E-01	3.24E-07	3.24E-07	6.37E-10	4.05E-10	8.20E-13	1.65E-03	
H (organic)	4.79E-02	1.17E-01	2.72E-08	2.72E-08	5.35E-11	3.40E-11	6.88E-14	1.65E-03	
Gas Stream Bulk Composition (wet basis)	mol.% or ppmv	mol.% or ppmv	mol.% or ppmv	mol.% or ppmv	mol.% or ppmv	mol.% or ppmv	mol.% or ppmv	mol.% or ppmv	mol.% or ppmv
H2O, mol.%			95.90	95.90	99.99	64.95	3.58		
O2, mol.%			0.0001	0.0001	0.0002	7.36	20.25		
N2, mol.%			0.0003	0.0003	0.0003	27.69	76.17		
CO2, mol.%									
HNO3, mol. %			4.10	4.10	0.00006	0.0001	0.00003		
CO, ppmv									
HCl, ppmv			107	107	0.12	0.001	0.0005		
C (organic), ppmv			10	10	0.020	0.013	0.00003		
H (organic), ppmv			10	10	0.020	0.013	0.00003		
PM (mg/wscm)			4	0.04	0.00003				
Hg (ug/wscm)			1.9E+04	1.9E+04	150	0.6	1.5		
Gas Stream Bulk Composition (dry basis)	mol.% or ppmv	mol.% or ppmv	mol.% or ppmv	mol.% or ppmv	mol.% or ppmv	mol.% or ppmv	mol.% or ppmv	mol.% or ppmv	mol.% or ppmv
O2, mol.%			0.003	0.003	3.07	21.00	21.00		
N2, mol.%			0.007	0.007	5.98	79.00	79.00		
CO2, mol.%									
HNO3, mol. %			99.93	99.97	1.21	0.0001	0.00003		
CO, ppmv									
HCl, ppmv			2.6E+03	2.6E+03	2.2E+03	0.004	0.0005		
C (organic), ppmv			2.5E+02	2.5E+02	3.9E+02	0.04	0.00003		
H (organic), ppmv			253	253	388	0.04	0.00003		
PM (mg/dscm)			101	1.0	0.6				
Hg (ug/wscm)			1.2E+06	1.2E+06	7.4E+06	3.4	2.4		
Total Mass Flow, kg/hr	4.42E+02	2.34E+02	3.48E+02	3.48E+02	2.75E+02	5.23E+02	2.48E+02	1.45E+02	7.23E+01
Canister Rate, canisters/day		4.00							
Total Canisters Generated		557							

Table C-11. Alkaline scrub balance, Tank WM-189 waste. (Continued).

Stream #	101	102	103	104	105	106	107	108	201
Radiological Composition	Ci/L	Ci/L	Ci/wscm	Ci/wscm	Ci/wscm	Ci/wscm	Ci/wscm	Ci/L	
Ra-226	7.17E-12	1.74E-11	5.55E-16	5.55E-18	4.81E-21	8.70E-26	2.22E-25	2.39E-17	
Ac-227	3.38E-11	8.21E-11	2.61E-15	2.61E-17	2.26E-20	4.10E-25	1.05E-24	1.13E-16	
Th-228	2.80E-09	6.82E-09	2.17E-13	2.17E-15	1.88E-18	3.40E-23	8.68E-23	9.34E-15	
Th-230	9.49E-10	2.31E-09	7.34E-14	7.34E-16	6.06E-19	1.15E-23	2.94E-23	3.01E-15	
Th-232	6.20E-16	1.51E-15	4.80E-20	4.80E-22	4.16E-25	7.53E-30	1.92E-29	2.07E-21	
Pa-231	7.82E-11	1.90E-10	6.05E-15	6.05E-17	5.24E-20	9.49E-25	2.42E-24	2.61E-16	
Pa-233	2.57E-06	6.24E-06	1.99E-10	1.99E-12	1.72E-15	3.11E-20	7.95E-20	8.55E-12	
U-232	2.22E-09	5.40E-09	1.72E-13	1.72E-15	1.43E-18	2.69E-23	6.88E-23	7.08E-15	
U-233	7.83E-11	1.90E-10	6.06E-15	6.06E-17	5.14E-20	9.49E-25	2.43E-24	2.55E-16	
U-234	1.54E-06	3.74E-06	1.19E-10	1.19E-12	6.84E-16	1.82E-20	4.76E-20	3.40E-12	
U-235	6.19E-08	1.51E-07	4.79E-12	4.79E-14	4.58E-17	7.57E-22	1.92E-21	2.27E-13	
U-236	7.18E-08	1.75E-07	5.56E-12	5.56E-14	3.00E-17	8.49E-22	2.23E-21	1.49E-13	
U-237	5.63E-09	1.37E-08	4.36E-13	4.36E-15	3.78E-18	6.84E-23	1.75E-22	1.88E-14	
U-238	3.41E-08	8.29E-08	2.64E-12	2.64E-14	1.02E-17	3.98E-22	1.06E-21	5.07E-14	
Np-236	2.70E-12	6.57E-12	2.09E-16	2.09E-18	1.81E-21	3.28E-26	8.37E-26	8.99E-18	
Np-237	4.57E-07	1.11E-06	3.54E-11	3.54E-13	2.54E-16	5.48E-21	1.42E-20	1.26E-12	
Pu-236	3.62E-09	8.81E-09	2.80E-13	2.80E-15	2.11E-18	4.35E-23	1.12E-22	1.05E-14	
Pu-238	8.36E-04	2.03E-03	6.47E-08	6.47E-10	4.85E-13	1.00E-17	2.59E-17	2.41E-09	
Pu-239	9.13E-05	2.22E-04	7.06E-09	7.06E-11	5.40E-14	1.10E-18	2.83E-18	2.68E-10	
Pu-240	1.35E-05	3.28E-05	1.04E-09	1.04E-11	7.88E-15	1.62E-19	4.18E-19	3.91E-11	
Pu-241	7.31E-04	1.78E-03	5.66E-08	5.66E-10	3.63E-13	8.72E-18	2.27E-17	1.81E-09	
Pu-242	1.06E-08	2.57E-08	8.18E-13	8.18E-15	6.17E-18	1.27E-22	3.28E-22	3.07E-14	
Pu-244	3.15E-16	7.67E-16	2.44E-20	2.44E-22	4.27E-25	4.10E-30	9.77E-30	2.12E-21	
Am-241	7.13E-05	1.73E-04	5.52E-09	5.52E-11	3.51E-14	8.49E-19	2.21E-18	1.74E-10	
Am-242m	1.34E-08	3.25E-08	1.03E-12	1.03E-14	9.13E-18	1.63E-22	4.15E-22	4.54E-14	
Am-243	2.28E-08	5.55E-08	1.76E-12	1.76E-14	1.50E-17	2.76E-22	7.07E-22	7.45E-14	
Cm-242	2.67E-08	6.50E-08	2.07E-12	2.07E-14	1.96E-17	3.26E-22	8.28E-22	9.73E-14	
Cm-243	3.29E-08	8.00E-08	2.54E-12	2.54E-14	2.10E-17	3.98E-22	1.02E-21	1.04E-13	
Cm-244	1.39E-06	3.39E-06	1.08E-10	1.08E-12	7.55E-16	1.67E-20	4.31E-20	3.75E-12	
Cm-245	3.46E-10	8.42E-10	2.68E-14	2.68E-16	2.21E-19	4.19E-24	1.07E-23	1.10E-15	
Cm-246	2.27E-11	5.53E-11	1.76E-15	1.76E-17	1.45E-20	2.75E-25	7.04E-25	7.20E-17	
H-3	8.94E-06	5.17E-06	7.49E-06	7.49E-06	7.48E-06	4.85E-06	2.79E-07	8.10E-06	
Be-10	2.63E-12	6.39E-12	2.03E-16	2.03E-18	1.76E-21	3.19E-26	8.14E-26	8.75E-18	
C-14	1.44E-10	3.50E-10	1.11E-14	1.11E-16	9.14E-20	1.74E-24	4.46E-24	4.54E-16	
Co-60	2.92E-05	7.10E-05	2.26E-09	2.26E-11	7.02E-15	3.38E-19	9.04E-19	3.49E-11	
Ni-59	1.23E-06	2.98E-06	9.48E-11	9.48E-13	6.61E-16	1.47E-20	3.80E-20	3.28E-12	
Ni-63	3.82E-05	9.29E-05	2.95E-09	2.95E-11	2.42E-14	4.62E-19	1.18E-18	1.20E-10	
Se-79	5.22E-07	1.27E-06	4.04E-11	4.04E-13	3.32E-16	6.31E-21	1.62E-20	1.65E-12	
Rb-87	2.56E-11	6.24E-11	1.98E-15	1.98E-17	1.72E-20	3.11E-25	7.95E-25	8.55E-17	
Sr-90	3.46E-02	8.42E-02	2.68E-06	2.68E-08	2.27E-11	4.20E-16	1.07E-15	1.13E-07	
Y-90	3.46E-02	8.42E-02	2.68E-06	2.68E-08	2.27E-11	4.20E-16	1.07E-15	1.13E-07	
Zr-93	1.94E-06	4.72E-06	1.50E-10	1.50E-12	1.30E-15	2.35E-20	6.01E-20	6.46E-12	
Nb-93m	1.49E-06	3.64E-06	1.16E-10	1.16E-12	1.00E-15	1.81E-20	4.63E-20	4.98E-12	
Nb-94	1.36E-06	3.30E-06	1.05E-10	1.05E-12	8.63E-16	1.64E-20	4.21E-20	4.29E-12	
Tc-98	2.26E-12	5.49E-12	1.75E-16	1.75E-18	1.51E-21	2.74E-26	7.00E-26	7.52E-18	
Tc-99	1.38E-05	3.35E-05	1.07E-09	1.07E-11	1.15E-14	1.70E-19	4.27E-19	5.74E-11	
Ru-106	1.12E-06	2.72E-06	8.64E-11	8.64E-13	7.09E-16	1.35E-20	3.46E-20	3.52E-12	
Rh-102	7.54E-10	1.84E-09	5.84E-14	5.84E-16	5.06E-19	9.16E-24	2.34E-23	2.51E-15	
Rh-106	1.12E-06	2.72E-06	8.64E-11	8.64E-13	7.09E-16	1.35E-20	3.46E-20	3.52E-12	
Pd-107	1.45E-08	3.52E-08	1.12E-12	1.12E-14	9.70E-18	1.76E-22	4.48E-22	4.82E-14	
Cd-113m	2.91E-06	7.07E-06	2.25E-10	2.25E-12	1.95E-15	3.53E-20	9.01E-20	9.69E-12	
Sn-121m	5.85E-08	1.42E-07	4.53E-12	4.53E-14	3.92E-17	7.10E-22	1.81E-21	1.95E-13	
Sn-126	4.92E-07	1.20E-06	3.80E-11	3.80E-13	3.12E-16	5.94E-21	1.52E-20	1.55E-12	
Sb-125	4.10E-04	9.97E-04	3.17E-08	3.17E-10	2.21E-13	4.91E-18	1.27E-17	1.10E-09	
Sb-126	5.03E-08	1.22E-07	3.90E-12	3.90E-14	3.38E-17	6.11E-22	1.56E-21	1.68E-13	

Table C-11. Alkaline scrub balance, Tank WM-189 waste. (Continued).

Stream #	101	102	103	104	105	106	107	108	201
Radiological Composition	Ci/L	Ci/L	Ci/wscm	Ci/wscm	Ci/wscm	Ci/wscm	Ci/wscm	Ci/L	
Te-125m	2.76E-06	6.71E-06	2.13E-10	2.13E-12	1.85E-15	3.35E-20	8.54E-20	9.19E-12	
I-129	6.38E-08	1.71E-07	1.54E-08	1.54E-08	2.13E-11	2.40E-13	6.72E-14	7.49E-08	
Cs-134	6.33E-05	1.54E-04	4.90E-09	4.90E-11	2.40E-14	7.45E-19	1.96E-18	1.19E-10	
Cs-135	9.99E-07	2.43E-06	7.73E-11	7.73E-13	6.37E-16	1.21E-20	3.10E-20	3.17E-12	
Cs-137	5.17E-02	1.26E-01	4.00E-06	4.00E-08	1.59E-11	6.04E-16	1.60E-15	7.91E-08	
Ba-137m	4.89E-02	1.19E-01	3.79E-06	3.79E-08	1.51E-11	5.71E-16	1.52E-15	7.48E-08	
La-138	1.67E-16	4.07E-16	1.29E-20	1.29E-22	1.12E-25	2.03E-30	5.18E-30	5.57E-22	
Ce-142	2.62E-11	6.37E-11	2.02E-15	2.02E-17	1.75E-20	3.18E-25	8.11E-25	8.72E-17	
Ce-144	7.54E-07	1.83E-06	5.83E-11	5.83E-13	4.78E-16	9.11E-21	2.34E-20	2.38E-12	
Pr-144	7.54E-07	1.83E-06	5.83E-11	5.83E-13	4.78E-16	9.11E-21	2.34E-20	2.38E-12	
Nd-144	1.41E-15	3.42E-15	1.09E-19	1.09E-21	9.44E-25	1.71E-29	4.36E-29	4.69E-21	
Pm-146	4.45E-08	1.08E-07	3.45E-12	3.45E-14	2.99E-17	5.41E-22	1.38E-21	1.48E-13	
Pm-147	2.03E-04	4.95E-04	1.57E-08	1.57E-10	1.29E-13	2.46E-18	6.30E-18	6.42E-10	
Sm-146	2.41E-13	5.87E-13	1.87E-17	1.87E-19	1.62E-22	2.93E-27	7.48E-27	8.05E-19	
Sm-147	6.45E-12	1.57E-11	4.99E-16	4.99E-18	4.32E-21	7.83E-26	2.00E-25	2.15E-17	
Sm-151	4.02E-04	9.78E-04	3.11E-08	3.11E-10	2.55E-13	4.86E-18	1.25E-17	1.27E-09	
Eu-152	2.58E-06	6.28E-06	2.00E-10	2.00E-12	1.68E-15	3.13E-20	8.00E-20	8.35E-12	
Eu-154	1.54E-04	3.75E-04	1.19E-08	1.19E-10	3.84E-14	1.79E-18	4.77E-18	1.91E-10	
Eu-155	1.45E-04	3.53E-04	1.12E-08	1.12E-10	3.43E-14	1.68E-18	4.49E-18	1.70E-10	
Ho-166m	4.03E-11	9.80E-11	3.12E-15	3.12E-17	2.70E-20	4.89E-25	1.25E-24	1.34E-16	

Table C-12 shows the expected properties of the evaporator bottoms product.

Table C-12. Revised baseline scheme evaporator product waste properties.

Major Radionuclides	WM-180 Ci/canister	WM-187 Ci/canister	WM-188 Ci/canister	WM-189 Ci/canister
Am-241	2.22E-01	2.15E-01	1.87E-01	2.06E-01
Pu-238	3.06E+00	3.62E+00	2.65E+00	2.39E+00
Pu-239	4.64E-01	3.98E-01	2.96E-01	2.62E-01
Pu-240	2.52E-02	4.43E-02	4.33E-02	3.89E-02
Pu-242	1.94E-05	3.48E-05	3.39E-05	3.04E-05
U-233	1.30E-07	2.41E-07	2.89E-07	2.26E-07
U-234	3.35E-03	3.95E-03	3.56E-03	4.44E-03
U-238	7.23E-05	6.77E-05	4.66E-05	9.86E-05
Sr-90	6.29E+01	9.69E+01	1.28E+02	1.00E+02
Cs-137	8.35E+01	1.42E+02	7.30E+01	1.49E+02
Y-90	6.29E+01	9.69E+01	1.28E+02	1.00E+02
Ba-137	7.90E+01	1.34E+02	6.90E+01	1.41E+02
Total of above 12 nuclides	292	474	400	493
Total of all nuclides	295	482	406	499
Fraction of the 12 to the total	0.989	0.983	0.985	0.987
	g/canister	**g/canister**	**g/canister**	**g/canister**
Am-241	6.45E-02	6.27E-02	5.44E-02	5.99E-02
Pu-238	1.78E-01	2.12E-01	1.55E-01	1.40E-01
Pu-239	7.46E+00	6.41E+00	4.77E+00	4.21E+00
Pu-240	1.10E-01	1.94E-01	1.90E-01	1.71E-01
Pu-242	5.08E-03	9.12E-03	8.88E-03	7.98E-03
U-233	1.35E-05	2.49E-05	2.98E-05	2.34E-05
U-234	5.36E-01	6.31E-01	5.69E-01	7.10E-01
U-238	2.15E+02	2.01E+02	1.39E+02	2.93E+02
Sr-90	4.61E-01	7.11E-01	9.35E-01	7.34E-01
Cs-137	9.60E-01	1.63E+00	8.39E-01	1.71E+00
Y-90	1.16E-04	1.78E-04	2.34E-04	1.84E-04
Ba-137	1.47E-07	2.49E-07	1.28E-07	2.62E-07
Fissile Gram Equivalents, g/canister	64	102	126	87
Pu Equivalent Curies	3.5	4.0	3.0	2.7
TRU content, nCi/g	2.7E+03	3.1E+03	2.3E+03	2.1E+03

Dose rates and heat generation rates have not been calculated for waste compositions shown in the present mass balances. However, the evaporator waste dose rate is expected to be very similar to that calculated for previous material balances. Based on a date of 2010, the evaporator product canisters are expected to have an average dose rate of 28 R/hr and generate 1.4 Watts of heat per canister (Bohn, 2002). The drums of grouted acid are estimated to have a dose rate of 0.015 mR/hr and a heat generation rate of 1.3 x 10^{-7} Watts per drum (Bohn, 2002).

Table C-13 shows additional properties of the grouted waste product. Radionuclides in the grouted waste sum to 2-5% of Hanford limit for Category 1 waste, or less than 1% of the Envirocare limits.

Table C-13. Grouted waste properties compared to Hanford and Envirocare WAC.

	Hanford Cat 1 WAC Ci/m3	**Envirocare WAC pCi/g**		
Sr-90	1.6E-02	2.5E+04		
Tc-99	2.3E-02	1.9E+05		
I-129	8.5E-03	3.1E+03		
Cs-137	5.5E-03	6.0E+04		
Pu-241	6.1E-02	3.5E+05		
Pu-238	4.7E-03	1.0E+04		
Pu-239	1.9E-03	1.0E+04		
Pu-240	1.9E-03	1.0E+04		
Am-241	2.1E-03	1.0E+04		
	Sum of fractions		**nCi/g**	**Total Ci/g**
WM-180	0.04	0.004	3.9E-03	6.4E-04
WM-187	0.05	0.006	3.2E-03	4.0E-04
WM-188	0.02	0.004	1.7E-03	4.4E-04
WM-189	0.04	0.005	1.5E-03	3.8E-04

C-7. UTILITIES SUMMARY

C-7.1 Revised Baseline Scheme

The direct evaporation process requires steam, fuel oil and cooling water. Fuel oil is required for the boiler that generates 150-psig steam for the evaporator. The LET&D reboiler uses 100-psig steam. Low-pressure steam is used in POG, VOG and LET&D off-gas superheaters. Steam is also used in the jets that transfer waste from the tank farm. Typically, the steam requirement for waste transfer is 5% of the waste volume.

Cooling water is used in as the cooling medium for the evaporator condenser, canister cooler, LET&D condenser, LET&D bottoms cooler and neutralization tank cooler. Expected utilities usages for the revised baseline scheme are shown in Table C-14.

Table C-14. Expected utilities for revised baseline scheme

		Duty, MM Btu/hr	Ave Usage	Total usage
Fuel oil		0.92	10 gph	115,000 gallons
Steam				
(evap)	150 psig*	0.69	573 lb/hr	6.9E+06 lb
(LET&D)	100 psig	6.7	5,660 lb/hr	9.0E+06 lb
(Stm jet)	100 psig	1.5	1,250 lb/hr	4.3E+05 lb
	35 psig	0.022	19 lb/hr	2.3E+05 lb
Cooling Water		1.3	60 gpm	4.2E+07 gallons

* 150 psig steam is generated in the treatment facility

C-7.2 Alkaline Scrub Scheme

Expected utilities for the alkaline scrub scheme are shown in Table C-15.

Table C-15. Expected utilities for alkaline scrub scheme.

		Duty, MM Btu/hr	Ave Usage	Total usage
Fuel oil		1.5	16 gph	188,000 gallons
Steam				
(evap)	150 psig*	0.9	710 lb/hr	8.5E+06 lb
(Stm jet)	100 psig	1.5	1,250 lb/hr	4.3E+05 lb
	35 psig	0.034	29 lb/hr	3.5E+05 lb
Cooling Water		0.19	9 gpm	6.2E+06 gallons

* 150 psig steam is generated in the treatment facility

C-8. EQUIPMENT LIST AND PLANT SCALE

The equipment list for the revised baseline scheme is shown in Table C-16, and for the alkaline scrub scheme in Table C-17. These tables present equipment sizes based on a 2.5-yr operating schedule. Following the tables is a discussion of how a shorter operating schedule would affect facility size.

Table C-16. Revised baseline scheme equipment list.

ID	Component Item	Number Required	Size or Capacity	Units	Diameter (ft.)	Height (ft.)	Notes	Materials of Construction
			Tanks					
VES-101	SBW Feed Tank	1	12,400	gal	12.0	13.5	a	SS
VES-102	SBW Mist Eliminator Zone A	1	13	ft^3	2.0	4.0	b	Alloy
VES-102	SBW Mist Eliminator Zone B	1	6	ft^3	2.0	2.0	b	Alloy
VES-103	Condensate Demister	1	16	ft^3	2.0	5.0	c	Alloy
VES-104	Condensate Tank	1	12,400	gal	12.0	13.5		SS
VES-105	VOG Demister	1	9	ft^3	2.0	3.0	c	SS
VES-106	Aluminum Nitrate Tank	1	30	gal				SS
VES-107	Flush Water Tank	1	70	gal				SS
VES-109	Grout Mixer Feed Tank	1	3,300	gal	8.0	9.0		SS
VES-110	Neutralization Tank	1	3,300	gal	8.0	9.0		SS
			Hoppers					
HOP-101	Portland Cement Hopper	1	1,860	ft^3	10.5	22		CS
HOP-102	BFS Hopper	1	620	ft^3	7.5	14		CS
HOP-103	Calcium Hydroxide Hopper	1	1,480	ft^3	10.5	17		CS
HOP-104	Cement Feeder Bin	1	300	gal				CS
HOP-105	BFS Feeder Bin	1	100	gal				CS
HOP-106	Ca(OH)2 Feeder Bin	1	230	gal				CS
HOP-107	Neut. Agent Hopper & Feeder	1	230	gal				CS
HOP-108	Silica Gel Hopper	1	30	gal				CS
			Evaporator					
WFE-101	Wiped Film Evaporator	2	1,100	lb/hr	1.3	10.67	d	Alloy
			Heat Exchangers					
HE-101	Condenser	1	60	ft2				Alloy
HE-102	POG Superheater	1	2	ft2				Alloy
HE-103	VOG Superheater	1	2	ft2				Alloy

Table C-16. Revised baseline scheme equipment list (continued).

ID	Component Item	Number Required	Fluid Rate	Units	Notes	Materials of Construction
			Pumps/Blowers			
P-101	SBW Feed Pump	2	3	gpm	Centrifugal pump	SS
P-102	Condensate Pump	2	1	gpm	Centrifugal pump	Alloy
P-103	Wash Recycle Pump	2	1	gpm	Centrifugal pump	Alloy
P-104	Condensate Transfer Pump	2	10	gpm	Centrifugal pump	Alloy
P-105	Aluminum Nitrate Pump	1	0.25	gpm	Centrifugal pump	SS
P-106	Neutralized Acid Pump	2	50	gpm	Centrifugal pump	SS
P-107	Flush Solution Pump	1	3	gpm	Centrifugal pump	SS
P-108	VOG Condensate Pump	1	1	gpm	Centrifugal pump	SS
P-109	Flush Waste Pump	1	5	gpm	Centrifugal pump	SS
P-201	Boiler Feed Water Pump	1	2	gpm	Centrifugal pump	SS
BL-101	POG Blower	1	12,000	acfh		SS
BL-102	VOG Blower	1	12,000	acfh		SS

ID	Component Item	Number Required	Fluid Rate	Units	Length (ft.)	Width/ Dia. (ft.)	Height (ft.)	Materials of Construction
			Filters					
F-101	POG HEPA Bank	1	12,000	acfh	11.25	2.0	2.5	SS
F-102	VOG HEPA Bank	1	12,000	acfh	11.25	2.0	2.5	SS
			Miscellaneous					
B-201	Boiler	1	800	lb/hr				
MIX-102	Continuous grout mixer	2	600	lb/hr	Note e			SS
	Stack	1	30,000	acfh				
	Pars	1						
	Master/Slave Manipulators	7						
	Sump Pumps	20	2	gpm				SS
	Bridge Cranes (Note f)	4						
	Agitator for jacketed tank	1						304 SS Shaft & Impeller
	Roller conveyor, straight, gravity	1	25’ long, 3" center for rollers, 30 " wide					CS
	Roller conveyor, straight, powered	17	20’ long, 4" centers for rollers, 30" width					CS
	Roller conveyor, straight, powered	2	30’ long, 4" centers for rollers, 30" width					
	Roller conveyor, straight, powered	1	25’ long, 4" centers for rollers, 30" width					
	Roller conveyor, straight, gravity	1	90 degree curve, 3" center for rollers, 30 " wide					

Notes
a. Include sparge
b. Include 12" mesh pad
c. Include 8" pad of York style 931
d. Provide an additional 11 ft of vertical clearance to remove shaft
e. One installed, the other a spare to be installed when needed
f. 5T with multiple remote operating stations

Table C-17. Alkaline scrub scheme equipment list.

ID	Component Item	Number Required	Size or Capacity	Units	Diameter (ft.)	Height (ft.)	Notes	Materials of Construction
			Tanks					
VES-101	SBW Feed Tank	1	12,400	gal	12.0	13.5	a	SS
VES-102	SBW Mist Eliminator Zone A	1	13	ft^3	2.25	4.0	b	Alloy
VES-102	SBW Mist Eliminator Zone B	1	6	ft^3	2.25	2.0	b	Alloy
VES-103	MgO Makeup Tank	1	32	ft^3	3.0	4.5	c	CS
VES-104	Alkaline Scrubber	1	42,000	SCFH	1.5	11.0		Alloy
VES-105	VOG Demister	1	9	ft^3	2.0	3.0	c	SS
VES-106	GAC Bed	1	38	ft^3	3.5	4.0		SS
			Evaporator					
WFE-101	Wiped Film Evaporator	2	1,250	lb/hr	1.3	10.67	d	Alloy

ID	Component Item	Number Required	Heat Transfer Area	Units	Materials of Construction
			Heat Exchangers		
HE-101	Scrub Solution Cooler	1	50	ft^2	Alloy
HE-102	POG Superheater	1	2	ft^2	Alloy
HE-103	VOG Superheater	1	2	ft^2	Alloy

ID	Component Item	Number Required	Fluid Rate	Units	Notes	Materials of Construction
			Pumps/Blowers			
P-101	SBW Feed Pump	2	4	gpm	Centrifugal pump	SS
P-102	Scrub Pump	2	6	gpm	Centrifugal pump	Alloy
P-103	Wash Recycle Pump	2	1	gpm	Centrifugal pump	Alloy
P-104	MgO Slurry Pump	2	0.5	gpm	Centrifugal pump	CS
P-108	VOG Condensate Pump	1	1	gpm	Centrifugal pump	SS
P-201	Boiler Feed Water Pump	1	2	gpm	Centrifugal pump	SS
BL-101	POG Blower	1	34,000	acfh		SS
BL-102	VOG Blower	1	12,000	acfh		SS

ID	Component Item	Number Required	Fluid Rate	Units	Length (ft.)	Width or Dia. (ft.)	Height (ft.)	Materials of Construction
			Filters					
F-101	POG HEPA Bank	1	34,000	acfh	11.25	2.0	2.5	SS
F-102	VOG HEPA Bank	1	12,000	acfh	11.25	2.0	2.5	SS
			Miscellaneous					
B-201	Boiler	1	1,000	lb/hr				

Notes

a. Include sparge

b. Include 12" mesh pad

c. Include 8" pad of York style 931

d. Provide an additional 11 ft of vertical clearance to remove shaft

e. Stack, pars, manipulators, sump, cranes and conveyors same as Table C-14

The Direct Evaporation Treatment Facility includes waste loading and canister handling operations in the lower level; hot cell process equipment on the ground floor and cold (nonradioactive) activities plus process and vent gas HEPA filtration on the second floor. The control room, offices, a decontamination room, a manipulator repair room and other support activities are located on the ground floor. Changing the scale of the process, i.e., designing for a shorter treatment schedule, would primarily affect four areas of the facility – the process hot cells, the grouting operation floor space, waste packaging and canister handling in the basement and lag storage for waste canisters.

The major equipment in the process hot cell includes the evaporator and four tanks. Other equipment is small and effects of scale on floor space for this equipment is minimal. The evaporator as sized for 2.5 years operation has an outside diameter of 19¼ inches and a length of 10-ft 8-in, and heat transfer area of 21.6 ft^2. For a shorter schedule, the heat transfer area would need to be increased by the schedule reduction ratio. Thus for a schedule of 1-year, the heat transfer area would be 21.6 x 2.5 = 54 ft^2. This area could be achieved in an evaporator 1.5-ft ID by about 17 feet or 2-ft ID by 14-ft. The effect on floor space due would be small, but the hot cell and building height would need to increase to accommodate clearance for evaporator shaft and rotor removal. Alternatively, two evaporators could be used.

Keeping all other factors equal, decreasing the processing schedule would increase the floor space required for process tanks by the inverse ratio of the decrease to the two-thirds power. For example if the schedule was decreased from 2.5 years to 1 year, the floor space for tanks would increase by $(2.5/1)^{0.667}$ = 1.84 or an 84% increase.

For the 2.5-year operating schedule, 5,840 drums of grout are produced, equivalent to an average of 12 drums per day. At this production rate, a single grouting line is adequate and would be adequate for shorter treatment schedules as well. Additional space would likely be included in a facility designed for a shorter schedule for empty 55-gal drums fed to the grouting line, to maintain the same schedule for receiving drums.

The area required for storage of grouted waste drums depends only on the lag storage requirement. Lag storage space in turn depends of the rate at which the disposal site can receive shipments and the initial lag between start of production and sending the first shipment. The intended disposal site for the grouted waste from the direct evaporator process has been Hanford or Envirocare. It is expected that either site could receive this waste at a shipment rate equal to the rate generated for either a 2.5-yr or a shorter schedule. However, this assumption has not been confirmed.

The alkaline scrub variation of the direct evaporation process, as well as the variation that neutralizes LET&D bottoms, does not produce a grouted waste product. Besides eliminating the grouting equipment and floor space, these schemes eliminate two of the four major tanks of the process.

The rate at which RH canisters of evaporator product are produced is directly proportional to the inverse of the processing schedule. For the 2.5-year schedule, on average, one canister is filled in about 10 hours. A single fill station could accommodate shorter processing schedules, but more floor space would be required in the cooling area. The cooling time has yet to be adequately determined, but is expected to be several days. Assuming three days for cooling, space for eight canisters would be needed for a 2.5-year schedule or twenty for a 1-year schedule.

Finally, the interim storage for RH waste is dependent upon the initial lag period between producing the first container of waste and having approval to ship that container to WIPP and the rate at which WIPP can accept waste. Based on discussions with WIPP personnel, it is expected that the disposal facility can receive at least 6 RH canisters per week from the INEEL, or about 300 per year.

Assuming an initial continuous 40-day operating period prior to waste shipment, storage for 80 canisters would be needed. However, since 1260 total RH canisters of waste are produced and WIPP can receive only about 300 per year, storage for 590 canisters would be required for a 2.5-year schedule, or 1,040 for a 1-year schedule. This equates into a 76% increase in storage space. A summary of plot space estimates is given in Table C-18 for the revised baseline scheme:

Table C-18. Plot Space Estimates.

	2.5-year treatment schedule	**1-year treatment schedule**
Process equipment (hot cell space, ground floor)	5,200 ft^2	6,200 ft^2
Grouting equipment and drum storage	18,000 ft^2	20,000 ft^2
Waste packaging & canister handling (to be verified in conceptual design)	1,200 ft^2	1,300 ft^2
Lag storage for RH canisters (to be verified in conceptual design)	3,300 ft^2	5,800 ft^2

C-9. LAYOUT DRAWINGS

Layout drawings for each floor of the Direct Evaporation Treatment Facility are shown on the following pages. The primary purpose of these drawings is to estimate floor space requirements needed in the facility. Equipment and room arrangements have not been optimized, nor has sufficient engineering design been performed to provide a basis for all of the areas of the facility. The layout drawings are similar to those prepared for the Direct Evaporation Feasibility Study (Kimmitt, 2003).

Storage is provided in the basement for 590 full waste canisters. This quantity is required for (a) lag storage prior to the initial shipment assumed to be equivalent to 40 production days plus (b) storage for the difference between the production rate and the shipping rate over the 2.5-year operating phase of the treatment process.

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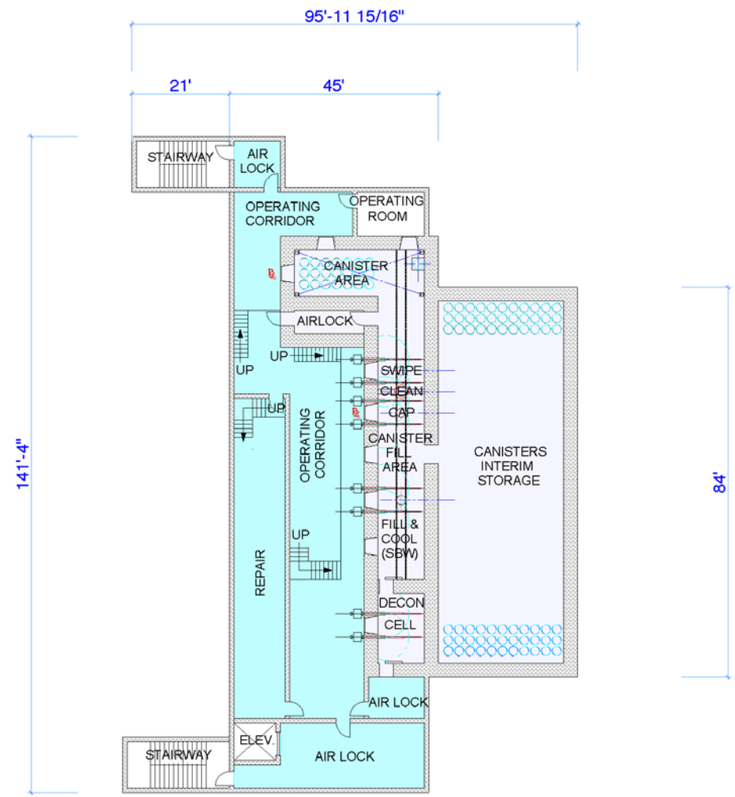


3449.86 sq ft

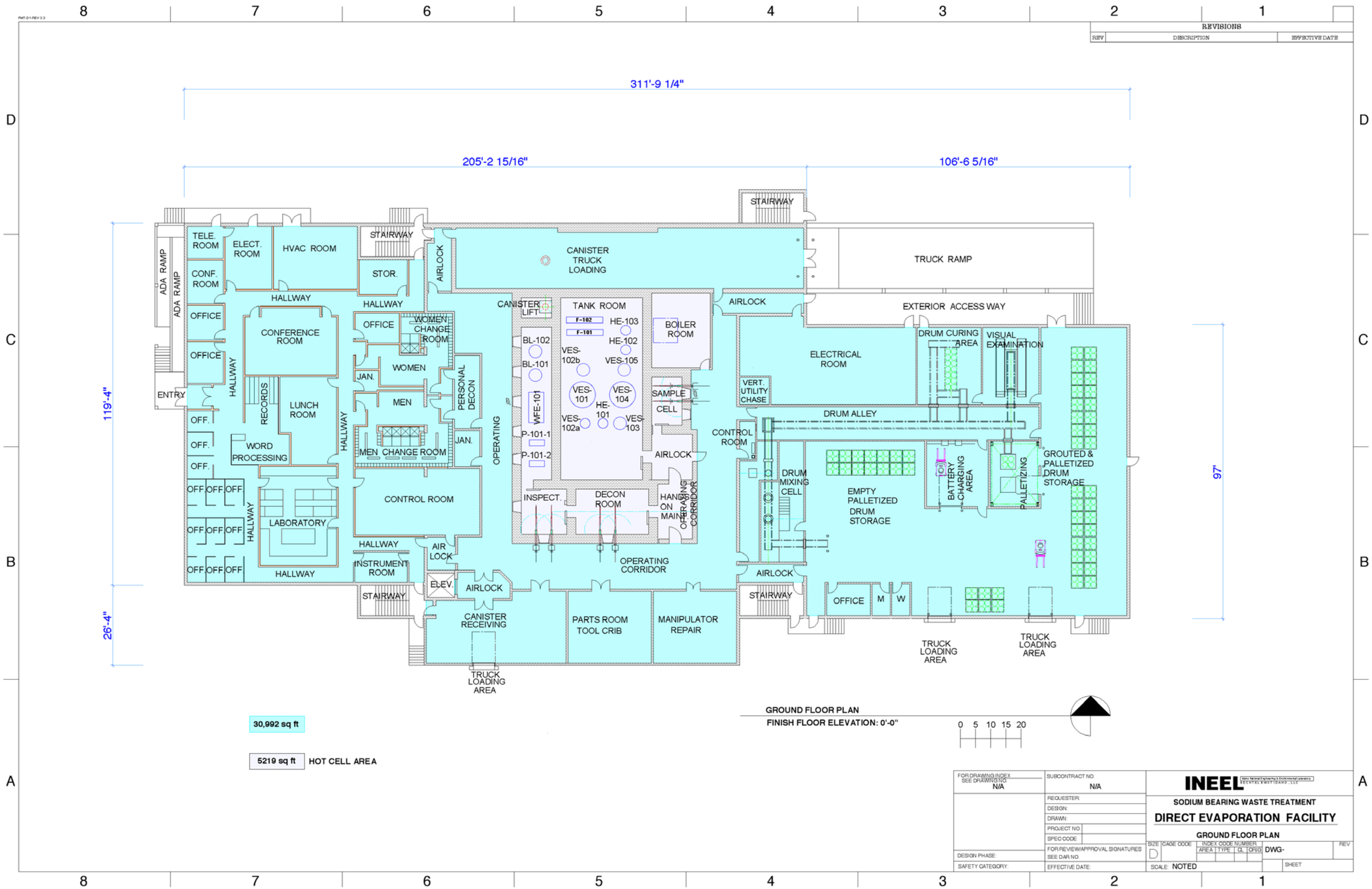
3450 sq ft

4472 sq ft HOT CELL AREA

BASEMENT FLOOR PLAN
FINISH FLOOR ELEVATION: -30'-0" & -37'-0"

0 5 10 15 20

FOR DRAWING INDEX SEE DRAWING NO. N/A	SUBCONTRACT NO. N/A	INEEL (Idaho National Engineering & Environmental Laboratory) BECHTEL BWXT IDAHO, LLC
	REQUESTER:	SODIUM BEARING WASTE TREATMENT
	DESIGN:	DIRECT EVAPORATION FACILITY
	DRAWN:	BASEMENT FLOOR PLAN
	PROJECT NO.	
	SPEC CODE	
DESIGN PHASE:	FOR REVIEW/APPROVAL SIGNATURES SEE DAR NO.	SIZE D / CAGE CODE / INDEX CODE NUMBER: AREA, TYPE, CL, ORIG / DWG- / REV
SAFETY CATEGORY:	EFFECTIVE DATE:	SCALE: NOTED / SHEET


311'-9 1/4"
205'-2 15/16"
106'-6 5/16"
119'-4"
26'-4"
97'
TELE. ROOM
ELECT. ROOM
HVAC ROOM
STAIRWAY
STOR.
AIRLOCK
CANISTER TRUCK LOADING
TRUCK RAMP
ADA RAMP
CONF. ROOM
HALLWAY
OFFICE
CONFERENCE ROOM
WOMEN CHANGE ROOM
WOMEN
JAN.
MEN
MEN CHANGE ROOM
PERSONAL DECON
CANISTER LIFT
TANK ROOM
F-102
F-101
HE-103
HE-102
VES-105
VES-102b
VES-101
VES-104
HE-101
VES-102a
VES-103
BL-102
BL-101
WFE-101
P-101-1
P-101-2
BOILER ROOM
SAMPLE CELL
AIRLOCK
EXTERIOR ACCESS WAY
DRUM CURING AREA
VISUAL EXAMINATION
ELECTRICAL ROOM
VERT. UTILITY CHASE
DRUM ALLEY
CONTROL ROOM
DRUM MIXING CELL
EMPTY PALLETIZED DRUM STORAGE
BATTERY CHARGING AREA
PALLETIZING
GROUTED & PALLETIZED DRUM STORAGE
ENTRY
OFF.
WORD PROCESSING
RECORDS
LUNCH ROOM
LABORATORY
CONTROL ROOM
INSTRUMENT ROOM
AIR LOCK
ELEV.
OPERATING CORRIDOR
INSPECT.
DECON ROOM
HANDS ON MAIN
CANISTER RECEIVING
PARTS ROOM TOOL CRIB
MANIPULATOR REPAIR
TRUCK LOADING AREA
OFFICE
M
W
GROUND FLOOR PLAN
FINISH FLOOR ELEVATION: 0'-0"
0 5 10 15 20
30,992 sq ft
5219 sq ft
HOT CELL AREA
REVISIONS
REV
DESCRIPTION
EFFECTIVE DATE
FOR DRAWING INDEX SEE DRAWING NO. N/A
SUBCONTRACT NO. N/A
REQUESTER:
DESIGN:
DRAWN:
PROJECT NO.
SPEC CODE
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INEEL
SODIUM BEARING WASTE TREATMENT
DIRECT EVAPORATION FACILITY
GROUND FLOOR PLAN
SIZE D
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SCALE: NOTED
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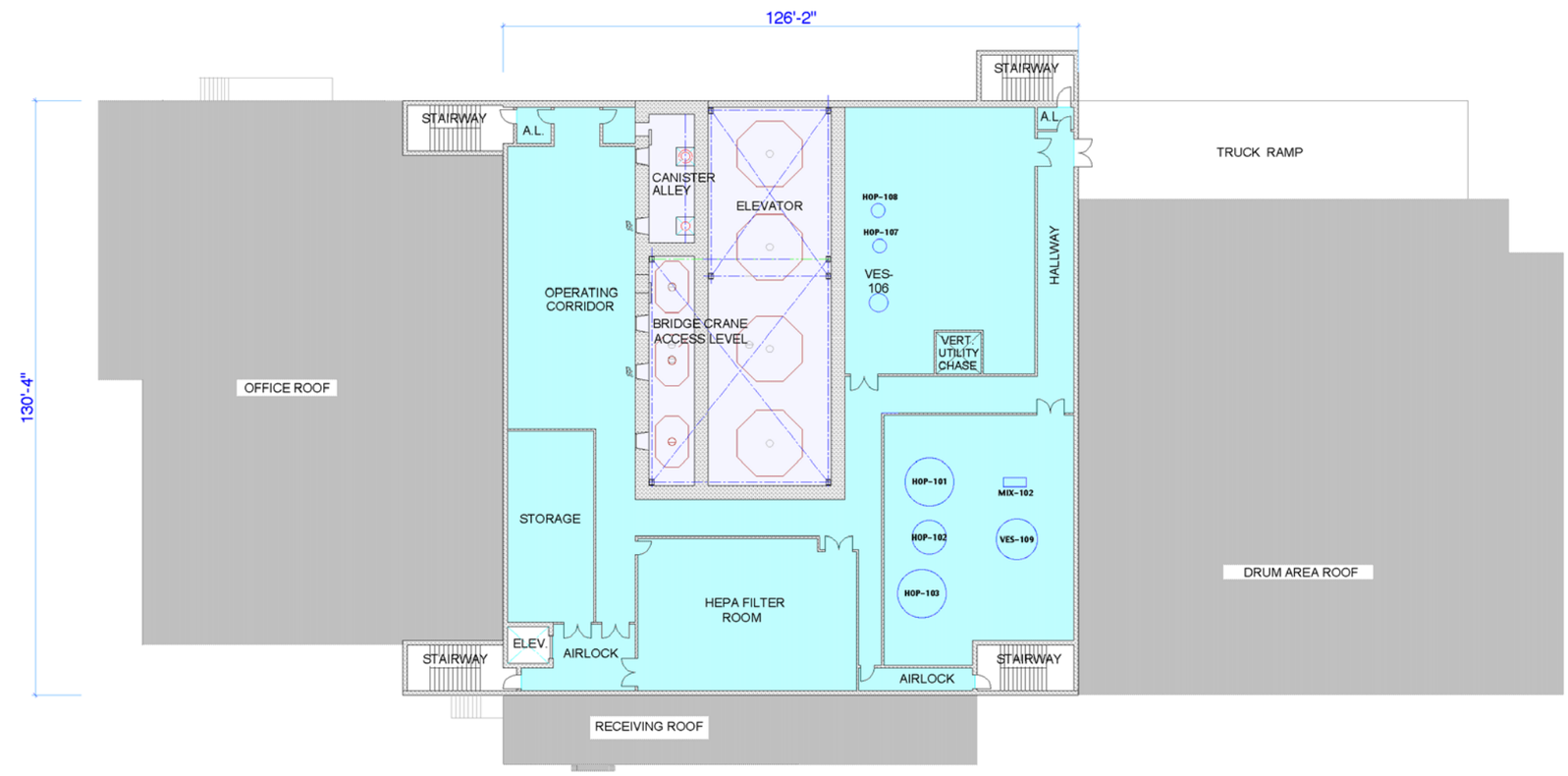

SECOND FLOOR PLAN
FINISH FLOOR ELEVATION: 23'-0" & 26'-0"

0 5 10 15 20

11548 sq ft

4025 sq ft HOT CELL AREA

FOR DRAWING INDEX SEE DRAWING NO. N/A	SUBCONTRACT NO. N/A	INEEL (Idaho National Engineering & Environmental Laboratory) BECHTEL BWXT IDAHO, LLC
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	DESIGN:	DIRECT EVAPORATION FACILITY
	DRAWN:	SECOND FLOOR PLAN
	PROJECT NO.	
	SPEC CODE	
DESIGN PHASE:	FOR REVIEW/APPROVAL SIGNATURES SEE DAR NO.	SIZE D; CAGE CODE; INDEX CODE NUMBER: AREA, TYPE, CL, ORIG; DWG- ; REV
SAFETY CATEGORY:	EFFECTIVE DATE:	SCALE: NOTED; SHEET

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C-10. REFERENCES

Barden, R. R. (2003), "Technical and Functional Requirements for the Direct Evaporation SBW Treatment Alternative," TFR-186, draft, May 2003.

Barnes, C. M., and C. B. Millet, (2002b), "INTEC Tank Farm Facility Management Plan," PLN-1112, September 30, 2002.

Barnes, C. M., R. A. Wood, and B. H. O'Brien, (2002a) "Process Design of SBW Treatment Alternatives," *Engineering Design File EDF-2373*, September 10, 2002.

Barnes, C. M., R. A. Wood, E. B. Packer, and N. A. Chipman, (2003a) "Direct Evaporator Process Condensate Treatment Alternatives Evaluation," *Engineering Design File EDF-3356*, July 22, 2003.

Barnes, C. M., S. K. Janikowski, and C. B. Millet, (2003b), *Feed Composition for the Sodium-Bearing Waste Treatment Process*," INEEL/EXT-2000-01378, Rev. 3, September 2003.

Bohn, T. S. (2002), Radiological Shielding Calculations for Screening of Sodium Bearing Waste (SBW) Treatment Alternatives, Rev. 1, *INEEL Interoffice Memorandum TSB-20*, August 26, 2002.

Boring, M. D., L. L. Fair, V. L. Fowler, and J. D. Hewitt, (1994), *Concentration of Melton Valley Storage Tank Surrogates with a Wiped Film Evaporator*, ORNL/TM-12768, August 1994.

Clark, M. L., (2003), "Study 18 – Calcine Packaging Facility Layout – Idaho Tank Farm Project – Calcination with MACT Upgrade SBW Treatment Alternative," *Engineering Design File EDF-3281*, April 30, 2003.

Griffith, D. L. (2003b), *Testing an Agitated Thin Film Evaporator for Solidifying a Mixture of Simulated Sodium-Bearing Waste and Undissolved Solids (Test Series 2),* INEEL/EXT-03-01189, November 2003.

Griffith, D. L., R. J. Kirkham, L. G. Olson, W. D. St. Michel, and S. J. Losinski, (2004), *Converting Simulated Sodium-Bearing Waste into a Single Solid Waste Form By Evaporation: Laboratory- and Pilot-Scale Test Results on Recycling Evaporator Overheads,* INEEL/EXT-04-00172, January, 2004.

Griffith, D. L., S. J. Losinski, B. E. Olaveson, and L. G. Olson, (2003a), *Testing an Agitated Thin Film Evaporator for Solidifying Simulated Sodium-Bearing Waste (Test Series 1)*, INEEL/EXT-03-00680, June 2003.

Herbst, A. K., J. A. DelDebbio, R. J. Kirkham, B. A. Scholes, and T. L. Watson, (2002), *Idaho Nuclear Technology and Engineering Center Sodium-Bearing Waste Treatment Research and Development FY-2002 Status Report*, INEEL/EXT-02-00985, September, 2002.

ICF Kaiser, (1995), *Tank Farm Heel Removal Project Conceptual Design Report*, RPT-034, February 3, 1995.

INTEC RCRA Interim Status Document – Liquid Effluent Treatment and Disposal Facility: Section A – General Description, *Interim Status Document ISD-1*, January 31, 2002.

Kimmitt, R. R. (2003), "Feasibility Study for Direct Evaporation of Sodium Bearing Waste," *Engineering Design File EDF-2524*, Rev. 0, May 20, 2003.

Kirkham, R. J., S. J. Losinski, B. E. Olaveson, and L. G. Olson, (2003), *Direct Evaporation of Sodium-Bearing Waste: Flask-Scale Testing of WM-189 Simulant*, INEEL/EXT-03-0657, July 2003.

Kirkham, R. J., to W. H. Landman, (1998) "Sodium Bearing Waste Solidification by Evaporation", Lockheed Martin Idaho Technologies Company Internal Correspondence RJK-6-98, September 29, 1998.

McCray, J. A., L. G. Olson, and S. J. Losinski, (2002), *Investigation of Direct Evaporation and Fractional Crystallization Technologies for Sodium-Bearing Waste Treatment*, INEEL/EXT-02-01043, September 2002.

McCray, J. A., to D. V. Croson, (1994), "Report on Freeze Crystallization and Evaporation/ Precipitation Testing for Sodium-Bearing Waste Treatment," Idaho National Engineering Laboratory Correspondence JAM-11-94, September 30, 1994.

McCray, J. A., to D. V. Croson, (1995), "Analysis of Sodium-Bearing Waste Treatment Using Evaporation/ Precipitation Technology Concept," Lockheed Idaho Technologies Company Interdepartmental Communications JAM-01-95, February 23, 1995.

Morrell, D. K., and D. T. Clark, (2003), "Mixing Pumps for Homogenizing TFF SBW Liquids and Solids – Calcination with MACT Upgrade SBW Treatment Alternative," *Engineering Design File EDF-3307,* April 24, 2003.

O'Brien, B. H. (2003), "Off-gas Chloride Control for the Calciner MACT Compliance Facility," *Engineering Design File EDF-2205,* April 3, 2003.

Packer, E. Bart ,"Preliminary Assessment of Evaporator Technologies for Direct Evaporation of Sodium Bearing Waste," *Engineering Design File EDF-3443*, April 8, 2003.

Perry, R. H., and C. H. Chilton, *Chemical Engineer's Handbook, 5th ed.*, 1973, New York:McGraw-Hill.

PRD-166, (1999) "INTEC PEW Chemical Acceptance Criteria Program Requirements Document," Rev. 4, October 1999.

Raman, S. V., A. K. Herbst, B. A. Scholes, S. H. Hinckley, and R. D. Colby, (2003), *Solidification of Simulated Liquid Effluents Originating form Sodium-Bearing Waste at the Idaho Nuclear Technology and Engineering Center, FY-03 Report*, INEEL/EXT-03-01096, September 2003.

Soelberg, N. R. (2003), "Offgas Mercury Control for the Idaho Tank Farm Project – Calcination with MACT Upgrade SBW Treatment Alternative," *Engineering Design File EDF-3292*, February 28, 2003.

Wood, R. ,D. Tyson, B. Bonnema, C. Olsen, A. P. Pinto, D. Wendt, S. Reese, and B. Raivo, (2001), *Feasibility Study for the Idaho Waste Vitrification Facilities Off-gas Treatment for Sodium-Bearing Waste*, INEEL/EXT-01-00995, September, 2001.

Wood, R., and D. K. Morrell, (2002) "Heel Solids Processing Evaluation for the SBW Treatment Project – Calcination with MACT Upgrade Alternative," *Engineering Design File EDF-3049*, December 4, 2002.