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TECHNICAL DATA SUMMARY
F/H EFFLUENT TREATMENT FACILITY

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TECHNICAL DATA SUMMARY

F/H EFFLUENT TREATMENT FACILITY

TABLE OF CONTENTS

CONTENTS, Contd

LIST OF FIGURES

LIST OF TABLES

LIST OF TABLES, Contd

LIST OF TABLES, Contd.

1.0 INTRODUCTION

1.1 Summary

In 1983 SRP embarked on a program to discontinue the practice of releasing its aqueous process effluents to seepage basins. Federal legislation enacted in October of 1984 may make this course of action mandatory, with a basin closure deadline of 1988.[1] This has made it necessary to develop a means of treating routine process effluents so that they may be released directly to the environment without presenting a hazard to either the public or the local ecology. The facility that will perform this function has been designated the F/H Effluent Treatment Facility (F/HETF). (Figure 1.1-1).

In the past, process upsets which resulted in the abnormal release of contaminated water were handled by diverting to large retention basins lined with Hypalon. The water was then treated to reduce the contamination to levels acceptable for release to the seepage basins. With the elimination of seepage basins, the F/HETF must also provide sufficient capacity and decontamination efficiency to handle acceptably all conceivable process upsets. The F/HETF will be located in F Area and will contain sufficient water treatment capacity for both separations areas. It is expected that there will be enough hold capacity for about two to four days of daily waste, so a premium will be placed on system durability and high attainment.

This document provides the technical basis for the design of the F/HETF. Some of the sections are described with options to permit simplification of the process, depending on the effluent quality criteria that the facility will have to meet. Each part of the F/HETF process is reviewed with respect to decontamination and concentration efficiency, operability, additional waste generation, energy efficiency, and compatability with the rest of the process.

1.2 Process Goals

The purpose of the F/HETF is to remove the hazardous and radioactive contaminants from the 200-Area effluent waste streams, concentrating them as much as possible for disposal. The decontaminated waste stream will then be released to the environment in an ecologically acceptable manner.

There are two sets of criteria that will determine the decontamination efficiency required of the F/HETF. The first of these will be the NPDES discharge limits that are agreed to by the

State of South Carolina (DHEC) for the conventional waste aspects of the discharged effluent stream. These are generally related to water quality guidelines that have been set for fresh water by the EPA. A copy of the discharge limits which have been proposed[2] by SRP for the F/HETF is shown in Table 1.2-1.[2]

The second set of standards applicable to F/HETF discharges are the guidelines that will be established for the discharge of radioactivity from the F/HETF to SRP streams. These will be based on the calculated dose for the maximum exposed individual (see Section 9.2, Offsite Dose Commitment) and can also be related to the current guidelines for releases to streams. The present DOE guidelines for radioactivity releases to Four Mile Creek from the 200 Areas are reviewed in Table 1.2-2.[3] The decontamination factors that would be required for the F/HETF to meet the same limits for released activity, assuming independence from other sources, are also listed in Table 1.2-2.

The waste volume generated by the F/HETF must be as small as possible due to the expense involved in its disposal. However, it is also necessary to maintain compatibility with tank farm operations, because waste concentrate would eventually be sent there in the event of a contaminated water release.

1.3 General Process Description

The treatment process that would best meet the goals stated above consists of three main stages. These include:

- Filtration
- Reverse osmosis
- Ion exchange

The entire F/HETF treatment process is shown schematically in Figure 1.3-1.

Just prior to the first stage, pH adjustment and feed preparation will aid the filtration of iron and suspended solids. This pretreatment will also be designed to reduce biological and organic fouling, and will convert any soluble reduced iron to its filterable oxidized state. The filtration stage will consist of a sintered metal tube, with flow going from inside out to maximize concentration efficiency. Two options appear to be viable in operating this kind of filtration system, and data will be presented for each. Reverse osmosis will be used in the second stage to remove about 95% of the salts and contaminants which pass filtration. Ion exchange will make up the final stage of the F/HETF process, and will provide any additional degree of decontamination that is needed.

Pretreatment and filtration are critical to the operation of reverse osmosis and/or ion exchange. If these are adequately designed, excess capacity will permit virtually 100% attainment by reverse osmosis, as observed in typical seawater desalination systems.

SECTION 1 REFERENCES

1. J. S. Roberts, Memorandum to J. D. Spencer, "SRP Environmental Weekly Report," November 16, 1984. (Re: Congressional Record, October 3, 1984 - H11103).

2. W. W. Collins, Memorandum to J. S. Roberts, June 4, 1984.

3. Technical Monthly Report for December 1983, DPSP-83-1-12, E. I. du Pont de Nemours and Company, Savannah River Plant, Aiken, SC (January 1984).

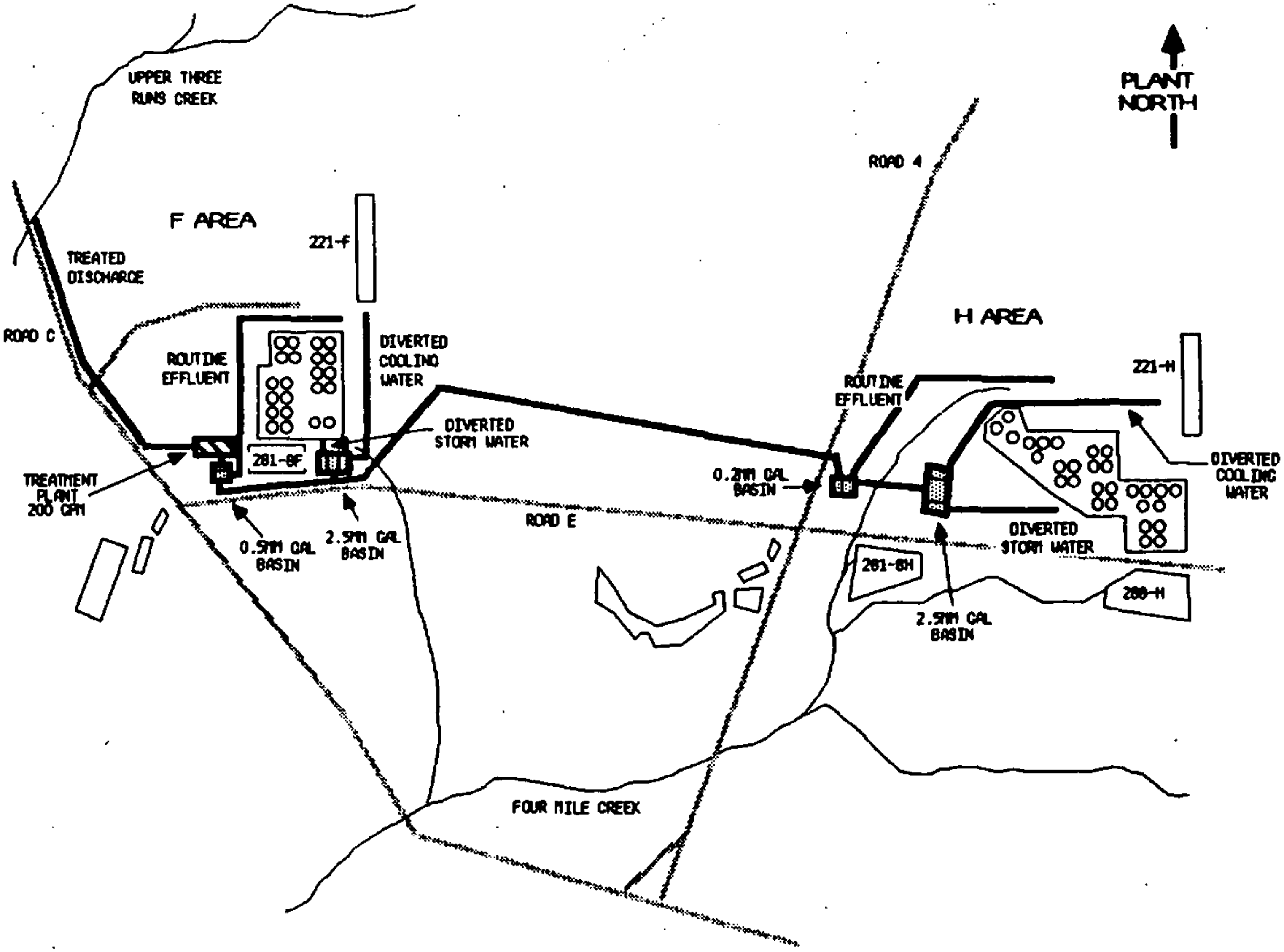

FIGURE 1.1-1. Proposed Site of the F/H Effluent Treatment Facility

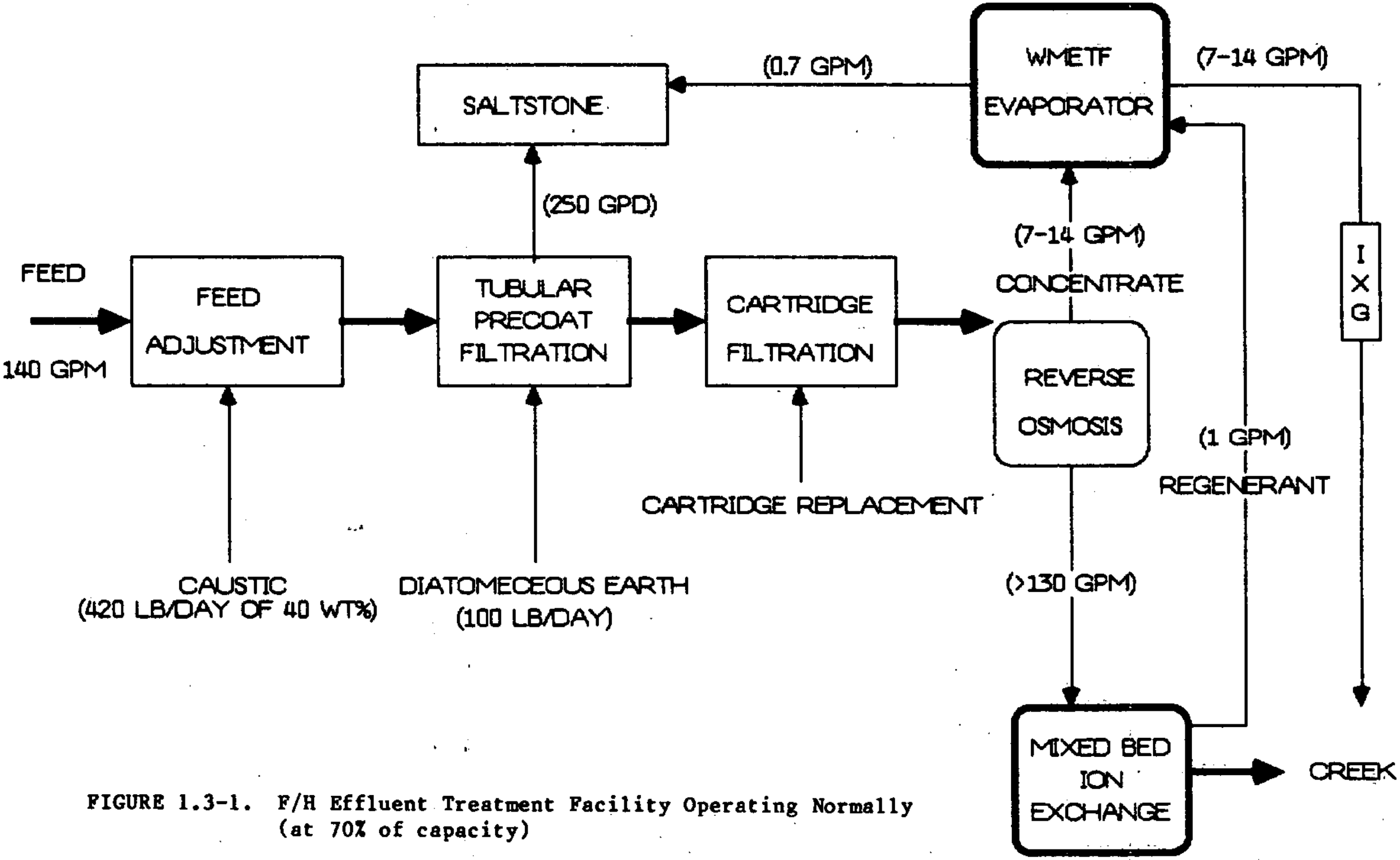

FIGURE 1.3-1. F/H Effluent Treatment Facility Operating Normally (at 70% of capacity)

TABLE 1.2-1

Proposed NPDES Discharge Limits

From Current NPDES Permit

pH 6.0 to 9.0

	Monthly Average (mg/L)	Maximum (mg/L)
BOD_5	20	40
TSS	30	60
Oil & Grease	10	15

From EPA Proposed Standards (Federal Register/Vol. 49, No. 26/ February 7, 1984)

	Monthly Average (mg/L)		Maximum (mg/L)	
	In Stream	Discharge*	In Stream	Discharge
Ammonia (Unionized)	0.004	1.0	0.019	5.0
Chlorine	0.0083	2.2	0.014	3.7
Chromium (Hexavalent)	0.0072	1.9	0.011	2.9
Mercury	0.0002	0.052	0.0011	0.29

From EPA "Quality Criteria for Water - 1976"

	Basis	In Stream Avg. (mg/L)	Discharge* Avg. (mg/L)	Discharge** Max. (mg/L)
Copper	0.1 x 96 hr LC50	0.0168	4.4	8.8
Zinc	0.01 x 96 hr LC50	0.0258	6.7	13
Lead	0.01 x 96 hr LC50	0.238	62	124

For other parameters listed in Table 3 for which specific limits are not available, toxicity studies will be performed to demonstrate that harmful effects on aquatic life and organisms will not occur.

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* Calculated from instream limits, the maximum facility discharge rate of 0.45 CFS and the Upper Three Runs Creek 7Q10 stream flow of 117 CFS.

** Maximum = 2 x average.

TABLE 1.2-2

Seepage Basin Receipts vs. Present Guidelines for Release to Streams[3]

	Tritium (Ci)	Sr-89, Sr-90 (mCi)	Cs-134, Cs-137 (mCi)	Other β or γ (mCi)	Total Alpha (mCi)	Water Volume
DOE Release guide for Four Mile Creek (FMC)	150	35	75	175	10	None
Presently released to FMC from other sources	140	10	75	35	6	3.7×10^9
Presently released to Basins (1983)						
F Area	7,000	150	1010	15,500	450	1×10^8
H Area	12,000	600	2600	10,500	25	2×10^8
Average contamination factor required to release basin effluents to FMC neglecting other sources to FMC	127*	22	49	149	48	
DF required if ETF effluents are included with other sources		30	-	186	119	

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*Tritium removal at the ETF is not practical.

2.0 DESIGN BASES

2.1 Process Feed Sources

2.1.1 Normal Daily Effluents

The normal source of waste water feeding the F/H Effluent Treatment Facility (F/HETF) will be the effluents from the 200 Areas that presently go to seepage basins. These consist mainly of evaporator overheads and floor drain sump discharges. The total recorded flow to the seepage basins in the separations areas is presently on the order of 150 gpm as a 24-hour yearly average. This is somewhat more than the reported releases from evaporators and sumps for that same period, largely due to the presence of cooling water from the tritium facility (Tables 2.1-1 and 2.1-2).[1] However, this excess volume is not expected to go to the ETF and flow should average roughly 135 gpm. Table 2.1-3 describes the flow volumes which are projected to come from evaporator overheads to the F/HETF.[2] The hazardous chemicals, radionuclides, and overall process chemistry of the routine effluents are described below.

2.1.2 Canyon Cooling Water

In addition to handling routine low-level effluent, the F/HETF will also be designed for treating contaminated canyon cooling water whenever necessary. The maximum credible release in cooling water has been evaluated at 100,000 Ci.[3] Although the probability of such an event is estimated to be less than once per 10,000 years,[4] releases of up to 300 Ci have occurred (see Table 2.1-4), proving the real need for an adequate treatment system.

It has been observed that over 90% of the activity in a contaminated cooling water release is released in the first 500,000 gal of flush water. For design purposes, this highly radioactive water would be contained separately, in the case of a maximal release, and sent directly to the tank farm for evaporation. Most of the remaining activity, roughly 10,000 Ci, would be contained in a volume of about 1.5 MM gal (although activity would still be detectable in flush water for some time) resulting in a concentration of 6.7 mCi/gal or less going to the F/HETF.[5-6]

2.1.3 Storm Water Runoff

Storm water runoff from the tank farm may also require decontamination if high level waste has been spilled. This situation arose in December of 1983 when a release from Tank 13 permitted 26 Ci to be sent to the 281-8H retention basin in 1.55E7 gal of storm water runoff. The resulting waste stream was analyzed for both radionuclides and standard water quality parameters providing data for water treatment system design. The contaminated water was treated by ion exchange before being released to the seepage basins, but poor decontamination efficiency (DF=3-12) was observed for cesium, the main contaminant, because of colloidal transport and channelling through the column. This incident provides a reasonable design basis for the F/HETF, and emphasizes the importance of efficient filtration in the decontamination of effluents by ion exchange.

2.2 Radionuclides

2.2.1 Normal Process Effluents

The 1984 plant guidelines are listed in Tables 2.2-1 for the release of activity to the 200-Area seepage basins. These guidelines are used throughout this document in calculations concerning the average quality of the effluent from the F/HETF on a normal yearly basis. Actual release data, as determined by SRP Health Protection, is also given in Tables A-1 and A-2 for comparison.

The performance that will be required of the F/HETF for decontaminating daily plant waste effluents will be determined on the basis of the offsite dose commitment. Treatment options are being evaluated with respect to dose commitment, and will be ranked accordingly. As a preliminary benchmark, the current stream release guidelines for Four Mile Creek are 35 mCi/yr Sr-90, 75 mCi/yr Cs-137, 175 mCi/yr other beta-gamma, and 10 mCi/yr alpha (Table 1.2-2). It is anticipated that these guidelines will not be relaxed significantly.

Knowing the distribution of activity sources throughout the 200 Areas permits the effect of process changes on the feed stream to the F/HETF to be forecast more accurately. A table of this information can be found in Appendix B.

2.2.2 Contaminated Cooling Water Incidents

The activity distributions that were used to calculate the results of contaminated cooling water incidents are listed in Table 2.2-3. These are taken both from theoretical decay calculations (First Cycle Feed) and actual measurements of High Activity Waste and First Cycle Feed. None of the vessels that were considered in the release scenarios contained enough fissile material to present a nuclear hazard (see Nuclear and Process Safety, Section 7.0).

2.2.3 Contaminated Storm Water

The activity that would be released in the event of a tank farm spill has the same distribution as normal aged caustic waste. This distribution for 5-year waste is listed in Table 2.2-3, Because of its solubility, the primary source of gamma activity is Cs-137, as indicated in Table 2.2-4.[14] Beta emitters are also important, especially if the effluents are to be released to plant streams rather than seepage basins.

The most recent incident of this type at SRP, Cs-137 was the only gamma emitter that was readily detectable. The initial activity was 2.7, µCi/L Cs-137 and 0.09, µCi/L Cs-134. Sr-90 was estimated to be less than 0.02 µCi/L.[7]

2.3 Hazardous Materials

Effluents to the SRP seepage basins typically contain nitrates and heavy metals. No other hazardous materials are released in detectable quantities.[2] EPA listed hazardous organic materials are not used in the separations areas, and strong acids and bases are at least partially neutralized before they are released. Oxidizing agents, such as dichromate, and reducing agents, like hydrazine or sulfamic acid, are mostly consumed before being released. Aside from their radioactivity, special feeds (i.e., contamination releases) contain insignificant amounts of hazardous material, since the primary water source is either rainfall or process water.

Of the hazardous metals in daily effluents, only mercury and lead are concentrated enough to be of concern, following even the most basic decontamination process for radionuclides.[15] A summary of the average heavy metals concentrations that were measured in the 200-Area effluents is given in Table 2.3-1.[2]

According to the Waste Management Technical Reports,[3] F Area released just under 2.5 lb of mercury to the seepage basins in 1983. This represents an average mercury concentration of 8.7 ppb in the liquid effluent streams from that area. H Area released 55 lb, an average of about 155 ppb (1.5×10^8 L) of mercury during the same year.[16] The analyses performed recently on trebler samples found 12-week averages of 4.2 and 43 ppb of mercury for F Area and H Area, respectively.[2]

2.4 Process Feed Chemistry

2.4.1 Normal Process Effluents

The chemistry of the F/HETF process is dominated by nitric acid and sodium nitrate. However, several of the minor constituents are also important for the effects that they can have on the the water treatment process. Iron, silica, humic acid, free chlorine, sulfate, phosphate, calcium, magnesium, manganese and zinc are examples. The most recent characterization study of 200-Area effluents is summarized in Table 2.4-1. A more complete description of the chemical matrix is listed in Appendix A.[2]

Total suspended solids in the F/HETF feed will range from 2 ppm to over 500 ppm (see Table 2.4-2). Likely process feeds also include a broad range of ionic strengths and waste component concentrations. These must be addressed in the system design, so that cycle times, operating pressures and even the procedures for backwashing and cleaning can be altered as necessary. The basic feed for the F/HETF consists largely of evaporator overheads, so many of the "problem" materials are either not present or are present at relatively low concentrations.[2] The 200-Area effluents are therefore an excellent candidate for concentration and decontamination by reverse osmosis and ion exchange.

2.4.2 Storm Water

Storm water runoff has been characterized.[7,13] Analyses performed on cold samples indicate that it contains more dissolved silica than the daily waste by a factor of about 2, and that aluminosilicates (i.e. clay) are also present (Table 2.4-3). Therefore, the concentration factor achieved by reverse osmosis may decrease from 20 to about 10-15 in going from normal process effluents to storm water, because of the limitations imposed by the solubility of silica. This effect may be reduced, or possibly even eliminated, by using ultrafiltration to remove colloidal silica. Silica can also be removed by flocculation. However, this substantially increases the volume of the waste concentrate.

A more recent analysis of storm water runoff was obtained during an actual contamination release situation.[7] The results indicate lower silica levels than previously believed (see Table 2.4-4). However, this difference may be seasonal (temperature related), since the high silica values were obtained in the summer, while lower concentrations were measured in January. Calcium and sulfate concentrations were also quite different. Therefore, design must accommodate the more stringent case.

Aside from the silica and total suspended solids, storm water runoff is relatively pure. It contains very low concentrations of dissolved solids, so it can be concentrated by several orders of magnitude once the silica and other suspended solids are removed. Any chemicals that might be in the storm water as a result of a spill would be diluted to the point where they would have little or no effect on the chemistry of the treatment process.

Filtration of the suspended solids (summer) at 10 microns was 90% effective.[13] However, experience with the actual contamination incident showed that 100 mesh basket strainers were ineffective, while 300 mesh strainers plugged rapidly.[8]

2.4.3 Contaminated Cooling Water

Canyon cooling water has roughly the same overall chemistry as the process water throughout SRP. From an operational standpoint, it poses no difficulties compared to routine waste, except for its potentially high radioactivity. Analyses of this stream (as a possible feed to the F/HETF) are reported in Table 2.4-2. As with storm water, any chemicals that might be in the cooling water as a result of a spill would be diluted to the point where they would have little or no effect on the chemistry of the treatment process.

2.4.4 Other

Situations will arise where special batches of material will be under consideration for disposal through the F/HETF. Therefore, it is appropriate to discuss changes in feed composition (i.e., waste components) which could affect the F/HETF. Generally, materials that tend to form insoluble salts, slimes, films, foams and separate phases can cause difficulty in water treatment systems. Therefore, large quantities of sulfate, calcium, magnesium, manganese, zinc, silicates, fluoride, aluminum, phosphate, dichromate, soap, oil and grease, should not be released to the ETF without prior notification of, and acceptance by, the F/HETF. In almost all cases, special feeds can be accommodated after some pretreatment at the source. But it would not be practical to use additives for all such eventualities on a continuous basis. A list of chemical concerns is given in Table 2.4-5 along with remedial actions to make these solutions acceptable to the F/HETF.

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1. E. V. Brown, Memorandum to E. R. Norton, "Reported Flows and Trebler Flows for the F and H Seepage Basins," August 15, 1984.

2. J. P. Ryan, Memorandum to H. D. Martin, "Effluent Characterization Study for the 200-Area Effluent Treatment Facility," DPST-84-511, May 31, 1984.

3. C. E. Pickett, Chairman, Contaminated Cooling Water Problems Committee, Memorandum to G. W. Wildes, "Evaluation of Contaminated Cooling Water Problems," DPSPU-82-272-9 (January 25, 1982).

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5. M. C. Healy, Memorandum to O. M. Morris, "Contaminated Water Control — Changes in Process Scope," June 6, 1983.

6. M. C. Healy, Memorandum to R. G. Beckwith, "Radionuclide Concentrations in Contaminated Cooling Water," April 2, 1982.

7. D. D. Walker, Memorandum to M. A. Ebra, "Decontamination of Retention Basin Water," DPST-84-277, January 1984.

8. C. J. Thomas, Memorandum to W. B. Bore, "Retention Basin (281-8H) Water Decontamination Program Test Results," DPSP-84-17-9, July 23, 1984.

9. E. I. du Pont de Nemours and Company, Savannah River Plant, Aiken, SC, DPSOP-40, Chapter IC, 5.5.1, Revision 72, July 1984.

10. Technical Monthly Report for December 1983, DPSP-83-1-12, E. I. du Pont de Nemours and Company, Savannah River Plant, Aiken, SC (January 1984).

11. C. E. Apperson, Jr., "Fission Product Activity Data Base for Mark 22," DPST-82-687, October 5, 1982.

12. J. R. Cadieux, Memorandum to J. R. Wiley, "Decontamination of Cooling Water by Ion Exchange," DPST-82-855, September 14, 1982.

13. T. Motyka and J. P. Ryan, Memorandum to R. B. Ferguson, "Preliminary Technical Data Summary: Contaminated Water Processing Facility," DPST-83-557, May 31, 1983.

14. E. I. du Pont de Nemours and Company, Savannah River Plant Technical Data Summary, Defense Waste Processing Facility, DPSTD-80-38-2, Revision 2 (September 1982).

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15. W. W. Collins, Memorandum to J. S. Roberts, June 4, 1984.

16. Technical Monthly Report for December 1983, DPSP-83-1-12, E. I. du Pont de Nemours and Company, Savannah River Plant, Aiken, SC (January 1984).

TABLE 2.1-1a

Reported Flows into the F-Area Seepage Basins (gal/month)

Production Month	221-F	Evaporators	Retention Basin	Total
January	1,630,140	316,356	0	1,946,496
February	1,906,501	365,985	0	2,272,486
March	1,504,596	368,826	0	1,873,422
April	1,406,139	423,095	0	1,883,234
May	744,105	426,780	0	1,170,885
June	942,192	323,712	0	1,265,904
July	1,094,891	232,243	0	1,318,134
August	Trebler Out of Service			
September	Trebler Out of Service			
October	1,458,218	292,655	0	1,750,873
November	391,534	210,930	861,000*	1,463,464
December	1,463,881	221,694	0	1,685,575

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* Freeze protection water included

TABLE 2.1-1b

Reported Flows into the H-Area Seepage Basins (gal/month)

Production Month	221-H	Evaporators and RBOF	Retention Basin	Tritium Cooling Water	Others*	Total
January	695,940	536,000	1,036,000	1,000,000	362,000	3,629,940
February	330,717	436,000	1,721,000	1,550,000	9,000	4,046,717
March	572,367	334,000	0	0	0	1,056,367
April	503,753	513,000	565,000	0	6,000	1,587,753
May	405,601	634,000	844,000	0	20,000	1,903,601
June	555,753	408,000	844,000	1,350,000	13,000	3,170,753
July	Insufficient Data					
August	436,551	478,000	242,000	1,550,000	5,000	2,711,551
September	417,279	583,000	3,330,000	1,550,000	12,000	5,862,279
October	702,911	573,000	900,000	100,000	6,300	2,282,211
November	666,451	538,000	280,000	1,350,000	6,400	2,840,852
December	Insufficient Data					

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* Others include contaminated canyon cooling water, catch tank and acid additions to the seepage basins.

TABLE 2.1-2a

Flow Comparisons for the F-Area Seepage Basins

Production Month	Reported Flows (gal/month)	Trebler Flows (gal/month)
January	1,946,496	2,229,800
February	2,272,486	2,330,600
March	1,873,422	2,019,400
April	1,883,234	1,754,000
May	1,170,885	1,308,100
June	1,265,904	1,313,900
July	1,318,134	1,520,100
August	Trebler Out of Service	
September	Trebler Out of Service	
October	1,750,873	1,738,700
November	Trebler Out of Service	
December	1,685,575	1,906,100

TABLE 2.1-2b

Flow Comparisons for the H-Area Seepage Basins

Production Month	Reported Flows (gal/month)	Trebler Flows (gal/month)
*January	3,629,940	6,187,700
*February	4,046,717	9,399,500
March	1,056,367	2,908,300
April	1,587,753	2,272,800
May	1,903,601	2,567,900
*June	3,170,753	3,927,600
*July	Insufficient Data	
*August	2,711,551	4,632,500
*September	5,862,279	7,841,900
October	2,282,211	2,411,300
*November	2,840,852	8,699,600
*December	Insufficient Data	

---

* Months of tritium cooling water releases to seepage (greater than 100,000 gallons)

TABLE 2.1-3

Projected Flows to the F/HETF

Source	Minimum Flow* (gal/day)	Average Flow* (gal/day)	Maximum Flow (gal/day)
F Area			
ARU	0	0	72,000
1CU	2,950	3,600	42,000
GP	0	0	13,000
Hydrate	4,100	5,000	5,900
1EU	24,500	30,000	35,500
Lab Waste	3,300	4,000	4,700
Tank Farm	16,000	16,000	16,000
Average	50,850	58,600	189,700
H Area			
ARU	5,350	8,350	11,100
GP	3,900	3,900	3,900
Tank Farm	16,000	16,000	16,000
Average	25,200	28,250	31,000

---

* Minimum and average values are based on the presumed success of the program to recycle evaporator overheads in F Area.

TABLE 2.1-4

Contaminated Cooling Water Releases

Size of Release, Ci	Number of Past Releases
0-1.3	94
1.3-280	10
280-7600	1
7600-100,000	0

TABLE 2.2-1

Guidelines for Radionuclide Releases to Seepage Basins

Radionuclide	Release Guides F Basin (Ci)	Release Guides H Basin (Ci)	Activity Distribution F Guides, %	Activity Distribution H Guides, %	DF to Meet Yearly Stream Release Guides
-Beta Gamma-					
Cr-51	0	5	-	13.97	
Co-58	0	1	-	2.79	
Co-60	0	1	-	2.79	
Zn-65	0	0.8	-	2.23	
Sr-89	0.2	0.4	0.53	1.12	57.14
Sr-90	0.4	1	1.06	2.79	57.14
Y-90	-	-	-	-	
Y-91	-	-	-	-	
Zr-95	4	1	10.58	2.79	
Nb-95	4	1.5	10.58	4.19	
Ru-103	2	1.5	5.29	4.19	
Ru-106	20	7.5	52.91	20.95	
Rh-106	-	-	-	-	
Sb-124	0	0.2	-	0.56	
I-131	0.8	0.4	2.12	1.12	
Cs-134	0.3	0.1	0.79	0.28	178.67
Cs-137	4	9	10.58	25.14	178.67
Ce-141	0.1	0.5	0.26	1.40	
Ce-144	1	2.6	2.65	7.26	
Pr-147	-	-	-	-	
Pm-147	0.5	1.5	1.32	4.19	
Other Beta-Gamma	0.5	0.8	1.32	2.23	
Total Beta-Gamma	37.8	35.8	100	100	
Non Cs/Sr Beta-Gamma	32.9	25.3	87.04	70.67	331.43
-Alpha-					
Am-241	0.02	0.002		8.7	
Cm-242/244	0.01	0.001		4.3	
U-235/238	0.2	0.005		21.7	
Pu-238	0.02	0.009		39.1	
Pu-239	0.02	0.006		26.1	
Pu-240	-	-		-	
Total Alpha	0.27	0.2		99.9	47.00
Total Alpha/B-G	0.0071	0.0056			

TABLE 2.2-2

Radionuclide Distribution in First Cycle Feed and High Activity Waste

Radionuclide	First Cycle Feed (1AF)*, %	High Activity Waste (HAW), %
-Beta Gamma-		
Cr-51	-	-
Co-58	-	-
Co-60	-	-
Zn-65	-	-
Sr-89	5.3	0
Sr-90	0.38	0.3
Y-90	0.38	-
Y-91	8.75	-
Zr-95	11.56	5.4
Nb-95	22.19	1.9
Ru-103	1.78	0.3
Ru-106	1.38	6.5
Rh-106	1.38	-
Sb-124	-	-
I-131	-	-
Cs-134	0.84	3.8
Cs-137	1.13	6.7
Ce-141	1.69	0.4
Ce-144	19.69	68.2
Pr-147	19.69	-
Pm-147	2.16	-
Other Beta-Gamma	1.72	-
Total Beta-Gamma	100	99.8
Non Cs/Sr Beta-Gamma	92.37	82.7

-Alpha-	Alpha Curie Distribution %
Am-241	-
Cm-242/244	-
U-235/238	-
Pu-238	99.1
Pu-239	0.43
Pu-240	0.43
Total Alpha	99.96
Total Alpha/ Total Beta-Gamma	0.00303

TABLE 2.2-3

Radionuclide Content of 5-Year In-Tank Waste

In-Tank Waste Description

Isotope	Ci/Gal	Isotope	Ci/Gal	Isotope	Ci/Gal
H-3	4.12E-03	Te-129M	4.073-16	Pb-212	3.46E-07
C-14	1.73E-07	I-129	9.42E-07	Pb-214	2.47E-12
Cr-51	1.05E-20	Xe-131M	2.72E-48	Bi-210	1.61E-13
Co-60	1.93E-02	Cs-134	3.89E-01	Bi-210M	5.37E-22
Ni-59	1.56E-04	Cs-135	6.72E-06	Bi-211	7.99E-12
Ni-63	3.85E-02	Cs-136	1.15E-42	Bi-212	3.46E-07
Se-79	1.61E-05	Cs-137	3.59E+00	Bi-213	2.34E-14
Rb-87	1.02E-09	Ba-136M	3.68E-43	Bi-214	2.47E-12
Sr-89	3.07E-09	Ba-137M	3.40E+00	Po-210	1.27E-13
Sr-90	3.43E+00	Ba-140	4.26E-41	Po-212	2.22E-07
Y-90	3.43E+00	La-140	4.91E-41	Po-213	2.29E-14
Y-91	1.06E-07	Ce-141	4.07E-15	Po-214	2.47E-12
Zr-93	1.27E-04	Ce-142	1.08E-09	Po-215	8.01E-12
Zr-95	1.12E-06	Ce-144	1.12E+00	Po-216	3.46E-07
Nb-94	3.65E-09	Pr-143	1.36E-38	Po-218	2.47E-12
Nb-95	2.40E-06	Pr-144	1.12E+00	At-217	2.34E-14
Nb-95M	1.42E-08	Pr-144M	1.34E-02	Rn-219	8.01E-12
Tc-99	5.53E-04	Nd-144	5.45E-14	Rn-220	3.46E-07
Ru-103	2.56E-12	Nd-147	1.44E-48	Rn-222	2.47E-12
Ru-106	3.35E-01	Pm-147	2.74E+00	Fr-221	2.34E-14
Rh-103M	2.56E-12	Pm-148	7.88E-15	Fr-223	9.96E-13
Rh-106	3.34E-01	Pm-148M	1.14E-13	Ra-223	8.01E-12
Pd-107	1.08E-06	Sm-147	2.16E-10	Ra-224	3.46E-07
Ag-110	1.93E-05	Sm-148	6.38E-16	Ra-225	2.37E-14
Ag-110M	1.45E-03	Sm-149	1.98E-16	Ra-226	2.48E-12
Cd-115M	1.08E-13	Sm-151	2.67E-02	Ra-228	1.58E-15
In-115	7.34E-16	Eu-152	4.27E-04	Ac-225	2.34E-14
In-115M	9.81E-18	Eu-154	7.02E-02	Ac-227	7.22E-12
Sn-121M	3.71E-06	Eu-155	5.56E-02	Ac-228	1.58E-15
Sn-123	3.01E-05	Eu-156	5.92E-36	Th-227	7.09E-12
Sn-126	1.71E-05	Gd-152	7.86E-18	Th-228	3.47E-07
Sb-124	8.12E-12	Tb-160	1.27E-10	Th-229	2.40E-14
Sb-125	9.60E-02	Tl-206	5.37E-22	Th-230	1.30E-09
Sb-126	2.40E-06	Tl-207	7.97E-12	Th-231	5.95E-09
Sb-126M	1.71E-05	Tl-208	1.24E-07	Th-232	1.90E-15
Te-125M	2.34E-02	Tl-209	5.06E-16	Th-234	3.27E-08
Te-127	1.02E-05	Pb-209	2.34E-14	Pa-231	5.17E-11
Te-127M	1.04E-05	Pb-210	1.64E-13	Pa-233	9.91E-07
Te-129	2.59E-16	Pb-211	7.99E-12	Pa-234	6.54E-08

TABLE 2.2-3, Contd

In-Tank Waste Description

Isotope	Ci/Gal	Isotope	Ci/Gal	Isotope	Ci/Gal
U-232	5.76E-07	Pu-239	7.96E-04	Cm-245	7.47E-10
U-233	6.78E-11	Pu-240	5.03E-04	Cm-246	5.97E-11
U-234	1.80E-06	Pu-241	9.45E-02	Cm-247	7.33E-17
U-235	5.94E-09	Pu-242	6.70E-07	Cm-248	7.66E-17
U-236	1.29E-07	Am-241	1.22E-03	Bk-249	3.23E-15
U-238	3.27E-08	Am-242	1.61E-06	Cf-249	4.46E-16
Np-236	1.95E-12	Am-242M	1.61E-06	Cf-250	1.76E-15
Np-237	9.91E-07	Am-243	6.49E-07	Cf-251	7.41E-18
Pu-236	7.04E-06	Cm-242	3.94E-06	Cf-252	1.88E-16
Pu-237	5.14E-16	Cm-243	6.25E-07	Cf-253	9.44E-48
Pu-238	8.45E-02	Cm-244	1.83E-05		

Total Activity	2.04E+01 Ci/Gal
Decay Heat	
Total Primary	4.29E-02 Watt/Gal
Total Gammas	1.75E-02 Watt/Gal

TABLE 2.2-4

Distribution of Radionuclides Between the Soluble and Insoluble Fractions of In-Tank Waste

Isotopes	Soluble, %	% Insoluble
Cs	95	5
Tc, Ru-Rh	50	50
Ag, Cd, I, Cr, Se Pd, Te, Tl	5	95
La, Ce-Pr, Pm, Nd, Sm, Tb, Sn-Sb	1	99
Sr-Y, Rb, Mo, Ba	0.2	99.8
Co, Zr-Nb, Eu, Np, U, Pu, Am, Cm	0.1	99.9

TABLE 2.3-1

Heavy Metals In 200-Area Effluents (ppm)

	F Area	H Area	F/H Average	F/H Weighted Average*	Maximum	Minimum
Cd	<0.01	<0.01	<0.01	<0.01	0.009	0
Pb	0.12	0.18	0.16	0.15	0.55	0
Hg**	0.004	0.043	0.024	0.016	0.28	0
Cr	0.013	0.072	0.043	0.031	0.36	0
Cu	0.010	0.43	0.22	0.14	2.7	0

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* Weighted average is based on 70% of flow from F Area, 30% from H Area. (Reference: ETF Basic Data Report, C. D. O'Leary and D. W. Gemar, January 16, 1984).

** The yearly average mercury concentration reported by Health Protection is higher (see Section 3.1).

TABLE 2.4-1

200-Area Effluents (September 23, 1983 to December 16, 1983)

Isotopes	F Area	H Area	F/H Average	F/H* Weighted Average	Maximum	Minimum
			(units are mg/Liter)			
Na	790	17.6	404	558	1900	6.1
Ca	0.5	28	14.3	8.8	239	0.01
Fe	1.7	5.1	3.2	2.7	25	0.01
Zn	0.3	3.1	3.2	1.1	26.5	0.01
NH	24	8	14	16.4	30	2
Ba	0.01	0.08	0.05	0.02	0.41	0
K**	0.67	1.0	0.84	0.77	1.7	0.11
Al	0.78	3.2	2.0	0.5	12.4	0
Mn	0.016	0.560	0.288	0.183	3.20	0
Mg	0.060	1.3	0.68	0.4	4.45	0
NO_3	1220	538	879	1015	6740	67
CO_3	131	47	89	106	180	0
NO_2	2	1	1.5	1.7	16	0
Cl	1.2	1.1	1.2	1.2	9.6	0
SO_4	4.6	3.9	4.3	4.4	31	0
F	1.5	0.1	0.8	1.1	12	0
Si (total)	7.1	6.3	6.7	6.9	39	0.6
Si (<0.45 μm)	5.0	6.1	5.5	5.3	22	0.4
P	2.2	0.6	1.4	1.7	4.4	0.09
pH	2.93	2.37	2.57	2.68	12.8	1.52
Suspended Solids	NA	NA	25	NA	208	10

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* Weighted average is based on 70% of flow from F Area, 30% from H Area. (Reference: ETF Basic Data Report, C. D. O'Leary and D. W. Gemar, January 16, 1984).

TABLE 2.4-2

200-Area Weekly Composites Total Suspended Solids*

Collection Date	F Area (ppm)	H Area (ppm)
8/9/84	34	208
8/17/84	<10	<10
9/28/84	<10	<10
10/19/84	510	190
10/26/84	5	2
11/2/84	2	2
11/9/84	2	3
Maximum	510	208
Minimum	2	2
Average	81	61

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* Trebler Monitor samples.

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TABLE 2.4-3

Water Quality Analysis of Nonroutine Sources

Analysis	Canyon Process Water F Area	Canyon Process Water H Area	Storm Water Runoff F Area	Storm Water Runoff H Area	Units
pH	7.1	7.7	6.1	6.0	pH units
Alkalinity	16.7	45.4	16.1	15.5	mg/L $CaCO_3$
Turbidity	3.6	2.4	39.9	81.2	mg/L SiO_2
Hardness	5	8	12	22	mg/L $CaCO_3$
Conductivity	96	145	70	58	mhos
Nonfilterable silica	3.2	3.9	12.3	15.0	mg/L Si
Filterable silica	0.1	0.1	1.2	0.1	mg/L Si
Suspended solids	2	2	61	89	mg/L
Calcium	1	3	4	7	mg/L Ca
Magnesium	0.3	0.4	0.5	0.7	mg/L Mg
Manganese	0.01	0.01	0.04	0.08	mg/L Mn
Potassium	1	1	1	1	mg/L K
Sodium	13	9	3	5	mg/L Na
Iron	0.7	0.4	2.4	3.6	mg/L Fe
Bicarbonate	20.3	55.4	19.6	18.9	mg/L HCO_3
Carbonate	1	1	1	1	mg/L CO_3
Sulfate	14.2	14.0	11.1	7.0	mg/L SO_4
Fluoride	1	1	1	1	mg/L F
Residual chlorine	0.5	0.5	-	-	mg/L Cl_2
Total dissolved solids	64	86	54	89	mg/L

TABLE 2.4-4

Nonradioactive Components in Retention Basin Samples (January 1984)

Date Time Location	12/30 3 pm Inlet	12/31 10 pm Inlet	12/31 10 am Outlet	1/1 11 am Inlet	1/1 11 am Outlet	1/2 7 am Inlet	1/2 7 am Outlet	1/3 7 am Inlet	1/3 7 am Outlet	1/9 8 am Outlet	1/13 2 am Inlet	1/13 2 am Outlet
Na (ppm)	11.	16.	16.	17.	16.	16.	15.	15.	16.	17.	14.	14.
Ca	4.0	4.3	4.3	4.5	4.5	4.4	4.6	4.5	4.4	3.9	3.9	3.9
Si	4.6	4.3	4.3	5.9	5.9	5.2	5.1	5.1	5.3	4.7	4.6	4.7
Al	0.8	1.1	1.1	1.1	1.2	0.6	0.5	0.6	0.6	0.3	0.3	0.4
Fe	0.4	0.5	0.5	0.54	0.53	0.29	0.26	0.29	0.30	0.9	0.2	0.3
Mg	0.4	0.4	0.4	0.45	0.45	0.43	0.43	0.42	0.43	0.4	0.4	0.4
Cu		0.011	0.010	0.012	0.015	<0.10	<0.10	<0.10	<0.10			
Hg								0.005	0.004			
SO_4	20	26	26	35.0	34.0	35.0	34.0	30.0	35.0			
Cl	1.6	1.9	1.6	2.2	2.0	2.2	2.0	2.8	2.9			
NO_2	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0			
NO_3	<1.0	<1.0	<1.0	<1.5	<1.5	<1.5	<1.5	<1.5	<1.5			
PO_4	<1.5	<1.5	<1.5	<1.5	<1.5	<1.5	<1.5	<1.5	<1.5			
F	<0.1	<0.1	<0.1	<0.1	<0.1	<1.5	<1.5	<1.5	<1.5			

TABLE 2.4-5

Concentrated Waste Chemical Disposal: Problems and Remedial Actions

Chemicals	Problem	Remedy
Potassium dichromate	Oxidation of RO membranes	Reduce to Cr(III)
Zinc	Filter and RO foulant	Complex with EDTA
Sulfate	Poor solubility RO foulant	Maintain low Ca, Ba Precipitate with Al
Permanganate	Oxidant, RO foulant	Reduce, dilute
Calcium	Poor solubility RO scalant	Precipitate (Oxalate) add RO antiscalant
Fluoride	Poor solubility corrosive	Maintain low Ca form Al complex
Aluminum	Possible RO foulant	Precipitate with SO_4 filter at pH7 Add acid or base to RO feed
Oil/grease	Filter and RO foulant	Separate disposal emulsify (for UF) activated carbon (for Precoat or UF) carbon bed (between filter and RO)

3.0 PRODUCT DESCRIPTION

3.1 Pretreatment Product

The object of the pretreatment stage is to produce a high quality feed for the the next process stage of the ETF, which is filtration. The definition of an acceptable product includes the following specifications.

- Excess oxidizing and reducing agents are to be eliminated. Iron should be present as Fe(III), with no detectable free chlorine or Cr(VI).
- The feed pH is to be adjusted in the range of 7-8.
- Algae and bacteria growth should be inhibited.
- Large grit particles that might interfere with pump performance should be removed.
- Heavy films and two-phase systems must be skimmed (until/unless the filtration system has proven its ability to handle them).
- Cationic surfactants are to be avoided (especially for UF/RO) but can be precipitated with anionic surfactants if necessary.

No decontamination factor is associated with pretreatment.

3.2 Filtration Product

The object of filtration is to remove all suspended material, including colloids, so that fouling and/or colloidal transport do not affect the subsequent stages of the F/HETF adversely.

The product of the filtration stage will go directly to reverse osmosis and then to ion exchange. Therefore, it should meet the following specifications.

- The Silt Density Index of the product must be less than 3.0 and preferably <1.0. (See Appendix E for a discussion of SDI measurement.)[1]
- The total iron concentration should be less than 0.1 ppm.
- The reactive silica concentration should not exceed 7.0 ppm as SiO_2 (for a 20:1 reverse osmosis concentration factor).
- The pH of the product should be in the range of 7-8, although extremes are tolerated for short durations by reverse osmosis membranes.

- The temperature of the product should be constantly maintained in the range of 35-40°C. Lower temperatures result in poor flux and fouling due to the precipitation of concentrated material.

The decontamination factor afforded by filtration may be significant (see Appendix C and Section 4.2).

3.3 Reverse Osmosis Product (Ion Exchange Feed)

The product from the reverse osmosis stage of the F/HETF will be relatively clean permeate which has been filtered through the reverse osmosis membranes. It will have the following characteristics.

- RO permeate will have a conductivity that is roughly 20 micromhos/cm, or 5% of the initial feed.
- Except for that selective transport of carbonate or ammonia, the permeate will be at roughly the same pH as the feed. However, dissolved gasses are not rejected.
- Acid or base may be added to the RO feed to minimize fouling problems or to improve rejection, thus adjusting permeate pH within the range of 4-10.
- The radioactivity in the permeate will be less than 5% of that present in the initial feed stream.
- The permeate will contain virtually zero suspended particles, colloidal material, and undissolved solids which could otherwise transport activity through ion exchange columns.
- The volumetric ratio of permeate to concentrate will range from 10 to 20:1, depending on the chemistry (i.e., silica concentration) of the feed. A ratio of 12.3 should be easily achievable with filtered F- and H-Area daily effluents at 35°C. This ratio can be improved considerably with the use of chemical additives to prevent RO scaling.

See Section 4.3 and Appendix C for Decontamination Factors.

3.4 Ion Exchange Product (to the Environment)

The final product of the F/HETF will be suitable to meet all current regulations concerning effluent quality. The proposed system would normally discharge neutral, filtered, deionized water, with virtually nothing else detectable by normal methods. The only measurable remaining contaminant would be tritium

See Section 4.4 and Appendix C for Decontamination Factors.

3.5 WMETF Evaporator Overheads

The overheads from the F/HETF evaporator will be carefully characterized before a final decision is made either to recycle them through all or part of the ETF or to release them to the environment. Any undesirable recycle buildup will be addressed by nonregenerable ion exchange. These questions will be decided on the basis of the criteria established for the F/HETF releases.

SECTION 3 REFERENCE

1. Permasep Engineering Manual, Bulletin 506, E. I. du Pont de Nemours and Company, Wilmington, DE 19898 (1982).

4.0 PROCESS DESCRIPTION

4.1 Pretreatment

The pretreatment process will provide a product consistent with the description given in Section 3.1. The process will consist of the following stages (Figure 4.1-1).

- A grit removal basket or chamber for removing foreign objects
- An underflow section for the separation of two-phase systems
- An oxidation step (preferably ozonolysis) to control algae and bacteria, to convert all iron to filterable Fe(III), to destroy phenol[1] and to reduce organic fouling
- pH adjustment (7-8) to minimize iron/silica solubility for more effective filtration. A two tank cascade with automatic on-line adjustment should be considered.
- Equilibration time (in pH adjustment) to allow for the dissipation of ozone
- Temperature adjustment (Range 35-40 C) for reverse osmosis
- Special chemical addition stage

Options also include the addition of flocculants, including alum and ferric iron, powdered activated carbon, and anionic surfactants. Pumping capability should be adequate for these materials.

4.2 Filtration

4.2.1 General

As stated in Section 3.2, the primary purpose of filtration is to provide a feed of adequate quality for treatment by reverse osmosis and ion exchange. Filtration will also reduce the amount of activity that the rest of the system will have to remove, but the decontamination factors will vary considerably from one radionuclide to another, depending on adsorption and solubility characteristics.[2-3] The main candidates for the filtration stage were tubular precoat filtration, multi-media filtration, and ultrafiltration. Tubular precoat filtration is the current reference process.

4.2.2 Tubular Precoat Filtration

4.2.2.1 General

Tubular precoat filtration is an efficient and inexpensive method of handling the low suspended solids streams expected as feed to F/HETF. Tubular precoat filters are widely used in the nuclear power industry, predominantly in fuel pool and reactor water loops.[5] Graver and Delaval filter demineralizers are typically operated in secondary water loops of pressurized water reactors to filter and deionize recycled water. The fiber wound tubes are precoated with powdered ion exchange resin and used in the filtration cycle until ΔP becomes large or ion breakthrough occurs. The resin is then backwashed as a dilute slurry and a fresh precoat is applied. A tubular precoat filter has been in operation at Savannah River for over 20 years.[6] The fuel pool in RBOF uses a Porostone filter precoated with diatomaceous earth as pretreatment for the mixed bed ion exchange column, which removes radioactivity and maintains deionized water in the system. The dilute backwash slurry from this filter currently goes to Tank 23.

The recommended filter for F/HETF is a Mott Inverted PHP (pneumatic hydropulse). Filtration is performed by a thin layer of filteraid (precoat) supported on the interior of a sintered metal tube. Filtration is inside out. The filteraid and accumulated solids are periodically removed by backpulsing the filter. A fresh precoat is applied and filtration resumes. As a result of lab and vendor (Mott Metallurgical) tests, the following operational parameters are recommended:

• Filteraid	Standard Supercel
• Precoat	0.1 lb/ft^2
• Body Feed	25 ppm
• Flux	1.0 gpm/ft^2
• ΔP	30 psi
• Media	2.0 μm

4.2.2.2 Feed Requirements

The pretreatment as outlined in Section 4.1 is compatible with tubular precoat filtration. A grit chamber will remove large, settled solids leaving a low suspended solids feed stream. Control of bacteria and algae by ozonation, chlorination, or ultraviolet is important to prevent blinding of the filteraid, and the resulting decrease in cycle time. Adjustment of the pH to neutrality minimizes iron and silica solubilities making filtration most efficient.

4.2.2.3 Product Quality

The primary goal of filtration is to produce a feed stream suitable for reverse osmosis. A relative measure of feed quality used in the RO industry is the Silt Density Index test. SDI values less than 3.0 are recommended for F/HETF. The SDIs on product from tubular precoat filtration are approximately 1.0. Feed for these tests has included simulant, Trebler composites and process cooling water (PCW) to simulate a cooling coil release (Section 4.2.2.5). Total suspended solids (TSS) which have been measured on feed and filtrate samples correlate well with the SDI values.

In addition to producing high quality feed for RO, filtration will provide significant removal of radioactivity. The insoluble radionuclides, e.g., Ce, Ru, Zr/Nb, will be removed by submicron filtration. The soluble radionuclides Cs and Sr also can be removed by using an ion-specific filteraid to adsorb these species and provide additional decontamination. Use of these materials may not be practical or beneficial in daily operation of F/HETF, but may prove useful in treating a high activity release.

4.2.2.4 System Design

In the reference process, stage one of F/HETF will include a 200 sq ft, Inverted PHP filter (Figure 4.2.2-1), a 5 M gal day tank for the precoat slurry, a 5 M gal body feed tank, and polishing cartridge filters. Filter operation is automated and cyclic:

- Precoat
- Filter
- Backwash

The tubes are precoated with a 0.25 wt % diatomaceous earth slurry in a once through mode (recycle not required). Filtration starts and continues until a predetermined ΔP is reached (~30 psi). Diatomaceous earth body feed (~25 ppm) is continually added online during filtration. The tubes are then backpulsed (air and/or filtrate) and the 20-30 wt % slurry transported to waste disposal. The cycle repeats. Precoat and backwash operations total approximately 5 minutes out of the >2 hour cycle. The batch operation of this filter requires either dual filters or adequate filtrate hold capacity to interface it with the continuous reverse osmosis process.

Downstream cartridge filters protect the reverse osmosis membranes against diatomaceous earth leakage or process upsets. Two cartridges in series, a 2-20 μm cartridge followed by a submicron membrane cartridge will produce RO feed of <0.1 ppm suspended solids.

4.2.2.5 Testing and Procedures

Sampling

A variety of samples were used in the experimental work to represent the extremes in feed composition expected for F/HETF. The feed will vary considerably depending on whether the facility is processing routine effluents or treating a canyon or tank farm release. The test samples ranged in activity from a cold simulant to the high activity samples representing a cooling coil release. Decontamination factors were obtained from the canyon and Trebler samples, while much of the process data came from testing with PCW and simulant. The following is a description of the test samples and what type releases they represent:

	Sample	Description	Radionuclide Content (d/m/mL)
1.	1AF/H	First cycle feed, H-Canyon (Vessel 12.3) 10^5 or 10^6 dilution	Ce-144 = 7.27E5 Ru-106 = 1.04E5 Cs-137 = 9.99E4 Zr-95 = 3.70E3
2.	Raw Metals/F	Dissolver solution, F-Canyon (Vessel 8.1) 10^5 dilution	Ce-144 = 2.73E4 Ru-106 = 7.43E3 Cs-137 = 3.98E3 Zr-95 = 1.40E3
3.	HAW/F	High activity waste evaporator, F-Canyon (Vessel 9.3) 10^5 dilution	Ce-144 = 2.52E5 Ru-106 = 9.46E4 Cs-137 = 4.09E4 Zr-95 = 7.91E5
4.	PCW	Process cooling water, Bldg 773-A	None
5.	Trebler	Weekly composite samples collected at the Trebler monitor (spiked with 1AF/H)	Cs-137 = 1E2 {Cs-137 = 2E2 Ce-144 = 1E2 - 1E3 Ru-106 <1E2
6.	Simulant[7]	Nonradioactive sample based on F & H-Area average effluent concentrations (addition of hazardous metals includes includes Cr, Cu, Hg, Pb, Zn)	None

Experimental

Initial batch testing was performed to determine decontamination factors for filtration using a variety of filteraids (Table 4.2.2-1). These tests were conducted by stirring a known amount of filteraid (50-5000 ppm) in a 15 mL test solution for one hour. The slurry was filtered (0.45 μm Millipore or Nalgene) and the filtrate analyzed. DFs were determined vs. filteraid composition and dosage.[8]

Process information as well as DFs for tubular precoat filtration has been obtained from constant rate tests in three different experimental setups. Preliminary test work at SRL was performed on a 45 mm diameter, 2.0 μm Mott sintered metal disc. The disc is typically precoated at 0.1 to 0.2 lb/ft^2, then feed is pumped through the filter at a constant rate, 1 GPM/ft^2. Run cycle time is determined by ΔP across the disc. At ~30 psi the run is terminated. Information gained from these tests includes: optimum precoat and bodyfeed amounts, run cycle time, flow rate, filtrate quality. Testing at Mott Metallurgical used a 70 mm disc (0.5, 2.0, and 5.0 μm media), and results were in agreement with earlier work.[9] Additional information from these tests includes: filter cake quality, wt % solids, cake release, and media fouling tendencies. Scaleup from disc to a single tube test unit was also conducted at Mott. This automated system simulated the cyclic operation of the recommended tubular precoat filter.

4.2.2.6 Results

Batch tests determined that use of a charged filteraid or powdered ion exchange resin can enhance the filtration DF by removing soluble radionuclides. The charged filteraid Cuno, zeolite, and powdered ion exchange resins each remove the soluble ionic species by providing ion exchange sites. The DF increases with filteraid dosage and at 5,000 ppm the Cs and Ru removal is significant (Table 4.2.2-2). Because these materials are not specific for the radionuclides (except for the zeolite), this mode of operation is not recommneded on a daily basis due to the increase in solid waste. In an accident scenario (typically low TDS) however, there is the option of replacing the standard diatomaceous earth filteraid wit an ion exchange material to obtain a higher DF. Though the powdered ion exchange resins provide a higher DF than Cuno, the charged material is almost identical to the Standard Supercel used in daily operation and can be substituted with no process changes.

Constant rate tests performed on both disc and tubular media[9] have been used to optimize the parameters (Section 4.2.2.1) for tubular precoat filtration (Table 4.2.2-3). Cycle time is based on a predetermined ΔP (~30 psi) and will vary depending on the feed solids level. Trebler samples have yielded cycle times from two hours to several days (extrapolated). The simulant generally gives cycles between 90 min and two hours. A two-hour cycle time is a conservative estimate of F/HETF daily operation (feed <25 ppm suspended solids). In the case of a cooling coil release the cycles are expected to be several days based on results using PCW. This is a low suspended solids feed compared to the daily effluents. The third type of feed is storm water from a tank farm spill. This stream is typically higher in suspended solids (~50 ppm) than the Trebler, and shorter cycle times can be expected. Constant rate tests will be performed on storm water samples collected at 200-Area outfalls.

Information on DFs has been obtained in several of the constant rate tests. Trebler samples are spiked with high activity waste (1AF/H) and Sr-85 to obtain detectable amounts of Ce, Ru, and Sr. Filtration generally removes all Ce-144 and Ru-106. When no Ce or Ru is detected in the filtrate, the DF is calculated based on the feed/lower limit of detection (Table 4.2.2-4). Removal of the soluble Cs and Sr is not expected and the corresponding DFs are ~1.0. The chemical species which can be removed by filtration are the insoluble (at pH=7) Fe and Al hydroxides. Soluble salts, i.e., Ca, Mg, Na are not removed. Silica will not be filtered unless it is part of a large colloid (>0.5 μm), or a coagulant such as alum or ferric chloride is added (Table 4.2.2-5).

4.2.2.7 Waste Generation

The waste solids in the stream from tubular precoat filtration will be almost 100% DE. The 20-30 wt % slurry may be directly incorporated into saltstone. Based on a 200 GPM, 20 ppm suspended solids feed, the waste stream from the filter operation on two- and eight-hour cycles will have the following composition:

Solids	Amount	Pound/Day	
Feed, suspended	20 ppm	48	
Precoat	0.1 lb/ft^2	240 (2 hr cycle) 60 (8 hr cycle)	
Body Feed	25 ppm	60	
Total Solids		348 2 hr cycle 168 8 hr cycle	(98% DE) (71% DE)

Addition of the filteraid will increase the F/HETF solid waste by 5-9% (by weight) depending on cycle times. Discussions of waste generation are continued in Section 4.6 and Table 4.2.2-5.

4.2.2.8 Service Life

The Inverted PHP is a rugged piece of equipment, fabricated entirely out of 316 and 316L stainless steel with the exception of viton seals and qarfoil gaskets. The low activity levels in the F/HETF[10] and the performance of Mott sintered metal filters during the in-tank precipitation demonstration,[11] indicate use in radioactive service will not cause system degradation.

In repeated testing the sintered metal media has shown no signs of fouling - confirmed by bubble point tests before and after testing. In operation the solids are periodically removed from the filter and a fresh precoat applied. These automated cycles prevent media fouling by allowing the filteraid to be the primary barrier. When flux is no longer returned after a backwash cycle, the filter can be cleaned with an oxalic acid rinse. This cleaning method is successfully used in RBOF and is effective in removing precipitated metal hydroxides.

4.3.3 Ultrafiltration

4.2.3.1 General

Ultrafiltration involves the use of a membrane to separate virtually all suspended material from a given feed stream. These membranes typically reject particles larger than 10-100 angstroms (0.001 to 0.01 microns). From a nuclear waste processing standpoint, the "state-of-the-art" form of ultrafiltration involves the use of a so-called "dynamically formed" membrane, which is formed in place on a tubular substrate, and can be removed and reformed without having direct access to the membrane-supporting substrate. This minimizes operator exposure, and results in high system attainment.

A series of tests have shown that the ultrafiltration membranes and modules built by Carre, Inc. (Seneca, SC) provide excellent filtrate quality and are both rugged and flexible in their application.[12,13] They use a zirconium oxide membrane on a sintered stainless steel tubular support, and operate at pressures in the 300-1000 psi range. Furthermore, this filtration is designed to be operated remotely.

4.2.3.2 Feed Requirements

The feed to the ultrafiltration stage should be pH adjusted to prevent the accumulation of partially soluble iron in the membrane pores. The membranes themselves will tolerate a broad range of pH (pH 2-14); but Fe(III) has a tendency to precipitate within the membrane pores if Fe(II) is present at a pH above 4. For this reason, a pH of 7-8 is recommended for converting Fe(II) to filterable Fe(III).[12,13]

The operating temperature of the ultrafilter determines the water flux through it, with log flux proportional to 1/T °K. The slope of the line describing this relationship is roughly 2000-3000 (negative), meaning that the flux approximately doubles for every 30°C of temperature increase (around ambient). However, temperature does not affect filtrate quality, except where changes in water solubility are involved. The SRL testing program has presumed that the ultrafilter would operate at the same temperature as the reverse osmosis system (35-40°C).

Cationic surfactants can have a detrimental effect on the performance of zirconium oxide membranes because they tend to accumulate and form a second membrane layer, resulting in a thicker membrane and less flux. They should therefore be avoided as much as possible. Anionic surfactants can be beneficial, however, as they tie up cationic surfactants and generally foster precipitate rejection.

4.2.3.3 Product Quality

As with reverse osmosis, the product from the ultrafiltration system is called the permeate. It is the highest quality feed that can be provided to reverse osmosis (short of using reverse osmosis permeate itself). It contains essentially no suspended solids, and only the amounts of oil, grease, and sparinglyly soluble salts that are actually dissolved in solution. The Silt Density Index of the product, referring to the relative pluggage rate of a filter (see Appendix E) by suspended solids, is invariably lower than could be conveniently measured, whenever tests with simulated feed were performed.[13] This indicates that ultrafiltration is an excellent pretreatment filter to condition feed for reverse osmosis and ion exchange as well.

Permeate can be produced continuously by the ultrafilter, making it directly compatible with reverse osmosis. Because its mechanism of operation is similar to that of reverse osmosis, it excludes material that has the potential to foul or ruin the reverse osmosis membranes. This includes emulsified oils and greases, ferric iron, and silica, but not dissolved materials (e.g., calcium sulfate, dissolved silica, etc.) which can form scale on RO membranes.

4.2.3.4 Waste Generation

The Carre tubular UF produces waste a concentrate made up of all the suspended solids in the original feed stream, including precipitated metal hydroxides, and almost all of the colloids and emulsified material in the feed as well. In the F/HETF, this concentrate stream would be about 5 gpm, and would be recycled until it became concentrated by a factor of about 5000, compared to the original feed. It would then be bled from the recycle stream, at the rate of about 2.4 gallons/hour. (Batch operation of this system has theoretical advantages, particularly using concentrate hold and batch recycle, but the desire for simplicity, combined with a need to produce a constant feed to the reverse osmosis system, seems to make a continuous, steady-state operation more attractive.)

A second source of waste arises from the use of cleaning and rinsing solutions to restore the flux (filtration rate) that the tubular UF loses after many hours of continuous operation. Straightforward chemical cleaning with citrate and caustic wash solutions restored 90% of the flux that was lost during high concentration tests over periods of 88 and 176 hours.[13] The cleaning solutions which proved most effective were:

- 2.5 wt % sodium citrate (pH 6.0)
- 1.0 g/L $NaHSO_3$ (pH 2.5)
- 1.0 M caustic

These were each used at the rate of about 1.5 gal/ft^2 in testing at SRL, and were projected for use about once a week. They were applied to the feed (concentrate) side of the UF membranes at a pressure of 300 psi.

An improved backflush (permeate side) cleaning procedure has been demonstrated. Using this method after a 12-hour high concentration (10 wt % ferric iron/silicate) test, flux was completely restored without the use of chemical cleaning agents.[13] Therefore, the use of chemicals is now projected to be far lower than was indicated in the preliminary SRL tests. Also, because of the lower chemical ($NaHSO_3$ and citrate) useage, almost all of the backflushed material may be recycled to the UF feed tank, rather than going to waste or to the F/HETF evaporator. The discussion of waste volume and character is continued in Section 4.5.

4.2.3.5 Design

The design parameters for ultrafiltration have been determined for waste of average composition, as defined in Section 2. Testing programs at Carre, Inc. and SRL have yielded the parameters required for system design. These have been applied to a system at the scale of 75 gpm in Table 4.2.3-1.[12] Scale-up to 200 gpm is essentially linear, and the design parameters have since been verified at SRL.[13]

As mentioned above, testing (at both SRL and Carre) has shown that this basic design can be maintained while using concentrate recycle to obtain concentration factors of 5000 or more on suspended solids concentrations of 25 ppm. Mixed ferric iron and silicate concentrations of over 10 wt % have been obtained with only a nominal loss of flux. Temperature corrected flux for a test witnessed at Carre was at least 0.09 (gal/ft^2-psi/day), even after the addition of excess reactive silica (water glass). Similar results were obtained at SRL (see Figure 4.2.3-2).[13]

In tests at Carre, loss of flux was reversed completely by backflushing with clean process water. Excellent flux recovery was also demonstrated at SRL.[13] Backflushing is accomplished by valving out the UF module, and pumping at 100 psi (or less) on the shell side, while rinse solution is pumped at less than half that pressure through the tubes. The backflush pump is required only to develop about 50 psi more pressure than in the filtration tubes. At this ΔP, the flow rate is only about 5% of normal (forward flow) for the module being backflushed.

4.2.3.6 Operation

The ultrafilter will produce permeate constantly at a rate determined by the speed of the high pressure feed pump and the backpressure which is let down through a throttle valve (or pump). Since the feed pump is positive displacement, the operating pressure of the system will be determined by the throttle valve, which, as in reverse osmosis, establishes the ratio of concentrate to permeate. The operation of the ultrafilter consists of monitoring the feed, permeate, concentrate, and concentrate recycle flows and the feed pressure. These remain relatively stable, with the feed pressure rising gradually in response to reduced flux through the UF membranes. A schematic of this equipment is shown in Figure 4.2.3-1.

At the start of operation, the concentrate stream would recycle continuously until a designated permeate rate or feed pressure is reached. The concentrate bleed valve (or pump) would then be opened to allow a constant bleed of concentrate. During this equalization period, permeate would be produced at a constant rate to feed reverse osmosis. Initial permeate flux would be somewhat higher than the design basis, so the pressure developed by the system would also be low initially (see Figure 4.2.3-3).[13]

The UF system would be designed to have extra modules (75 ft^2 @) that could be valved into service as others were taken offline for cleaning. At a rate of one cleaning per module-week, a forty module system would require that eight modules be valved out, backflushed, and cleaned, every day shift. Although backflushing could be accomplished automatically, the cleaning procedure would have to be monitored if chemical cleaning were required.

4.2.3.7 Service Life

The filtration equipment described above is extremely rugged, being fabricated entirely of 304L and 316 stainless steel, except for valve seats, gaskets, and the pump diaphrams. The calculated impact of radiation on the materials of construction is minimal, because of the generally low amounts of activity that will be encountered. Worst case process feed (containing .05 Ci/gal) has been calculated to irradiate a polyethylene tank liner at the rate of 11.6 rad/hr. Normal dose rates were found to be only 50 mrad/hr.[10] Therefore, teflon materials (damage threshold = 1E5 rads) may be considered if they are most appropriate for a specific application (e.g., diaphrams on the high pressure pump).

Except for their tendency to plug with iron (below pH 6.5) the ultrafiltration membranes have not given any indication of failure in the hundreds of hours over which they have been tested.[12,13] However, continuous online pilot testing is necessary to accurately predict membrane life.

Should a membrane failure occur, the manufacturer will either reform the membrane in place (remotely) on a service contract basis, or they will provide the necessary training and reagents so that this can be done by SRP employees. Plugged UF modules regain their initial flux and overall performance following a 4 to 6 hour stripping and regeneration procedure. This was demonstrated at Carre[12] and at SRL.[13] Modifications to the original cleaning procedure appear to restore membrane performance without having to resort to regeneration. Fees and arrangements for this service are negotiable, depending on the projected service life in the intended application and the response time demanded. As part of a service contract, the vendor would provide improved membrane formulations as they were developed.

4.2.4 Multiple Deep Bed Filtration with Polishing

Multiple deep bed filtration was the process defined to meet the scope of the original project to decontaminate accidental radioactive discharges to the 200-Area diversion basins. It was not intended for continuous operation over several years. Therefore, the range of feed compositions and the filtrate quality requirements were not as demanding as they now are for the F/H Effluent Treatment Facility.[14]

The multiple deep bed filtration system which was proposed for the original application is shown in Figure 4.2.4-1. It is similar to systems that are widely used in conventional water treatment, and would normally provide an acceptable feed for reverse osmosis. However, routine operation of this system on F and H-Area effluents would produce large backwash volumes (i.e., 10-20 gpm) which would require further volume reduction. Furthermore, there is evidence that filtrate quality would be inadequate for some feeds.[15,16]

4.3 Reverse Osmosis

4.3.1 General

The primary function of reverse osmosis (RO) in F/HETF is to remove the bulk of the dissolved solids ($NaNO_3$) prior to ion exchange. In this mode of operation RO preserves ion exchange capacity and thus lowers the total waste volume generated. Because RO also will remove any suspended solids remaining after filtration, it will provide an excellent quality feed for ion exchange. Use of the RO as a filter however, can be detrimental. Concentration of the suspended solids in the RO will tend to foul the membranes resulting in decreased productivity and salt rejection.

4.3.2 System Design

The reverse osmosis section of F/HETF will be a three-staged system As described by Figure 4.3-1 the RO concentrate is staged and the permeate from each stage is collected and sent to ion exchange for further decontamination. This design provides maximum waste concentration - 90 to 95% of the dissolved salts are concentrated in 5 to 10% of the initial volume. Based on a feed concentration of 2000 ppm at 200 GPM the RO will produce a 111 ppm permeate stream (20 GPM) and a 18,960 ppm concentrate stream (180 GPM).

4.3.3 Feed Requirements

Successful operation of reverse osmosis is directly related to feed quality. Proper design of pretreatment and filtration steps to deliver high quality feed will minimize membrane fouling and insure optimum performance and life. As discussed in Section 3.0, membrane fouling is prevented by minimizing the levels of colloidal material, bacteria and algae, and sparingly soluble salts of calcium and magnesium. Each of these materials will potentially precipitate forming a thin film on the membrane surface and lowering productivity. The polyaramide membranes must be protected against oxidants such as chromium (VI), iron(III), and chlorine, and extremes in temperature and pH.

4.3.4 Experimental

Sampling

A variety of samples were used in the experimental work to represent the extremes in feed composition expected for F/HETF. The feed will vary considerably depending on whether the facility is processing routine effluents or treating a canyon or tank farm release. The test samples ranged in activity from a cold simulant to the high activity samples representing cooling coil releases. Salt concentrations varied from less than 100 ppm to 2000 ppm. A description of test samples is outlined in Section 4.2.3.5.

Equipment and Procedures

Extensive bench scale testing has been carried out on three single-staged RO units.[17-19] Two similar units are located in SRL (Figure 4.3-2). One, in the High Level Cells, is used for testing high activity samples; and the second, located in a radiohood, is used for low activity and cold samples. The third system located at TNX, is used for cold testing. This RO unit originally was used to demonstrate rinsewater recycle in M Area. Unlike the two SRL units it contains three membranes in parallel. The feed pump is capable of supplying one or all membranes at 3 GPM.

All RO testing has been done with the FilmTec SW membrane (single element 2.5 x 40 in). This membrane has been chosen for F/HETF for several reasons:

- The FilmTec SW has a high salt rejection, especially nitrate. Membrane rated for 99.7% NaCl rejection.
- The spiral wound configuration is more tolerant of colloidal material than the hollow fiber.
- The polyaramide/polysulfone composition, unlike cellulose acetate, is resistant to bacterial attack.

Because each unit is single-staged, maximum water recovery in a single pass experiment is 13 to 19%. Water recoveries up to 95% are obtained by recycling the RO concentrate while continually removing the permeate (Figure 4.3-3). Typical operating parameters for the RO testing are listed in Table 4.3-1). Pretreatment consisted of feed neutralization and cartridge filtration (0.5 to 5.0 µm). The feed flow rate to each membrane was approximately 3 GPM. Lower pressure (400-500 psi) runs represent first stage operation while those at 700 psi represent operation of the concentrate stage (Figure 4.3-1).

The reverse osmosis runs are monitored by online conductivity measurements. Total salt rejection (SR) is determined by conductivity and defined as:

$$SR = 1 - \frac{\text{permeate conductivity}}{\text{feed conductivity}} \times 100\%$$

Design system salt rejection for F/HETF is 95% at 90% water recovery (Figure 4.3-1). Species salt rejections of DFs are determined by elemental analyses and gamma counting.

4.3.5 Product Quality

Reverse osmosis will remove any suspended solids remaining after filtration and 90-95% of all soluble salts (based on F/HETF system design). Efficient salt removal is important to preserve downstream ion exchange capacity and the associated evaporation and chemical expenses of regeneration. Primary concern in F/HETF, however, is decontamination or removal of radionuclides and hazardous metals, either of which may govern plant design and operation. (Discharge criteria currently being negotiated will ultimately determine DF requirements, Table 1.2-1.) Salt rejection data and DFs for radionuclides and hazardous metals were obtained from both simulated and real plant samples (Section 4.2.3.3).

A canyon process upset or tank farm spill has the potential to produce the highest activity feed for F/HETF. Samples 1-3 have been chosen for testing because they are early in the separations process and therefore contain a broad range of radionuclides. DFs are determined for the following gamma emitters: Ce-141, 144, Ru-103, 106, Cs-134, 137, and Zr/Nb-95 as well as by gross beta-gamma counting (Table 4.3-2). Much of the activity in these samples is filterable (Ce, Ru, Zr/Nb), and what remains due to incomplete filtration* or slight solubility is efficiently removed by RO.

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* RO test work used only minimal filtration-typically 0.5 to 10.0 microns.

At 90% water recovery decontamination factors for cerium and Ru were quite high. There is generally no Zr detected in the permeate (Table 4.3-2). The soluble radionuclide of concern in these tests is Cs-137. As expected, no DF is observed for filtration but cesium is removed by RO.

Both simulated and real process effluents have been used to determine RO performance in daily operation (samples 5 and 6). Compared to upset scenarios this feed is a high salt, low activity stream. Efficient salt removal is observed in simulant and Trebler tests - >97% salt rejection at 90% water recovery (Table 4.3-2). Specific ion rejections are at least as high as the total salt rejection determined by conductivity. Of particular interest is the complete rejection of silica. Silica concentrations are potentially the limiting factor for system water recovery. If the solubility limit of SiO_2 (140 ppm) is exceeded in the RO concentrate, the membranes will foul and flux will decline.

Complimentary to the observed salt removal data are the radionuclide decontamination factors. Cesium and Sr DFs were always greater than the system design value of 19 (Table 4.3-3). The higher DFs observed for Sr as compared with Cs are consistent with the behavior of mono and divalent ions.

The hazardous metals Cr, Cu, Hg, Pb, and Zn are present in the daily effluents in varying amounts. None of these will be significantly removed by filtration, so RO/IX will be expected to provide sufficient decontamination. In the test samples (5 and 6) the concentrations of all metals are generally greater than expected in the Treblers to insure reliable analyses (Table 4.3-4) In the batch concentration experiments a range of DFs has been observed, but in general metals removal is greater than total salt removal (design DF=19). Similar DFs are observed for mercury in both the ionic and metallic states.

4.3.6 Waste Generation

Two waste streams are generated by reverse osmosis. The concentrate stream will be 5% (at 95% system water recovery) of the feed flow rate and will go directly to evaporation (10 GPM). Periodic membrane cleaning will be required to maintain system performance. The cleaning solution either citric acid, BIZ or NaOH is needed to remove scalants (predominantly metal hydroxides) from the RO membranes. This solution will be sent straight to evaporation. The frequency of cleaning will be determined in pilot testing at the H-Area Trebler, but is expected to add an insignificant volume to the evaporators.

4.3.7 Service Life

No system degradation is expected due to radiation. Piping, valves and connections can be fabricated out of stainless steel. The durability of the polymeric membrane materials in a radiation field was tested. No degradation in membrane (FilmTec, Permasep and Desal) performance was observed after irradiation at up to 50 megarads in a Co-60 source.[20]

When in-situ cleaning no longer restores performance, membrane and housing will be removed and replaced.

4.4 Ion Exchange

4.4.1 General

Ion exchange includes three catagories of adsorption substrates. These are: ion exchange resins, selective ion exchange media that are regenerable, and nonregenerable zeolites.

4.4.2 Feed Requirements

Ion exchange adsorption occurs at the molecular (ionic) level. Therefore, a contaminant has to be dissolved in the column feed solution in order to be efficiently removed by ion exchange. Contaminants on particulate matter tend to pass through ion exchange columns. There are several materials that can interfere with ion exchange efficiency as it applies to the decontamination of waste effluents. Particulates, foulants and "poisons" can all be detrimental, and concentrated salt solutions tend to use up ion exchange capacity quickly, which results in undesirably short service cycles.

Chemicals which may act as foulants or "poisons" include ionic surfactants, oils, greases, and certain amines and heavy metals which react with ion exchange columns but are difficult to elute. Most of these materials are rejected by the filtration systems that are described for reverse osmosis pretreatment, but many column poisons are not. These problems are mostly eliminated by preceding the ion exchange stage with reverse osmosis, however.

The service cycle of an ion exchange column is dependent upon the salt load which reaches it. This is especially true of non-selective adsorption substrates, where reducing the salt load increases the length of the service cycle proportionately. Treatment of the feed stream by reverse osmosis is projected to remove 95% of the salt load to the ion exchange system. Therefore, with reverse osmosis pretreatment, the same ion exchange column will operate approximately 20 times longer on each service cycle, and provide a higher decontamination factor in the process.

In any case, a highly efficient filtration system is required in front of ion exchange if the full decontaminating potential of the ion exchange system is to be realized. This prevents contamination from moving through the column in an undissolved form and protects the column from materials that would degrade its performance.

4.4.3 Product Quality

Given that the feed has been treated to optimize the performance of the ion exchange system, the quality of the product will depend entirely on the type of exchange system that is chosen. Selective ion exchange can provide a high decontamination factor, but only for specific contaminants. On the other hand, mixed bed ion exchange can provide a significant decontamination factor for virtually all species (except for tritium). Estimates of the contamination that would be released by each of the F/HETF processing options are listed for selective and nonselective ion exchange in the curie balance (Decontamination Factor) tables in Section 4.6.

The specific resistance of the product obtained using a strong acid-strong base resin mixture for a typical well water feed can be on the order of 18 megohm with adequate feed preparation.[21] Dow Chemical estimates more conservatively for their product, at 1-4 megohms or 0.2-0.5 ppm total dissolved solids (TDS) for a feed stream that contains less than 500 ppm TDS (as $CaCO_3$).[22] Even so, this corresponds to a decontamination factor of approximately 1000 for gross conductivity. Higher TDS feeds and those which contain large organic molecules and particulates are generally deionized with less efficiency. Conversely, efficiencies are generally improved in the treatment of high quality feed streams (i.e., permeate from a reverse osmosis system).

At SRP the MG-1 resin typically provides decontamination factors of better than 20-30 in a deionized recirculating system which operates behind a precoat filtration system.[6] Actual performance may be much better, because the effluent activity is well below the detection limits of the monitoring system.[23] In practice elsewhere, decontamination factors of 1000 have been obtained for low level activity by using mixed bed ion exchange.[24]

The effluent quality from ion exchange systems is dependent on the completeness of the regeneration process. Material that is adsorbed on a column must be eluted as completely as possible to prevent it from eventually leaking into the product stream. Mixed bed ion exchange is normally an exception to this rule when the resins are used in the acid and base forms, because the equilibrium driving force, the formation of water, is highly favorable (K_w=1E-14). However, the effect of regeneration completeness on decontamination efficiency requires experimental evaluation.[25]

4.4.4 Ion Exchange Resin

4.4.4.1 Mixed Bed

Because of the broad range of contaminants,the highest decontamination factor that can be designed into the F/HETF would be provided by mixed bed ion exchange, possibly together with an additional, more selective column (or columns). Because it is normally regenerated to only about 90% of full capacity, mixed bed ion exchange is also competitive in terms of the waste volumes it would generate, compared to separate anion and cation exchange columns. Both of these observations are considered in Section 4.6.

There are several mixed bed resins suitable for application in the F/HETF. The deionizers which are presently used at SRP contain a mixture of two different resins made by Rohm and Haas Company (Philidelphia, PA), one a strong acid resin (IR-120), and the other a strong base resin (IRA-400).[21] Together, called MB-1, these can provide excellent performance in the total deionization of water. Savannah River water contains roughly 0.5 meq/L, and would consume MB-1 mixed bed resin at the rate of about one bed volume of resin per 1500 bed volumes of water. Without reverse osmosis pretreatment, the 200-Area effluents carry about 60 times that salt load, and the same resin would be consumed in only 20 bed volumes.

An attractive option to the IR-120/IRA-400 system is to use strong acid resin mixed with weak base resin. These resins are extremely useful in applications like the F/HETF where the removal of extremely weak acids (i.e., silica) is not critical. Rohm and Haas MB-4 (a mixture of IRA-94 and IR-200) and Dow Chemical Company's Dowex MWA-1 are examples of new products of this type, and are reported by their respective manufacturers to have far better kinetics than older weak base ion exchange resins. They can, therefore, provide excellent effluent quality combined with optimal regeneration efficiency. This combination results in less waste generation and lower chemical usage. Weak base resins are also resistant to poisoning by amines, and the macroreticular products are reported to be resistant to fouling also.

A stoichiometric mixture of MB-4 contains roughly 710 meq/L. If the average feed to the F/HETF contains 30 meq/L, this resin would have the capacity to treat approximately 26 bed volumes of feed during each service cycle. However, reverse osmosis pretreatment would eliminate 95% of the salt load, permitting the treatment of over 500 bed volumes before regeneration was required. This translates to the consumption of less than 70 ft^3 of resin in 24 hours of processing at 200 gpm. Mixed bed regeneration frequency would be reduced much further by including dual bed treatment immediately after reverse osmosis (Figure 4.4.4-1) making a three-bed ion exchange process.

4.4.4.2 Multiple Bed Ion Exchange

While recognizing that the fundamental aim of the F/HETF is decontamination, not deionization, multiple bed design is more effective from a decontamination and waste generation standpoint than either a dual bed or a mixed bed system along (see Table 4.4.4-1). The designs that have been considered are given schematically in Figure 4.4.4-1). Design 1 is a standard multiple bed system, which would perform roughly as described in the decontamination and waste generation tables under the descriptor "dual bed". Design 2 combines mixed bed and dual bed ion exchange into an efficient three-bed system.

4.4.4.3 Selective Ion Exchange

The selective exchange substrates that were considered in the design ot the F/HETF include zeolites, organic resins, and ion exchange glasses. These materials are generally selective for cesium and strontium, but some measure of decontamination can be obtained for most polyvalent cations. Of the regenerable materials, the Durasil glasses and Epicor Cs-1 resin appear most promising, as they have good capacity for Cs-137 and can be regenerated. The main deficiency of selective adsorption substrates is their inability to treat the entire range of radioactive contaminants (see Section 4.6).

Nonregenerable exchange materials are classified here as zeolites. They are capable of excellent performance on selected contaminating species, but they require special design for solid waste handling. Probably the best option in using these materials would be to design a canister which would act as the disposal cask after serving as the adsorption column.

4.4.5 Ion Exchange Design

The interfacial flow velocity permitted for ion exchange feed ranges up to 25 $g/m/ft^2$ in typical deionization processes. However, channeling can be detrimental to the performance of ion exchange beds, and is less prevalent at slower flow rates. A good design flow range is 5-10 g/m/ft^2.

Regeneration may be critical to the operation of the system. Efficient regeneration requires slow flow rates, to prevent resin mixing and permit almost complete equilibrium between the resin and regenerant. A sufficient amount of regenerant is essential also, which translates to both time and waste volume. All of these parameters should be optimized at the pilot scale, but a regenerant flow rate of 0.5-1.0 gpm/ft^3 is recommended (Rohm and Haas).

Ion exchange regeneration at SRP is typically performed with sodium hydroxide and nitric acid. Furthermore, the ion exchange load to the F/HETF is almost entirely sodium nitrate. Therefore, design will need to include temperature control and adequate circulation to prevent overheating and rapid oxidation of the resin. Procedures at SRP cover cation exchange regeneration with nitric acid, as well as resin classification and anion exchange regeneration.

The most practical design for ion exchange polishing in the F/HETF is a three-bed system (Figure 4.4.4-1). This combines relatively simple operation with highly efficient decontamination. The beds could be designed for bimonthly regeneration of the mixed bed resin column, most of the salt load being handled by the dual ion exchange columns, which can be regenerated in place relatively easily. Duplication would be necessary for continuous operation.

4.5 Evaporation

4.5.1 Feed

The evaporator feed will consist of all concentrate from the reverse osmosis system. This will be approximately twenty times more concentrated in all soluble ions than the F/HETF feed, except those removed by the filtration system (i.e., iron). A summary of the average feed chemistry is given in Table 4.5-1.

Feed may also contain up to about 1% suspended solids as the result of cleaning filtration equipment, and activity levels will be 2 to 20 times more radioactive than F/HETF feed.

4.5.2 Product Quality

The evaporator overheads are to provide a decontamination factor of approximately 1E4 for all nonvolatile materials. Concentrate (bottoms) is to be released to approximately 30 wt %. Overheads will be released to the environment after the appropriate polishing treatment, but will be recycled through the F/HETF if necessary.

4.5.3 Design

The evaporator must be designed to handle high solids content, without fouling. Evaporator-Crystallize technology may be required to keep many of the minor components from contributing to scale formation.

Polishing, consisting of ion exchange treatment, should be available in case inadequate DF's are achieved in the evaporation process. The resin should be buried upon exhaustion, unless the regerant is sent directly to waste solidification, in order to avoid a recycle loop.

4.6 Waste Production

4.6.1 General

There are four basic processes in the F/HETF which may generate waste. These are filtration, reverse osmosis, ion exchange and evaporation. The contribution of each process to the total waste volume will depend on several factors, but can be calculated once interdependencies are taken into account. The basis for these calculations is discussed below.

4.6.2 Filtration

The waste generated by filtration is characterized by the mass of filterable solids in the feed (about 70 ppm), the feed volume (mass/unit time), and the volume of waste concentrate. Also of interest are the qualities of the waste concentrate, including its density and rheological properties which affect processability. The projected flow volumes and concentrations for pretreatment and filtration are listed in Table 4.6-1 for each of the filtration processes which have been considered for the F/HETF. Final waste volume and any flows to the F/HETF evaporator are also given. The variables in Tables 4.6-1 and 4.6-2 are represented schematically in Figures 4.6-1, 4.6-2, and 4.6-3.

Tubular precoat filtration (TPF) involves the addition of filter aid to the feed stream, as a "body feed", as well as a layer of filter aid "precoat", which is laid on the filter cartridge before exposing it to the feed. The body feed and the precoat make up most of the solids in the filter backflush, which is the waste concentrate (see Figure 4.6-1). This stream can be up to 30 wt % solids.

Approximate waste volumes and concentrations for tubular precoat operation are listed in Table 4.6-1 (also see Table 4.2.2-6). Cases 1-3 are in the range expected for operating on daily waste and contaminated cooling water. Storm water treatment would presumably require additional body feed and more frequent cycling. The TPF calculations are based on filter fluxes of 1 gpm/ft^2 and precoat application at 0.1 lb/ft^2 on each cycle.

Of the three filtration systems which have been examined for the F/HETF, multiple deep bed filtration and ultrafiltration can operate without the addition of solids. The properties of the concentrate are therefore determined entirely by the feed and the limitations of the ultrafilter and concentrate processing equipment. Testing has indicated that 15 wt % iron and ferric silicate sludge concentrates are achievable without difficulty by ultrafiltration, and cleaning has been performed without generating additional waste, using a permeate backflush (ultrafilter case 4, Table 4.6-1). Heavy scale can also be removed periodically with caustic, which would then be transferred either to the pretreatment process to assist in pH adjustment or sent to the F/HETF evaporator. As a result, solids may not be added to the waste besides those required for pH adjustment.

Unusual instances of fouling that could require a significant degree of cleaning may add waste chemicals to the the evaporator feed stream. A conservative calculation, based on cleaning efficiencies which have already been demonstrated, has shown that a maximum of 4.6 gallons of cleaning and remembraning solutions could be be required per square foot of fouled ultrafilter membrane area. However, this would be an infrequent occurrence, with a projected frequency of less than 0.2 ft^{-1} $months^{-1}$ based on high solids simulant testing[11,12] and vendor experience.

4.6.3 Reverse Osmosis and Ion Exchange

The flow to the WMETF evaporator will consist almost entirely of ion exchange regenerant and reverse osmosis concentrate. The waste volume produced by ion exchange depends on the degree of regeneration required, and on the regeneration frequency. The later is substantially reduced if the ion exchange system is acting as a polisher for reverse osmosis and not as the entire deionization system. These relationships are described in Table 4.6-2, and Figures 4.6-1 and 4.6-2.

The concentrate volume from reverse osmosis and the degree of "water recovery" depend on the chemistry of the feed and the adequacy of pretreatment. Operating projections by Permasep and Filmtec indicate that reverse osmosis will recover about 95% of the water as permeate in daily service. Storm water processing may be somewhat less efficient (i.e, 90% recovery), depending on the silica concentration in the feed after pretreatment. The dissolved solids concentration in reverse osmosis concentrate will normally be less than that of the ion exchange regenerant. Since the concentration factor for evaporation depends on the evaporator feed concentration (i.e., total mass of solids), the F/HETF evaporator will produce less concentrate if reverse osmosis is used, regardless of reverse osmosis recovery.

The values of the terms in Table 4.6-2 are based on 200 gpm of feed going to the F/HETF. Ion exchange calculations are based on a normalized feed of 2924 ppm $NaNO_3$. Mixed bed cation exchange regeneration volumes were 1.15 and 1.4 times theoretical for anion and cation exchange, respectively. Dual bed regeneration volumes were 3 times theoretical, which would assure "salt leakage" values of less than about 6% for both the anion and the cation exchange beds.[32-33]

4.6.4 Evaporator Feed

The feed volume going to the evaporator will be essentially as described above. Additional flows will originate from cleaning solutions used in reverse osmosis and filter cleaning. However, those which are designated as compatible (e.g., dilute caustic cleaning solutions) will be added to the F/HETF feed in the pretreatment system, rather than being sent directly to the evaporator. Except for caustic, waste cleaning solutions on the order of 1 wt % or greater would be treated most economically by the evaporator. These additional flows to the evaporator will be less than 1 gal/min.

4.6.5 Waste Volume

Based on the waste volume (i.e., mass of salt) presently going to the 200-Area seepage basins, the total amount of salt produced in a single year by an effluent treatment facility (ETF) working at 100% efficiency would be approximately 578,000 lb (Table 4.6.5-1). Of this, about 545,000 lb would be sodium nitrate. The total volume of salt would be roughly 190,000 gal (30 wt % solution, density 1.23). This would be converted to 5.4×10^4 ft^3 saltstone.[26]

Allowing 9400 ft^3 for the waste volume from ion exchange polishing and 6400 ft^3 from the filtration,* the total volume of saltcrete produced each year would be 7.0×10^4 ft^3. This would cover about 0.23 acres,** if the DWPF reference saltstone process is used.[27]

The fact that 95% of the waste generated by the proposed effluent treatment facility (F/HETF) would be either nitric acid or sodium nitrate suggests that operating changes might be extremely useful in reducing waste volume. Once the effluents are directed away from the seepage basins, the excess nitric acid that has been maintaining the seepage rate will simply be an undesirable waste product. It will then be important to minimize the amount that is lost to evaporator overheads and thus released to the ETF.

In terms of the F/HETF waste treatment process, the only way to significantly reduce the volume of waste concentrate going to evaporation, and eventually to solidification, would be to eliminate sodium nitrate retention by the day-to-day treatment system. Selective removal of all contaminating material would be required to accomplish this.

---

* Basis: from two-column mixed bed (MB-4 Rohm and Haas) plus 10 wt % waste in filter concentrate from 20 ppm TSS feed.

** The solid/waste concentrate ratio is 2.16, and the average depth of saltcrete in Z Area will be 7.9 ft^2.

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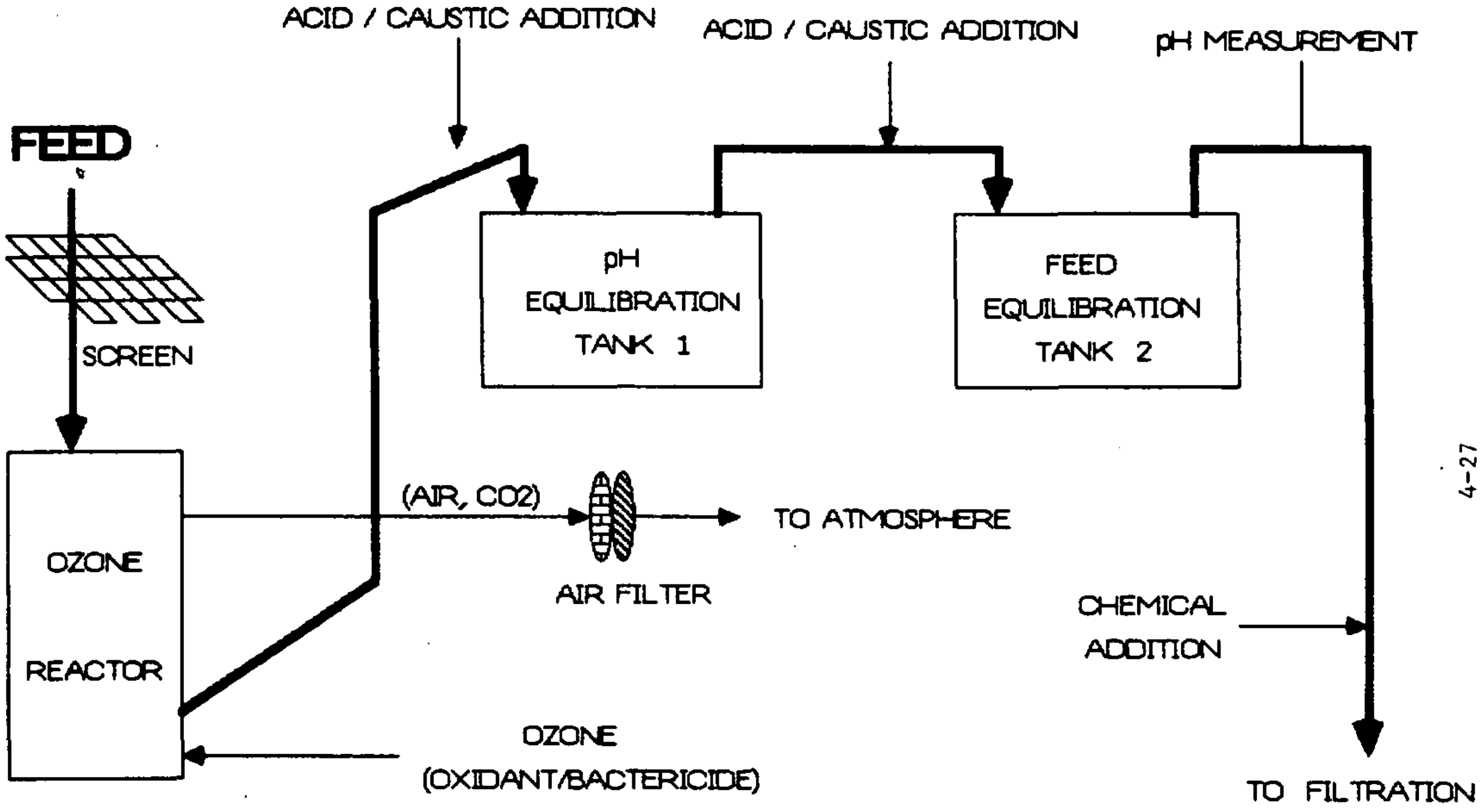


FIGURE 4.1-1. F/HETF Feed Pretreatment

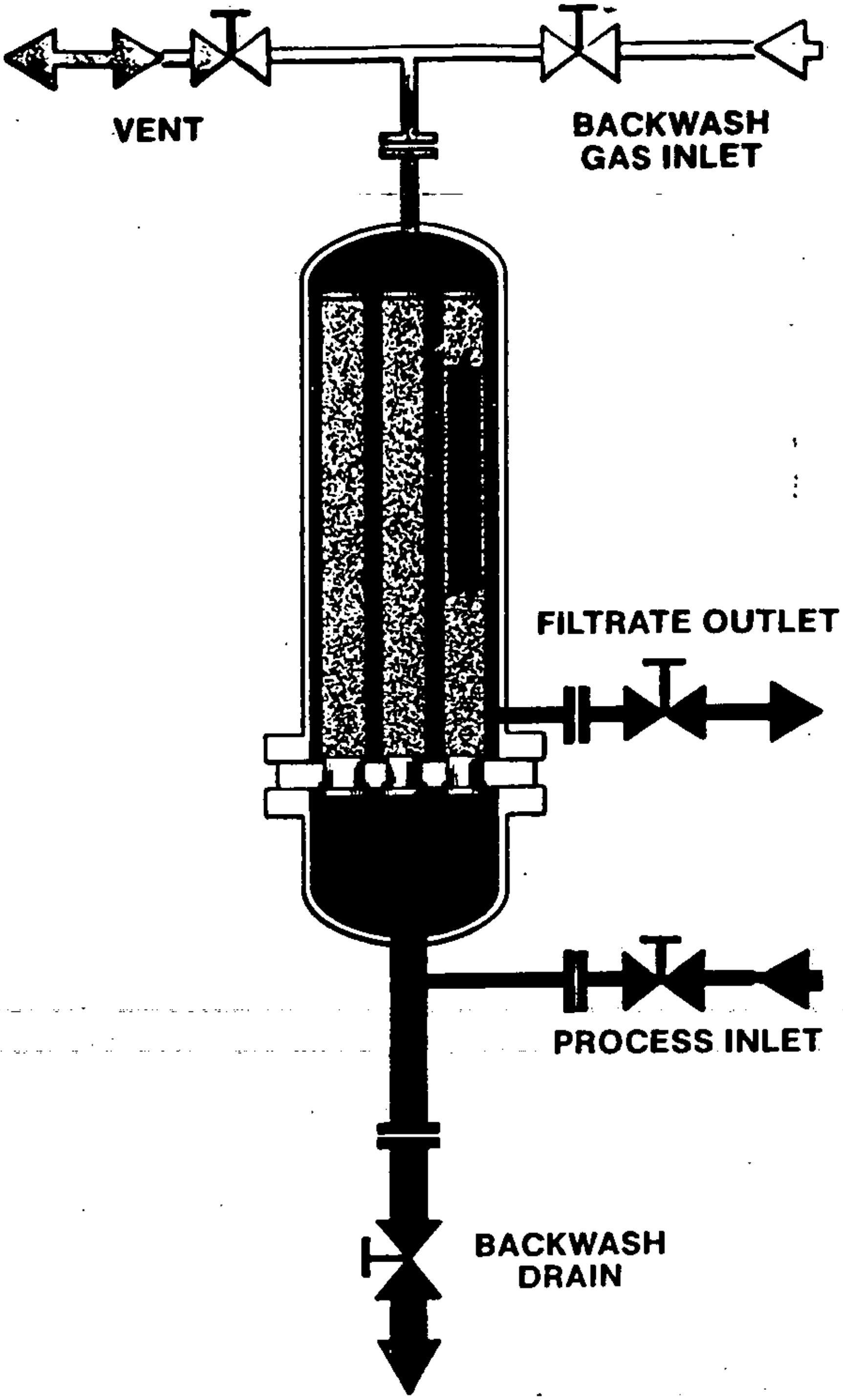


FIGURE 4.2.2-1. Inverted PHP Filter

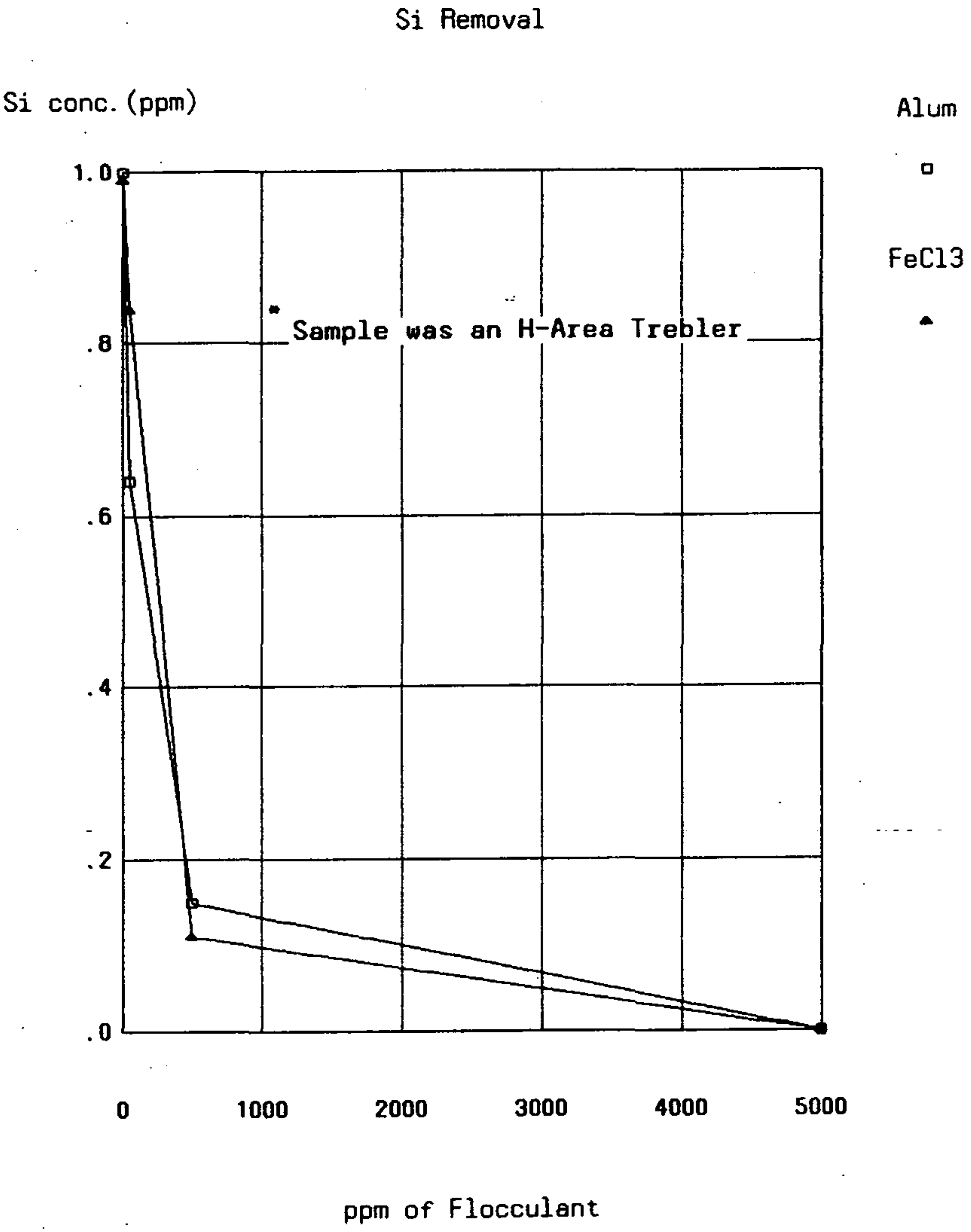


FIGURE 4.2.2-2. Silica Removal

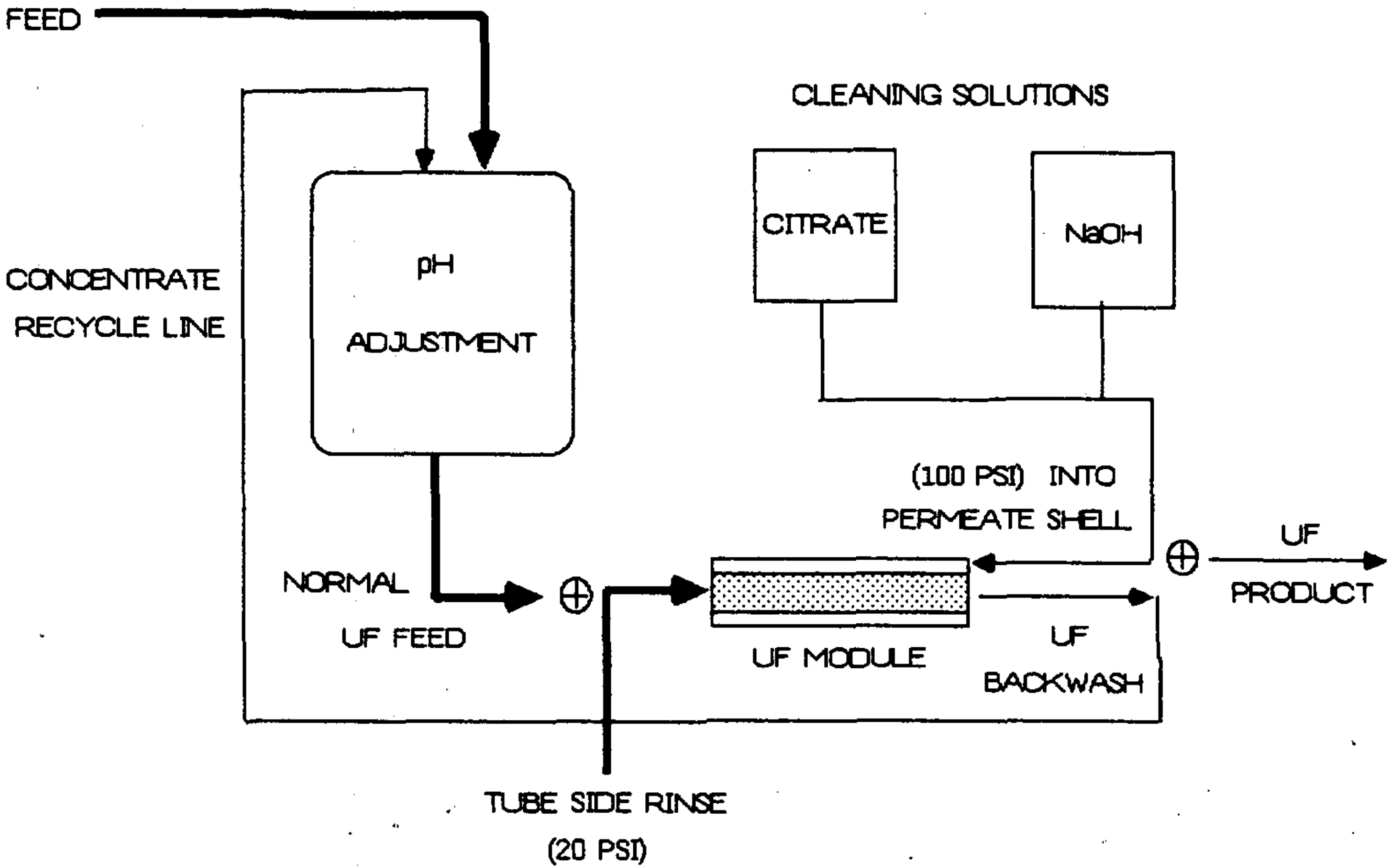


FIGURE 4.2.3-1. Ultrafiltration Schematic

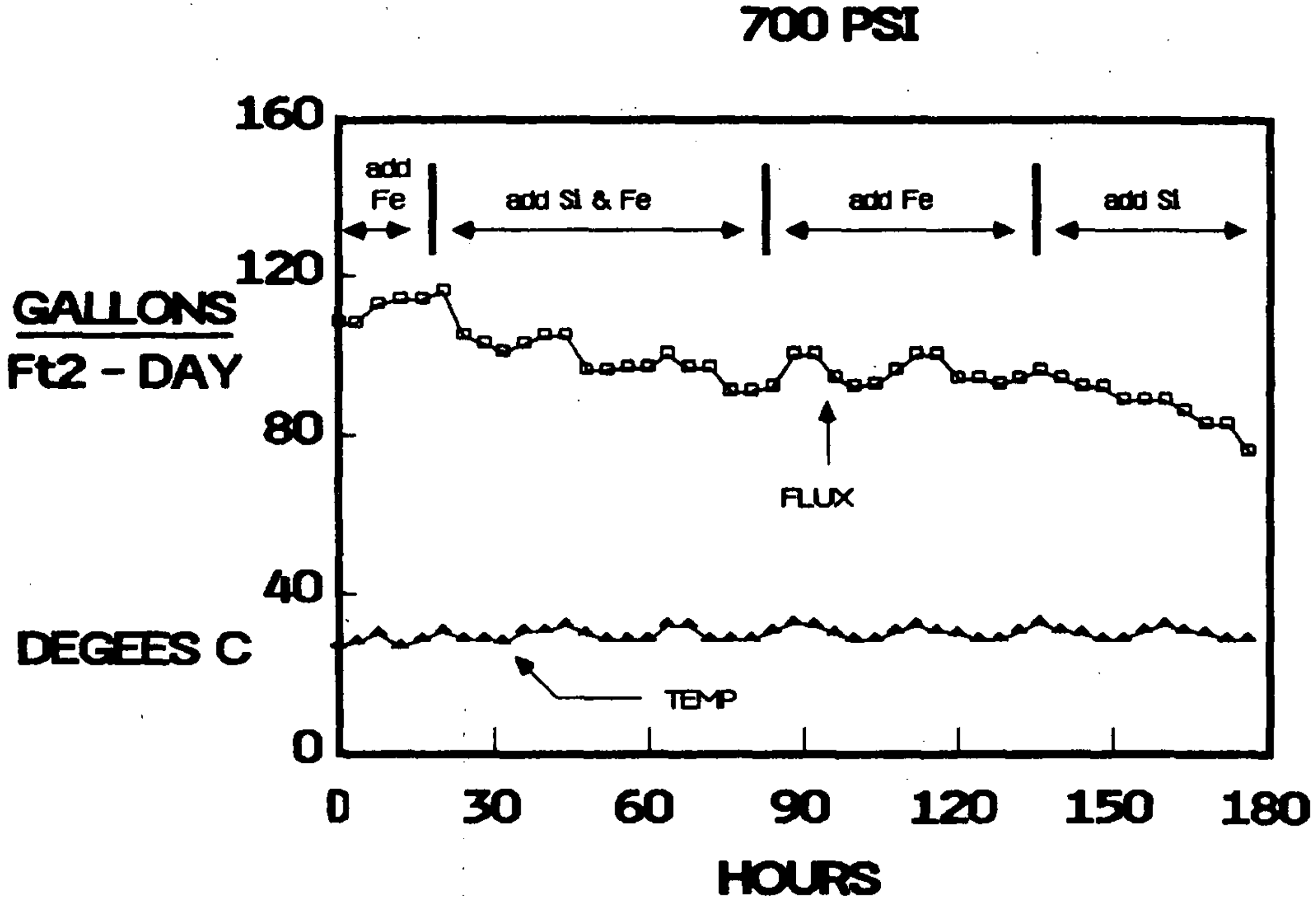


FIGURE 4.2.3-2: Ultrafiltration of Concentrated Iron and Silica Solutions

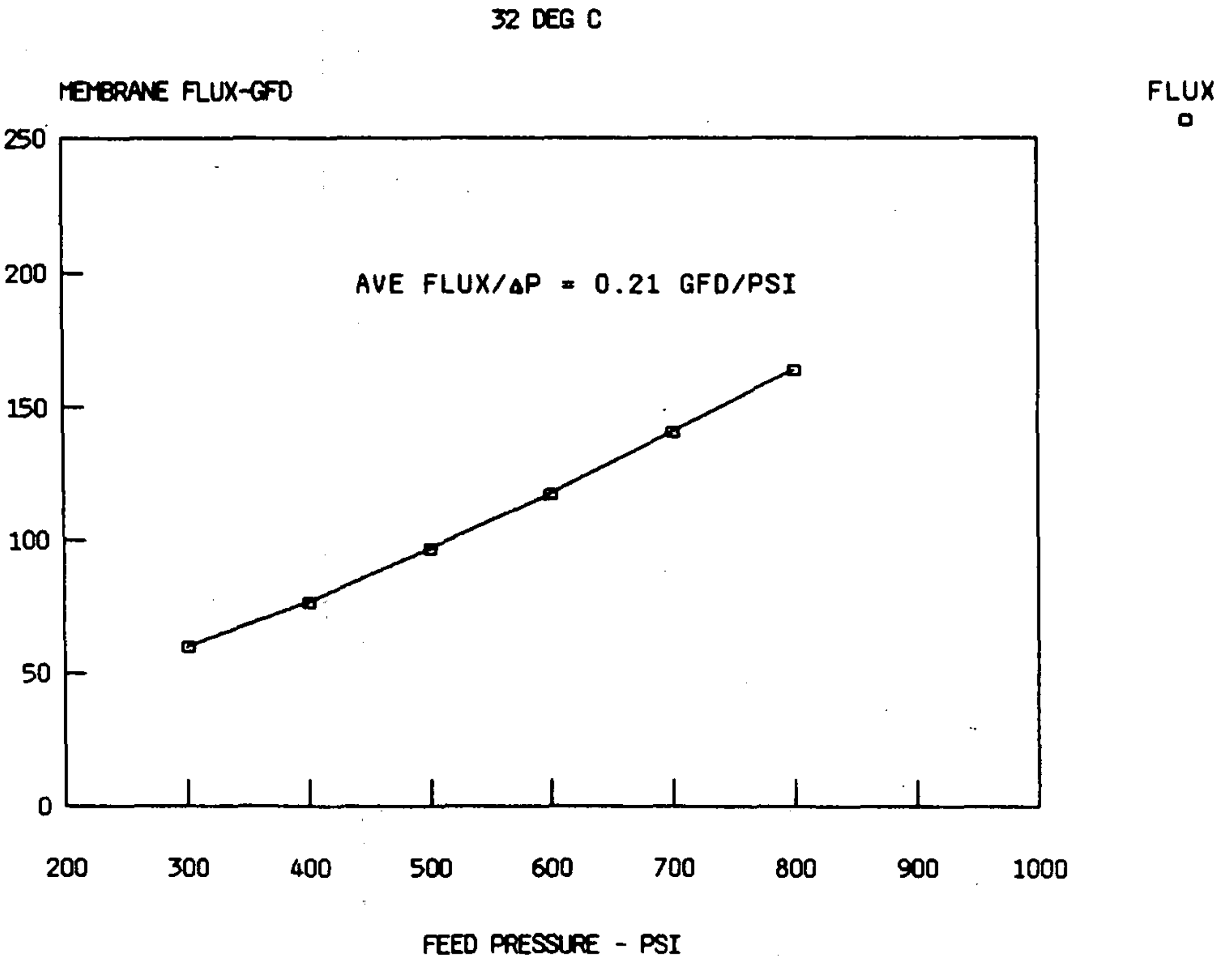


FIGURE 4.2.3-3. Initial Ultrafiltration Membrane Flux

("REFERENCE PROCESS")

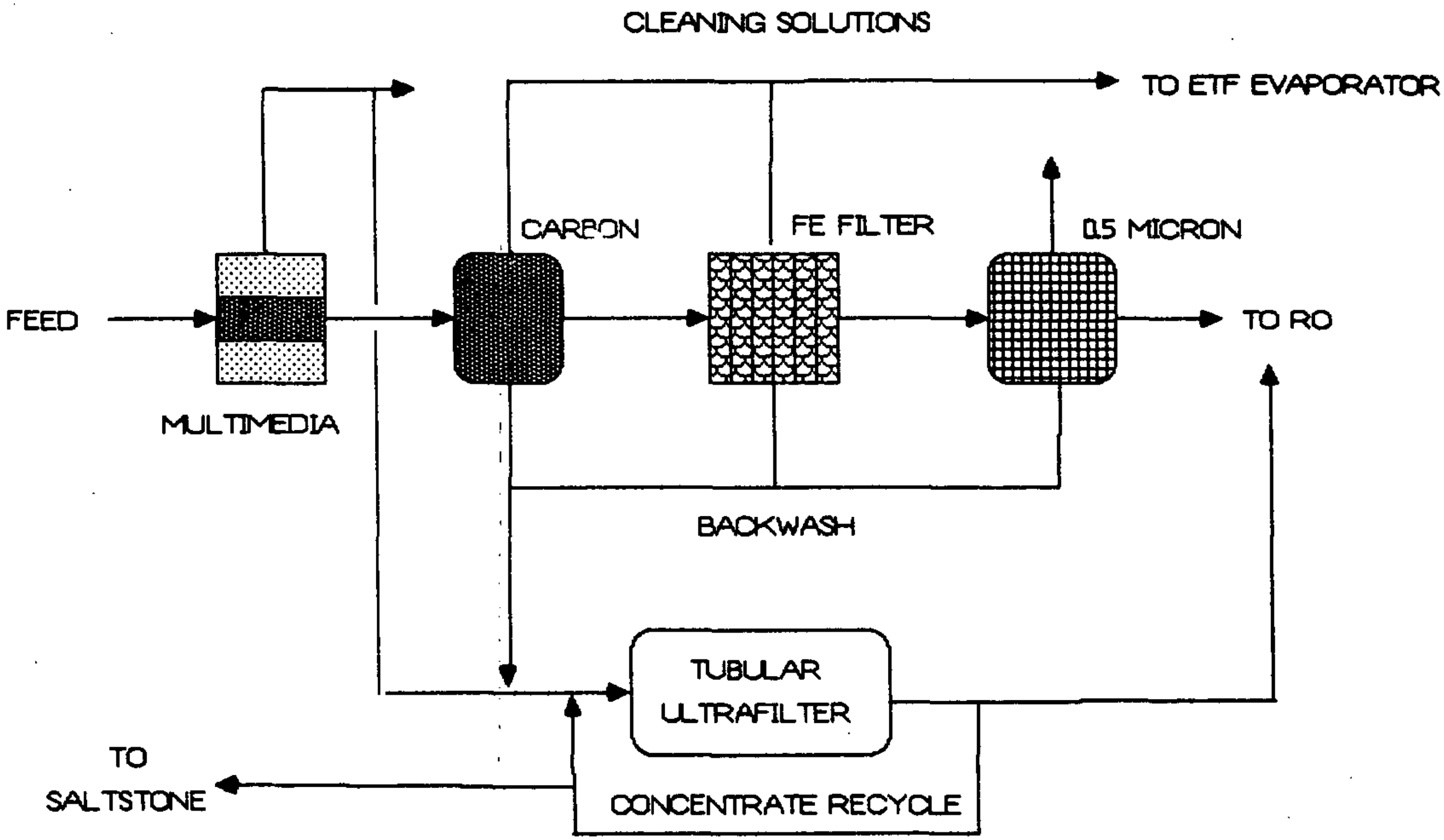
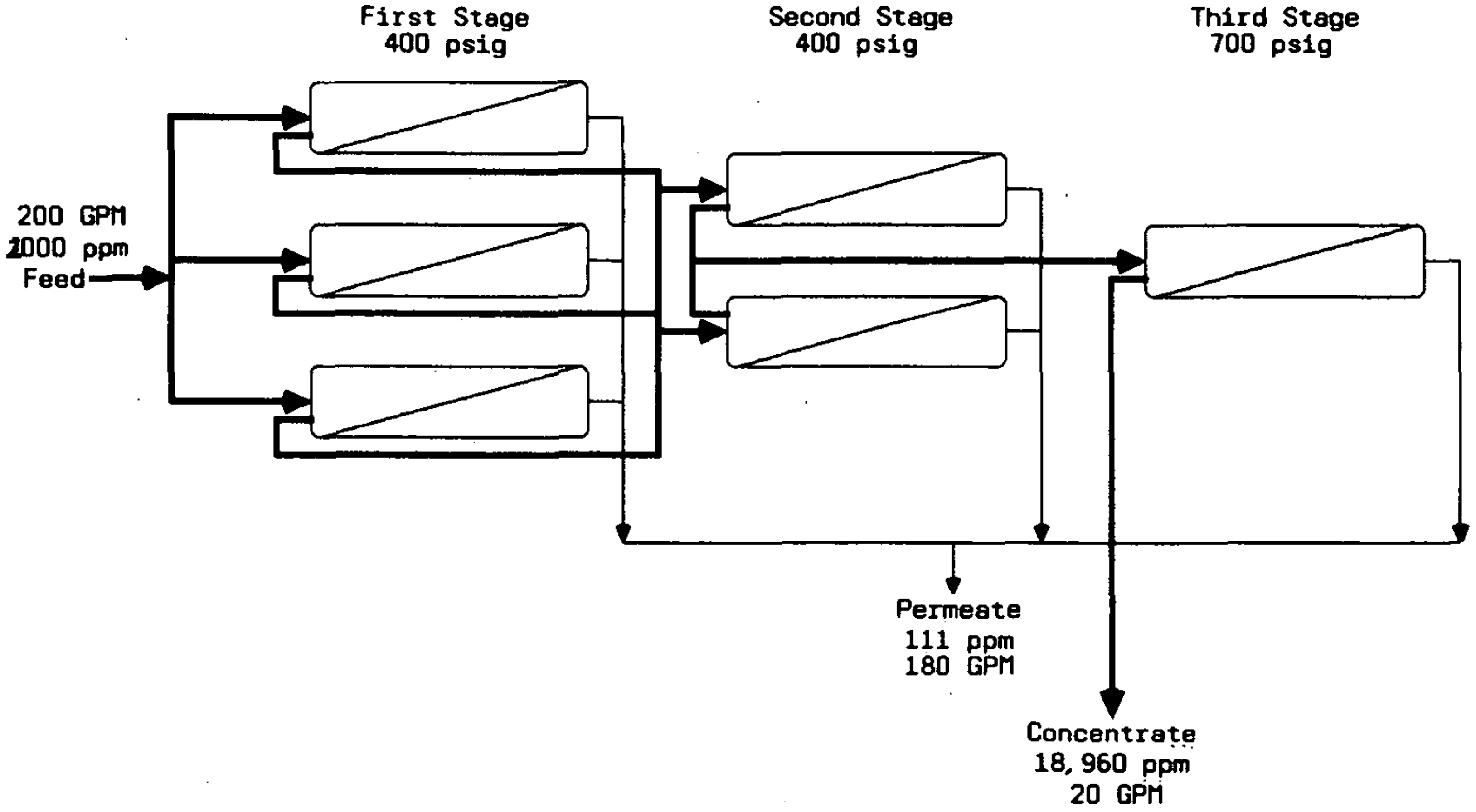


FIGURE 4.2.4-1. Multibed Filtration



* The number of modules and elements in each stage will be determined in the final design

FIGURE 4.3-1. Schematic of F/HETF Reverse Osmosis Staging

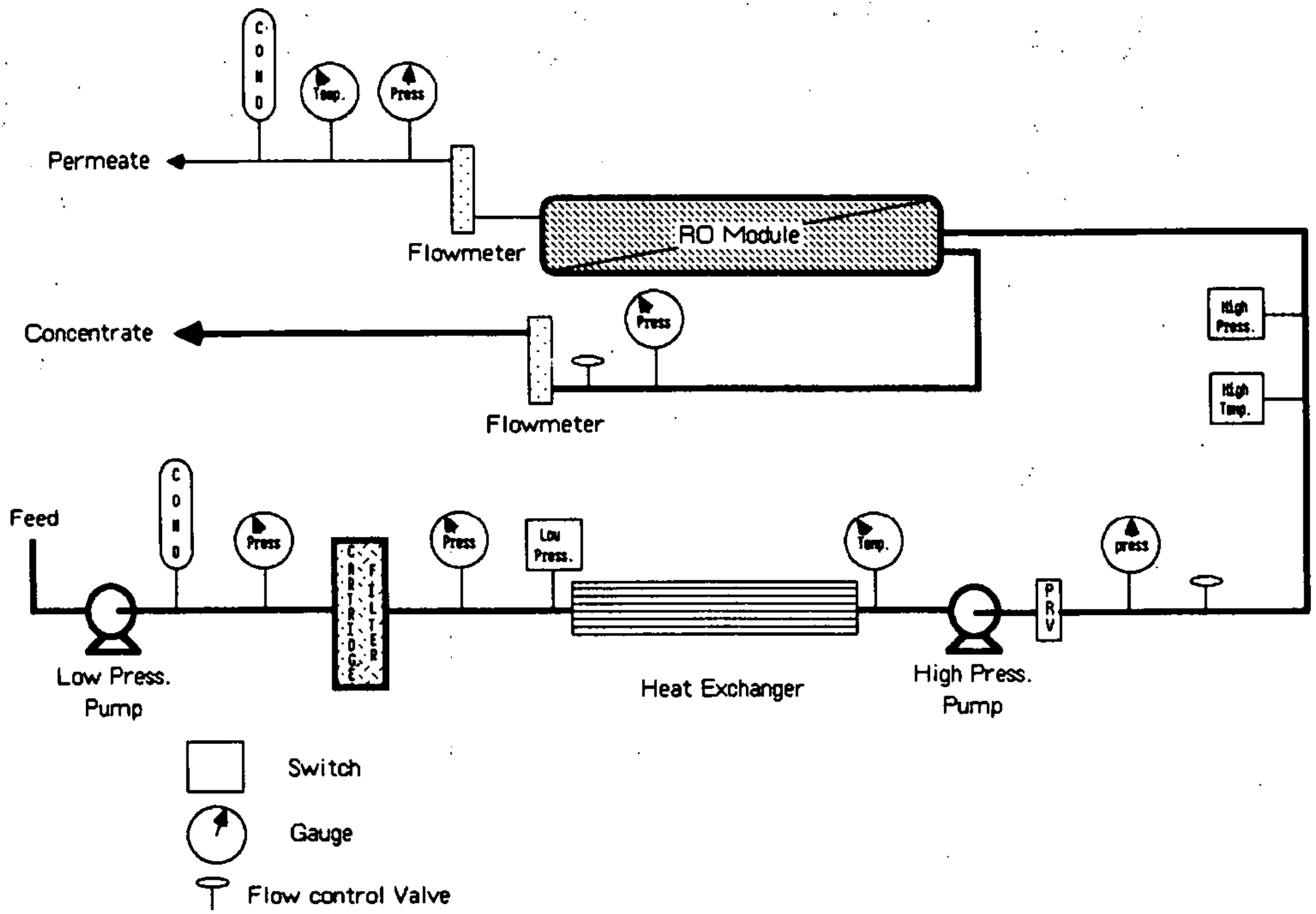


FIGURE 4.3-2. Reverse Osmosis Schematic

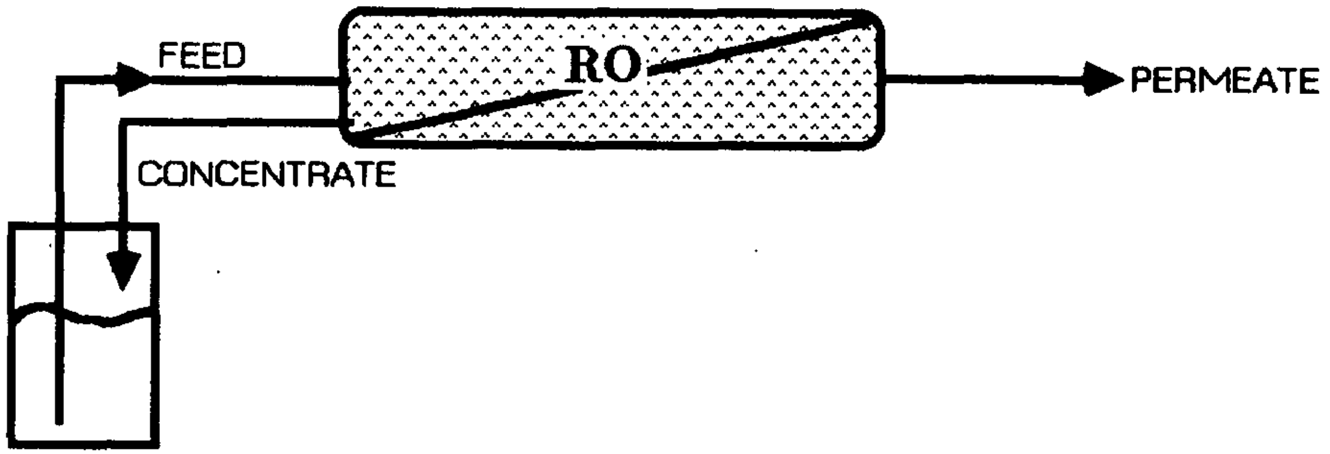
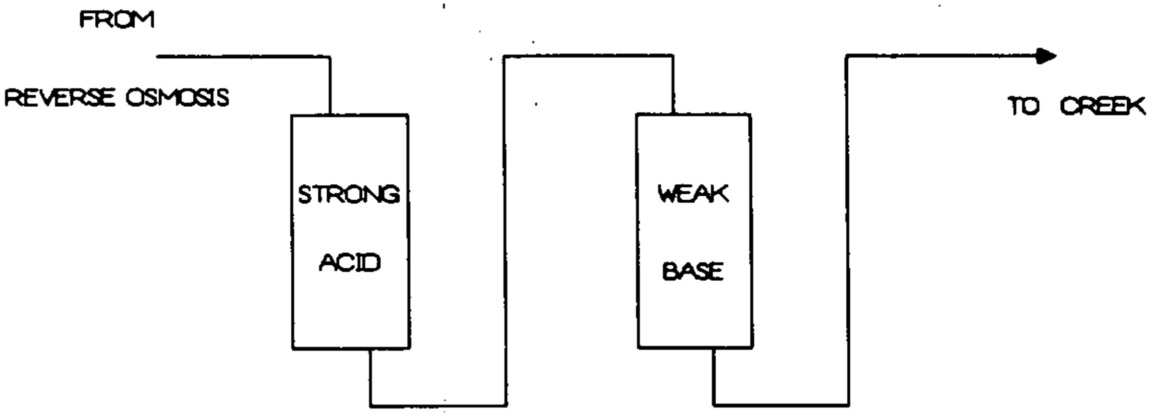


FIGURE 4.3-3. Reverse Osmosis Testing

DESIGN 1: DUAL-BED ION EXCHANGE



DESIGN 2: THREE-BED ION EXCHANGE

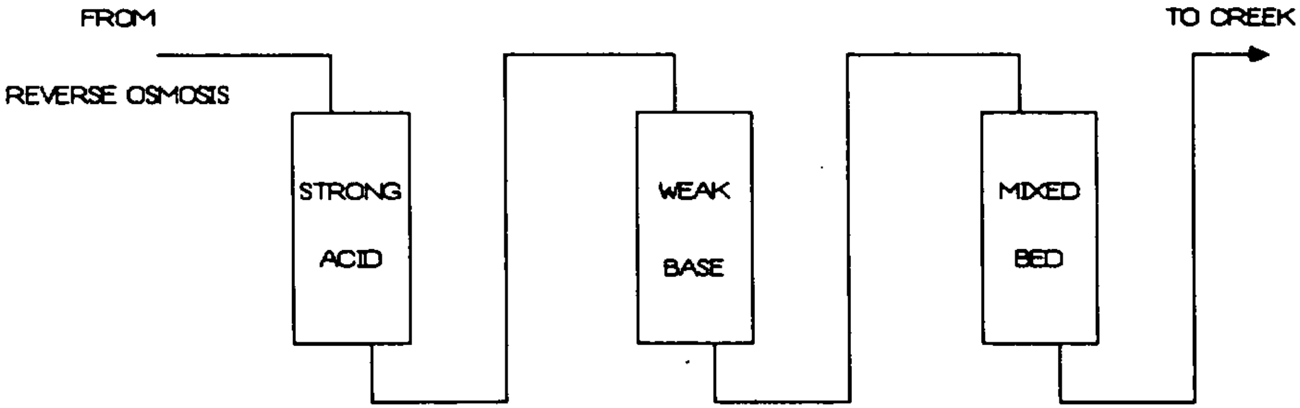
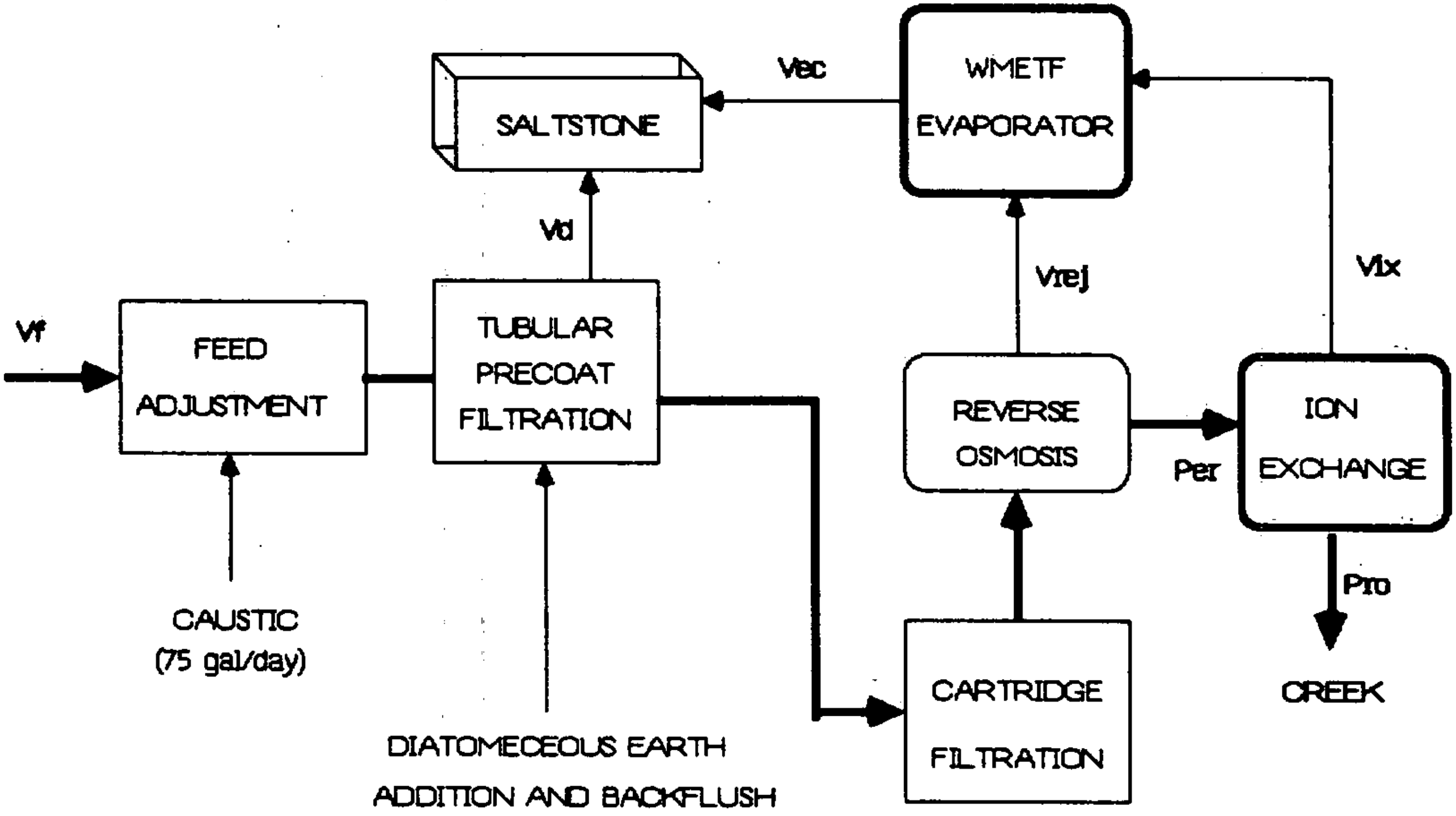
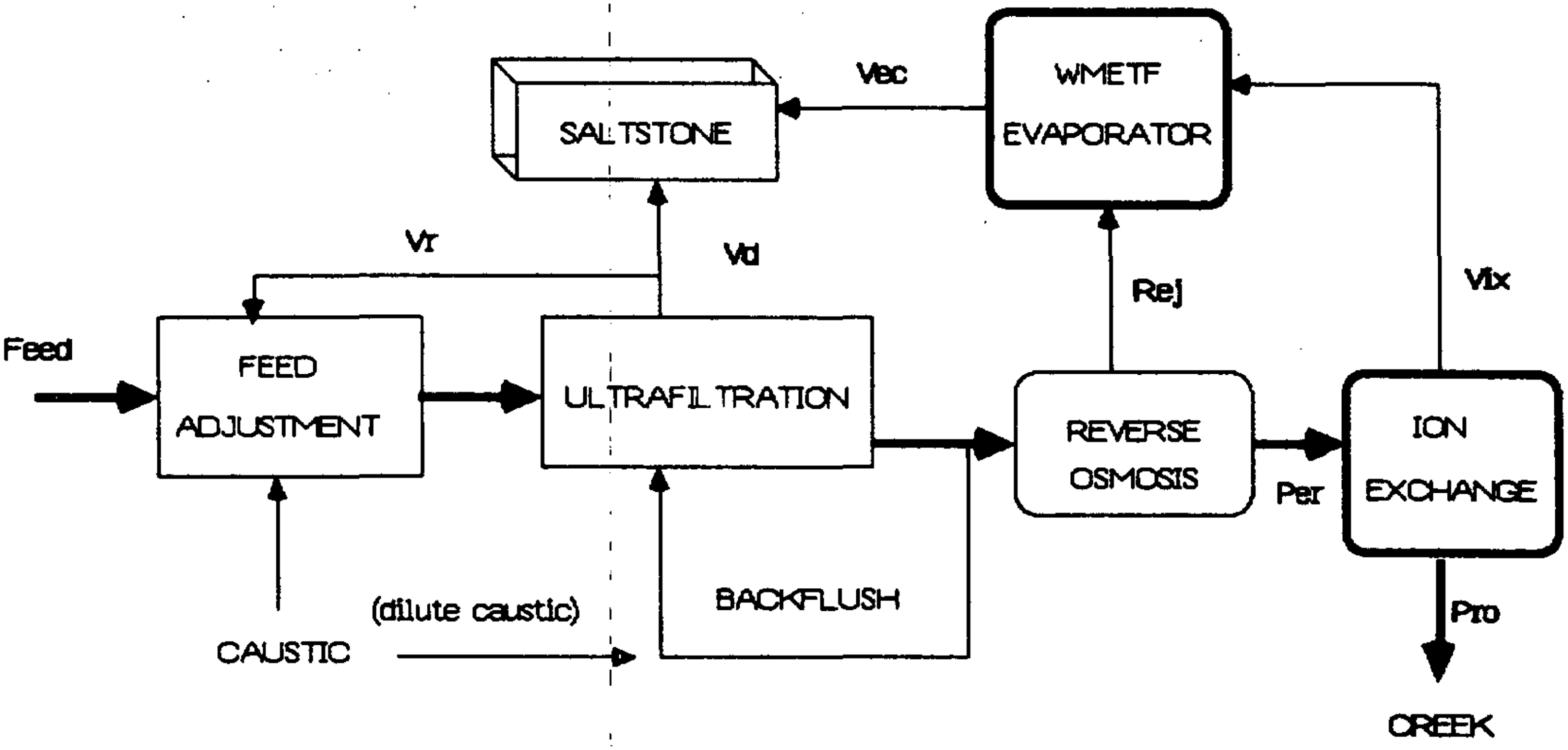


FIGURE 4.4.4-1. Multiple Bed Ion Exchange



NOTE: SEE TABLES 4.6-1 AND 4.6-2 FOR FLOW RELATIONSHIPS

FIGURE 4.6-1. Tubular Precoat/Cartridge Filtration Followed by Reverse Osmosis and Ion Exchange



NOTE: SEE TABLES 4.6-1 AND 4.6-2 FOR FLOW RELATIONSHIPS

FIGURE 4.6-2. Tubular Ultrafiltration Followed by Reverse Osmosis and Mixed Bed Ion Exchange

TABLE 4.2.2-1

Filteraids and Adsorbents

CUNO M-902	COATED DIATOMACEOUS EARTH - FINE
CUNO M-802	COATED DIATOMACEOUS EARTH - MEDIUM
CUNO M-901	COATED PERLITE - FINE
DURASIL-10	BOROSILICATE GLASS
GRAVER GL-98	MIXED BED ION EXCHANGE RESIN 30% DRY WT, CATION/ANION = 2.5
GRAVER GL-102	MIXED BED ION EXCHANGE RESIN CATION/ANION ~1.0
GRAVER GL-103	MIXED BED ION EXCHANGE RESIN CATION/ANION ~1.0
EPIFLOC PRECOAT D	MIXED BED ION EXCHANGE RESIN CATION/ANION ~1.0
ECODEX	MIXED BED ION EXCHANGE RESIN CATION/ANION ~1.0
ZEOLITE	CHABAZITE - PHELPS DODGE
MIDCONTINENT	MIXED BED ION EXCHANGE RESIN CATION/ANION ~1.0

TABLE 4.2.2-2

Filtration DFs

TAG NO.	FILTERAID (ppm)	Ce-144	Ru-106	Cs-137	Zr-95
167	NONE (0.45 μm)	110	13	1.2	18
168	NONE (0.20 μm)	138	15	1.2	
169	CUNO M902 (50)		20	1.6	10
170	CUNO M902 (500)		24	2.6	
171	CUNO M902 (5000)		60	12	
173	GRAVER GL98 (50)		33	1.5	
190	GRAVER GL98 (50)	680		1.1	
174	GRAVER GL98 (500)		54	3.4	
191	GRAVER GL98 (500)	1060		1.7	
172	GRAVER GL98 (5000)	104			
192	GRAVER GL98 (5000)	3021			
294	DURASIL-10 (50)	104	49.6	1.60	10.9
293	DURASIL-10 (500)	202	17.9	2.61	
292	DURASIL-10 (5000)	6094	18.1	21.4	
303	ZEOLITE (50)	405	17.7	4.93	
302	ZEOLITE (500)	1580	22.6	37.4	
301	ZEOLITE (5000)	71.0	20.5	122	91.9

FEED: TANK 12·3/H 10^5 dilution 35210-41-1

	d/m/ml	(Background)
Ce144	685,787	(0)
Ru106	30,826	(277)
Cs137	110,345	(291)
Zr95	3,845	(173)

---

* IX Resin wts on wet basis - Dry wt is approximately 30%
cation/anion = 2.5

Durasil-10 Dry wt is 50%.

TABLE 4.2.2-2, Contd

Filtration DFs

TAG NO.	FILTERAID (ppm)*	Ce-144	Ru-106	Cs-137	Zr-95	ADD NO.
235	NONE	1315	41	1.1		57853
229	CUNO 802 (50)		16	1.2	14	57847
230	CUNO 802 (500)	706	64	1.9		57848
231	CUNO 802 (5000)		52	8.1	23	57849
232	CUNO 901 (50)	104	18	1.3		57850
233	CUNO 901 (500)		18	2.8	21	57851
234	CUNO 901 (5000)		24	28		57856
237	EPIFLOC PRECOAT D (50)	1388	22	1.9		57951
238	EPIFLOC PRECOAT D (500)	2904	18	3.8		57952
239	EPIFLOC PRECOAT D (5000)	276	8.5	23		57953
240	DURASIL - 10 (50)	2082	24	1.1		57954
241	DURASIL - 10 (500)			1.4		57955
242	DURASIL - 10 (5000)	2775		235		57956
249	MID CONTINENT (5000)			219		57969
245	GRAVER GL-102 (500)	374	14	2.2	15	57965
246	GRAVER GL-102 (5000)	5.8	1.5	34	1.1	57966
247	GRAVER GL-103 (500)		41	1.6	26	57967
248	GRAVER GL-103 (5000)		47	26		57968

FEED: TANK 12.3/H 10^5 DILUTION 35210-41-3 8/14/84

	d/m/ml	(Background)	pH 6.29	>7.0
Ce144	726,645	(0)		
Ru106	104,413	(857)		
Cs137	99,947	(332)		
Zr95	3,704	(81)		

---

* Durasil and IX resins concentrations are on a wet basis
Durasil dry wt is 50 wt %.
IX resin dry wt is 30%.

TABLE 4.2.2-3

Constant Rate Tests

Sample (TSS)	Test No.	Precoat Type	lb/ft^2	Body Feed (ppm)	Cycle Time Hr:Min	Flow Rate gpm/ft^2	P_i	P_f	Filtrate TSS	Filtrate SDI	Media (μm)
PCW (0.33)	8	CUNO M-902	0.1	50	3:30	1.0		3.5	1.3+ 0.04	-	2.0
PCW	9/17	STD Supercel	0.1	25	1:10	1.0	6.1	7.6	-	-	0.5
PCW	9/17	STD Supercel	0.1	25	0.57	1.0	5.2	6.0	-	-	0.5
PCW	9/19	STD Supercel	0.1	25	1:17	1.0	9.0	9.5	-	-	0.5
Simulant	9/21	STD Supercel	0.1	25	1:10	1.0	7.0	30.0	-	<1.3*	0.5
Simulant	9/24	STD Supercel	0.1	25	1:20	1.0	9.5	20.0	-		
Simulant	9/25	STD Supercel	0.1	25	1:20	1.0	6.4	28.5	-	<0.67*	0.5
Simulant	10/8	STD Supercel	0.1	25	1:40	1.0	4	28	-	0.94	2.0
Simulant	10/9	STD Supercel	0.1	25	1:45	1.0	3.6	27	-		2.0
Simulant (13.3)	9	CUNO M902	0.1	50	2:00	1.0	-	35	0.04 0.02	-	2.0
Simulant (13.3)	10	CUNO M902	0.1	100	2:15	1.0	-	32.5	0.12 0.5	-	2.0
Simulant (11.0)	3	Ecodex	0.25	0	1:40	1.0	-	30.0	3.6 4.2	-	2.0
Trebler(H Area)*	10/11	STD Supercel	0.1	25	2:20	0.7	2.5	6.2	-	-	2.0
Trebler	10/22	STD Supercel	0.1	25	2:30	0.65	2.6	5.4	-	-	2.0
Trebler**	11/08	STD Supercel	0.1	25	2:00	0.7	3.6	20.5	-	-	2.0
Trebler**	11/09	STD Supercel	0.1	25	1:40	1.0	4.5	23.5	-	-	2.0

---

* Extrapolated From 10 min Run Time

** Bottoms of Trebler Sample Container - A Worst Case

TABLE 4.2.2-3, Contd

Constant Rate Tests

Sample (TSS)	Test No.	Precoat Type	lb/ft^2	Body Feed (ppm)	Cycle Time	Flow Rate gpm/ft^2	P_i	P_f	Filtrate TSS	Filtrate ISD	Media (μm)
PCW (0.5)	2-2	M-902	0.1	50	4:15	1.0	–	6.3	0.24 →0.10	0.8	2.0
Simulant	7-11	STD Supercel	0.1	0		1.0					2.0
Simulant	7-2	STD Supercel	0.1	25		1.0					2.0
Simulant	8-1	STD Supercel	0.1	25		1.0				2.15	0.5
Simulant	8-2	None	0	25		1.0				1.35	0.5
Simulant	9-1	STD Supercel	0.1	25		1.0				1.42	5.0
Simulant	7-6	STD Supercel	0.1	25		1.0					2.0
MOTT Tube Tests (0.116 ft^2) – Automated Cycles											
Simulant	11-1	STD Supercel	0.1	25		0.95			0.19	1.54	2.0
Simulant	12-1									0.318	2.0
Simulant	12-2									0.174	2.0
Simulant	11-2								0.17	1.12	2.0
Simulant	11-3								0.09	0.92	2.0
Simulant	11-4								0.10	0.71	2.0
Simulant	11-5								0.03	0.24	2.0
Simulant	11-6									0.41	2.0
Simulant	11-7										
Simulant	11-8										

SDI Composite 11 - 3→8 = 1.20

TABLE 4.2.2-4

Constant Rate Tests and Filtration Decontamination Factors

	Run	Cycle Time (Hr:min)	P_i	P_f	Ce-144	Ru-106	Cs-137	Sr-85	SDI
1.	10/11	2:20	2.5	6.2					
2.	10/22	2:30	2.6	5.4	>267	>8.13	1.0	1.0	
4.	11/8	2:00	3.6	20.5	>32.8	>9.04	1.0	1.0	
5.	11/9	1:40	4.5	23.5	52.7	14.7	1.0	1.0	
6.*	11/14	1:50	3.5	31	>1000	>8.32	1.0	1.0	0.49

Test Conditions: Precoat 0.1 lb/ft^2 STD Supercel
Bodyfeed 25 ppm
Media 2.0 μm

Samples: Weekly Trebler Composites - H-Area
* F Area

TABLE 4.2.2-5

F & H Areas Effluent Treatment Facility

Total Solids Loadings from Proposed Tubular Precoat Filter

Avg. Flow (gpm)	Filter Area (ft^2)	Precoat††			Body Feed (ppm)	Total Solids Load (ppd) at 25 ppm TSS Crud Loading & Various Cycle Times (hr)				Solids (ppd) at¶ Only 12.5 ppm TTS Crud and 8-Hour Cycle
		Type	(lb)	(lb/ft^2)		2	8	24	36	
200*	200	DE	20	0.1	25	360	180	140	133	150
					50	420	240	200	193	210
					100	540	360	320	313	330
		PIX	40	0.2	25	600	240	160	147	210
					50	660	300	220	207	270
					100	780	420	340	327	390
50**	200	DE	20	0.1	25	270	90	50	43	83
					50	285	105	65	58	98
					100	315	135	95	88	128
		PIX	40	0.2	25	510	150	70	57	143
					50	525	165	85	72	158
					100	555	195	115	102	188
125†	200	DE	20	0.1	25	315	135	95	88	116
					50	353	173	133	126	154
					100	428	248	208	201	229
		PIX	40	0.2	25	555	195	115	102	176
					50	593	233	152	139	214
					100	668	308	228	215	289

---

* Assumed original maximum 200 gpm design flow

** Based on yearly average Plant flows per R. E. Stimson, SRL (10^8 L/yr)

† Original F- and H-Areas design flow per basic data

†† Precoats: DE = diatomaceous earth (e.g., Cuno M-902, Standard Super Cel);
PIX = powdered ion exchange resin (e.g., Graver, Epifloc, mid-continent)

¶ Assumed typical average operating conditions

TABLE 4.2.3-1

Design Parameters for SRP Ultrafiltration System (at 75 gpm)

The permeability at 30 C is .188 GFD/PSI
The step length is 10 feet
The entering concentration is 1
The pressure drop per U-Bend is .5Q
The target concentrate flow rate is 1 GPM
The entering flow rate is 75 GPM

	This Design				
Segment Number	Diameter (Ins)	No. Tubes	Length (Feet)	Mult	Area Sq Ft
1	0.625	6	2760	1	451.604
2	0.625	4	1840	1	301.069
3	0.625	2	920	1	150.535
4	0.625	1	460	1	75.2673

Total Area 978.474 Sq Ft

Segment Number 1

Inlet and outlet concentrations	1	2.02093
Inlet and outlet pressure (PSI)	717.384	594.507
Inlet and outlet velocities (FPS)	13.072	6.46832

Section outlet flow rate 37.117
The average flux for this section is 120.812 GFD
The area for this section is 451.604 Sq Ft

Segment Number 2

Inlet and outlet concentrations	2.02093	4.87228
Inlet and outlet pressure (PSI)	594.507	527.678
Inlet and outlet velocities (FPS)	9.70248	4.0244

Section outlet flow rate 15.3932
The average flux for this section is 103.879 GFD
The area for this section is 301.069 Sq Ft

Segment Number 3

Inlet and outlet concentrations	4.87228	13.4018
Inlet and outlet pressure (PSI)	527.678	482.144
Inlet and outlet velocities (FPS)	8.0488	2.92618

Section oulet flow rate 5.59628
The average flux for this section is 93.7166 GFD
The area for this section is 150.535 Sq Ft

Segment Number 4

Inlet and outlet concentrations	13.4018	74.7281
Inlet and outlet pressure (PSI)	482.144	460.778
Inlet and outlet velocities (FPS)	5.85236	1.04957

Section outlet flow rate 1.00364
The average flux for this section is 87.8655 GFD
The area for this section is 75.2673 Sq Ft

TABLE 4.3-1

RO Operating Parameters

Flow Rate (GPM)	
Concentrate	2.5
Permeate	0.3
Pressure	400-700 psi
Temperature*	25-30°C

---

* During concentration runs temperature was maintained at ~30°C by a heat exchanger. Cooling is required only during the recycle testing where the feed is continually heated by the high pressure pump. In WMETF the RO will operate on a once through basis and temperature regulation of the feed will be sufficient.

TABLE 4.3-2

CCW Runs Decontamination Factors*

Step	Ce-144	Ru-106	Cs-137	Zr-95	Cond/ Na	βγ	Salt Rejection**
1. Filtration	2.44	2.09	1.02	1.43	--		
Recycle	>190	--	104	>2.0	32/65.2		
51% WR	>190	>3.58	19	--	28/52.7		
90% WR	43	>3.58	131	--	33.2/31.9		97%
Feed Analysis (d/m/mL)	2.26E4	1.16E3	1.03E4	3.01E2			
2. Filtration (millipore	2.80	1.56	1.04	2.72			
frit)	10.4	1.28	--	>9.5	--		
15% WR	>229	>23	16.5	--	14.4/		
50% WR	>229	>23	13.2	--	13.0/		
90% WR	>229	15.8	10.9	>9.5	11.2/		91.1%
Feed (d/m/mL)	2.73E4	7.43E3	3.98E3	1.40E3			
3. Filtration							
5.0 μm	9.8	5.3	1.0	>29			
0.6 μm	14.1	4.5	1.0	11.7			
15% WR	>5471	>42	13.0	--	13.4/16		
50% WR	16	4.0	9.0	--	13.7/8		
90%	14	12	4.4	--	11.8/5.8		91.5
Feed	6.51E5	3.52E4	1.10E5	4.31E3			
4. Filtration		- None -					
15%	1789	>165	17	>1176			
50%	[illegible]	63	10	102			
90%	250	>165	7.5	>1176			
Feed (d/m/mL)	2.25E5	5.35E4	1.48E4	1.74E5			
5. Filtration	1.2	1.0	1.0	1.1	--		
16%	>1429	>36	14	--	16.5		
50%	>1429	>36	9.3	>5.2	15.9		
90%	35	19	4.5	--	11.0		90.9
Feed (d/m/mL)	1.70E5	1.16E4	1.15E5	7.63E2	--		
6. Filtration	9.1	2.3	1.1	41	--		
16%	21	--	70	316	11.1	212	
90%	239	43	36	2330	13.9	68	92.8
Feed (d/m/mL)	2.52E5	9.46E4	4.09E4	7.91E5	--		

---

* DF qualified by > indicates radionuclide concentration is below detection limits.

** Based on conductivity measurements.

TABLE 4.3-3

Salt Rejection - Process Effluents

Feed Conductivity (µmhos/cm)	Feed	Water Recovery	Rejections (%)				
			Salt*	Na	Ca	Si	NO_3
2350	Simulant	88%	98.5	98.6	98.8	>99	98.7
1960	Simulant	90	97.1	96.8	>99.7	>99.8	
--	Trebler	90		97.4	89.1	>99.5	
1190	Trebler	90	97.5		>99.2	>99.8	
--	Trebler	90		95.1	97.3	>99.6	
--	Trebler	90		97.6	96.4	98.8	
1190	Hot 1	87	97.5	--	99.2	99.6	
--	Hot 2	88	--	95.2	97.3	99.5	

---

* Total salt rejection determined by conductivity.

** P = 700 psi to simulate second stage of reverse osmosis.

TABLE 4.3-4

Radionuclide DFs-Process Effluents

Run	Ce-144	Sr-85	Cs-134	Cs-137	Ru-106**
Hot 1	--	--	>4.86	14.3	--
Hot 2	--	--	>10	65	--
Hot 3	>131*	67.5	24.3	23.4	--
Hot 4	>45.8*	115	42.4	41.0	--
Hot 5	--	--	11.5	16.1	
Hot 6	>13.2			>339	

All data is at 90% water recovery

* Decontamination factor based on the lower limit of detection of the gamma counter.

** Ru-106 concentration is below the detection limits after filtration.

TABLE 4.3-5

Process Effluents - Reverse Osmosis

Run	Hazardous Metals DFs Cr	Cu	Hg	Pb	Zn	% Water Recovery
L	>3.93	233	23.4	>28.2	32.6	95
Hot 3	183	>404	--	>12.8	893	92
Hot 4	101	>247	--	3.01	59.3	89
Hot 5	7.57	24.1	16.0*	1.54	3.40	91
Hot 6	--	--	30.2*	--	--	86

---

* Metallic Hg

Hazardous Metals Concentrations

Metal	Test Solutions	Proposed NPDES Discharge Limits* Monthly Average (ppm)	Monthly Maximum (ppm)
Cr	0.16 - 5.0	2.5	5.0
Cu	0.01 - 4.0	4.4	8.8
Hg	0.018 - 0.486	0.1	0.2
Pb	0.09 - 60.7	2.5	5.0
Zn	0.01 - 9.0	6.7	13

---

* Proposed to SCDHEC 7/13/84

TABLE 4.4.4-1

Typical Performance of Deionizer Systems*

	Two-Bed	Four-Bed	Mixed Bed	Two-Bed Plus Mixed Bed
TDS, ppm	2.0-3.0	0.2-1.0	0.02-0.5	0.04-0.10
Silica (as SiO_2) ppm	0.01-1.0	0.01-0.05	0.01-0.05	0.01-0.05
Conductivity micromhos	2	1	0.25-1.0	0.07-0.25
Specific Resistance ohms-cm	500,000	1,000,000	1,000,000-4,000,000	4,000,000-15,000,000

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* Feed <500 ppm dissolved solids.

TABLE 4.6-1

Waste From Filtration

Feed Volume = 200 gal/min	(S_A) Solids Added to Feed (ppm)	(V_C) Average Conc Volume (gal/min)	(V_B) Backwash or Cleaning Volume (gal/min)	(V_R) Recycle Volume from Conc & Bkwsh (gal/min)	(V_D) Volume Directly to Waste (gal/min)	Recovered Solids Directly To Waste (wt %)	Total Solids Directly To Waste (wt %)	(CF) Solids Directly To Waste (concentration factor)
Multimode (Mott) with Polishing Cartridge								
Case 1 Basis: high filter aid use (2 hr precoat cycle, 150 ppm average body feed)	250	0.14	4.2	1.25	0.147	2.4	30.0	1361
Case 2 Basis: medium filter aid use (2 hr precoat cycle, 50 ppm average body feed)	150	0.08	3.0	.75	0.088	4.0	30.0	2273
Case 3 Basis: low filter aid use (8 hr precoat cycle, 50 ppm average body feed)	75	0.04	1.0	.375	0.044	8.0	30.0	4545
Ultrafilter (ATI)								
Case 1 Basis: UF cleaning volume = 4.6 gal/ft^2/wk (70% as 1M NaOH; 30% as 2.5 wt % citrate)	134.3	2.00	1.32	2.42	0.5	0.8	0.8	400
(no caustic recycle)	234.3	2.00	1.32	0.50	0.5	0.8	0.8	400
Case 2 Basis: UF cleaning volume = 2.3 gal/ft^2/wk, 10/1 concentrate recycle	22.9	2.00	0.61	2.23	0.2	2.0	2.0	1000
Case 3 Basis: UF cleaning volume = 2.3 gal/ft^2/wk, 50/1 concentrate recycle	22.9	2.00	0.61	2.39	0.04	10.0	10.0	5000
Case 4 Basis: UF cleaning volume = 2.3 gal/ft^2/wk, caustic only, with permeate backwash, 50/1 recycle	0	2.00	3.00	4.96	0.04	10.0	10.0	5000
Multibed Process (Emco)								
Case 1 Basis: No clarifier, backwash partially to waste	0	0.56	1.40	-	1.00	0.40	0.40	200
Case 2 Basis: Backwash to clarifier, overflow evaporation to 15 wt %	0	0.56	1.40	-	0.0	-	-	-
Case 3 Basis: Backwash to ultrafilter, concentrate to 10 wt %	0	0.56	1.40	2.06	0.04	10	10	5000

TABLE 4.6-1, Contd

	Solids to ETF Evapor (wt %)	(V_e) Volume to ETF Evapor (gal/min)	(V_w) Total Volume to Waste (gal/min)	Evaporator Concentrate (wt % Solids)	Feed Solids Concentration in Waste (wt %)	Overall Volumetric Concentration Factor	Feed Flow Rate (gal/min)	Feed Solids (ppm)
Multimode (Mott)								
Case 1								
Basis: 150 ppm, 2 hr	0	0	0.15	15	3.68	1361	2.00E+2	20
Case 2								
Basis: 50 ppm, 2 hr	0	0	0.09	15	5.75	2273	2.00E+2	20
Case 3								
Basis: 50 ppm, 8 hr	0	0	0.04	15	9.92	4545	2.00E+2	20
Ultrafilter (ATI)								
UF Case 1:	2.50	0.40	0.57	15	2.46	400	2.00E+2	20
(no caustic recycle)	4.11	1.32	0.86	15	6.76	232	2.00E+2	20
UF Case 2:								
10/1 conc recycle	2.50	0.18	0.23	15	3.72	868	2.00E+2	20
UF Case 3:								
50/1 conc recycle	2.50	0.18	0.07	15	12.16	2837	2.00E+2	20
UF Case 4:								
Backwash, 50/1 rec	0.0	0.0	0.04	-	10	5000	2.00E+2	20
Reference Multibed (Emco)								
Case 1:								
Basis: conc to waste	0.35	0.96	1.02	15	0.72	196	2.00E+2	20
Case 2:								
Basis: conc to clarif	0.38	1.96	0.05	15	15	4076	2.00E+2	20
Case 3:								
Basis: conc to UF	0.0	0.0	0.04	-	10	5000	2.00E+2	20

TABLE 4.6-1, Contd

Waste Volume from Filtration

V_B - Backwash volume (gal/min).

V_C - Volume of concentrate produced automatically by the filtration system (gal/min).

V_D - Volume of concentrate sent directly from the filtration system to waste (gal/min).

V_e - Volume of waste from pretreatment going to evaporation (gal/min).

V_W - Total volume of pretreatment waste after evaporation (gal/min).

V_R - Recycle volume back to ultrafilter or precoat filter feed tank (gal/min).

TABLE 4.6-2

Waste from Reverse Osmosis and Ion Exchange

*Ion Exchange Basis is 2924 ppm Dissolved Solids as $NaNO_3$	(R) RO Waste Solids (Salt Rejection)	(B) Ion Exchange Base Factor	(Ec) Cation Eluent Solids (HNO_3 only)	(Ect) Cation Eluent Solids (Total)	(Ea) Anion Eluent Solids (NaOH only)	(Eat) Anion Eluent Solids (Total)	(Sc) Solids to ETF Evapor (As Fraction of Feed)	(Rej) Average RO Conc Volume (Fraction of Feed)
MIXED BED (SA/WB)								
After 95% REC RO	0.95	0.05	0.052	0.065	0.027	0.054	1.12	0.050 3.6 wt %
After 90% REC RO	0.95	0.05	0.052	0.065	0.027	0.054	1.12	0.100 1.8 wt %
Without RO	0	1	1.038	1.308	0.541	1.071	3.38	0.0 -
DUAL IXG BEDS (CATEX-ANEX SERIES)								
After RO	0.95	0.05	0.111	0.125	0.071	0.097	1.22	0.050 3.6 wt %
After RO	0.95	0.05	0.111	0.125	0.071	0.097	1.22	0.100 1.8 wt %
Without RO	0	1	2.224	2.494	1.412	1.941	5.44	0.0 -
SELECTIVE BED								
After RO (Kd=800, d=1.8)	0.95	0.05	0.0 0.035	0.0	-	-	0.05	0.050 3.6 wt %
Without RO (Kd=800, d=1.8)	0	1	0 0.694	0 0.694	-	-	0	-

TABLE 4.6-2, Contd

*Ion Exchange Basis is 2924 ppm Dissolved Solids as $NaNO_3$	Vci Cation XG Regn GPM/WT % (Feed=200GPM)	Anion XG Regn Volume (Fraction of Feed)	Vai Anion XG Regn GPM/WT % (Feed=200 GPM)	(Ve) Liquid to ETF Evapor GPM (Feed=200 GPM)	Liquid to ETF Evapor WT % (Feed=200 GPM)	Cation XG Regn Volume (Fraction of Feed)
MIXED BED (SA/WB)						
After 95% REC RO	0.75 4.85 wt %	0.0016	0.31 9.5 wt %	11.1	3.85	0.0038
After 90% REC RO	0.75 4.85 wt %	0.0016	0.31 9.5 wt %	21.1	2.02	0.0038
Without RO	15.1 4.85 wt %	0.031	6.3 9.5 wt %	21.3	5.6	0.075
DUAL IXG BEDS (CATEX-ANEX SERIES)						
After RO	1.61 4.35 wt %	0.0041 6.64 wt %	0.82	12.4	3.90	0.0081
After RO	1.61 4.85 wt %	0.0041	0.82 9.5 wt %	22.4	2.16	0.0081
Without RO	32.3 4.85 wt %	0.082 9.5 wt %	16.4	48.7	4.5	0.161
SELECTIVE BED						
After RO (Kd=800, d=1.8)	-	-	-	10	3.6	-
Without RO (Kd=800, d=1.8)	-	-	-	-		-

---

* Ion exchange rinse and RO cleaning volumes are recycled.

TABLE 4.6-2

Waste from Reverse Osmosis and Ion Exchange

Note: Variables below are normalized fractions of unit feed (volume or total solids mass).

B - Ion exchange base factor. The fraction of feed solids which pass through reverse osmosis.

Ea - Solids from anion exchange regenerant (NaOH consumed) per unit feed solid mass.

Eat - Total solids in anion exchange eluent as a fraction of the solids in the F/HETF process feed.

Ec - Solids from anion exchange regenerant (NaOH consumed) per unit feed solid mass.

Ect - Total solids in the cation exchange eluent as a fraction of the solids in the F/HETF process feed.

R - Reverse osmosis system salt rejection. The fraction of solids which stay in the reject stream.

Rej - The flow volume of the reverse osmosis reject concentrate stream, as a fraction of F/HETF feed volume.

Sc - Total solids to the F/HETF evaporator from ion exchange and reverse osmosis.

Note: Variables below are calculated on the same basis used in Table 4.6-1.

Vci - Volume of cation exchange regeneration flow (gpm).

Vai - Volume of anion exchange regeneration flow (gpm).

Vix = Vai + Vci (gpm).

Ve = liquid flow to the evaporator.
= Vix + Vrej

Vf = F/HETF feed volume (200 gpm for calculations in Table 4.6-2).

Vrej = Volume of reject concentrate from reverse osmosis
= Vf (Rej)

TABLE 4.6.5-1

Estimated Releases to Basins

	1983*		1975**,†	
Ion	F Area (lb/yr)	H Area (lb/yr)	F Area (lb/yr)	H Area (lb/yr)
NH_4	3,100	3,600	110	<50
Ca	84	1,2300	730	4150
Mg	9	570	350	1480
Na	12,000	7,740	4200	45,400
Fe	270	2,230	2080	1260
Cu	1.6	1.28	<70	<270
Al	120	1,400	270	3770
Pb	18	89	<270	<1100
Zn	46	1,200	680	<2700
CO_3	20,400	20,800	0	21,600
Cl	190	484	200	3770
NO_2	310	308	30	600
NO_3	190,000	237,000	101,000	227,000
SO_4	720	1,700	3350	10,100

---

* Based on the extrapolation of 4Q83 average concentration over the entire year (2.5 x 10^8 liter volume).[7]

** Based on F and H-Area flows of 311,700 and 1,261,000 gal/week, respectively.

† The pH range for F Area was 2.0 to 2.7, H Area was 3.0 to 8.4. Phosphate releases were 180 and 28,300 lb/yr for F and H Area, respectively.

5.0 PROCESS DESCRIPTION

5.1 General

The major process options for the F/HETF are described in this section, including a schematic representation of each, followed by the projected material and curie balances. These options consist of combinations of the various stages described in Section 4 (above), and are presented here as complete systems to permit comparitive evaluation.

Process Option 1, the reference process for the F/HETF, is depicted schematically in Figure 4.6-1 (see also, Figure 1.3-1). Pretreatment for this and other process options consists of pH adjustment, aeration (or oxidant addition) and biological control.

5.2. Option 1 - Tubular Precoat/Cartridge Filter/RO/Ion Exchange

After pretreatment, the first stage of the process consists of tubular precoat filtration followed by a bank of cartridge filters, as described in Section 4, to produce a clean feed stream for the reverse osmosis stage. The rest of the system consists of reverse osmosis treatment and ion exchange polishing. The decontamination projections are based on mixed bed ion exchange. The F/HETF evaporator is expected to provide an average DF of at least 1E4, but the overheads will still require filtration and ion exchange polishing.

The decontamination factor provided by the tubular precoat filtration stage depends somewhat on the type and amount of filter-aid. Table C-5.2.1 (Appendix C) considers the case where precoat addition is optimized for minimum waste volume rather than decontamination efficiency. The first two pages of this table project the performance of this design for the F/HETF as it applies to the decontamination of daily waste, using the present standards for yearly releases to the 200-Area seepage basins as a source term for the feed stream. Releases to the F/HETF of 1000 Ci from first cycle feed (1AF) and high activity waste (HAW) are treated in the last four pages of Table C-5.2.1.

The average decontamination factor provided by this process also depends on the source of contamination in the feed. There may be some advantage to providing a greater DF in the filtration stage by using up to 5000 ppm of charged filter aid (Appendix C, Table C-5.2-2), with the disadvantage being additional waste generation.

Decontamination efficiency for heavy metals with this process is excellent, as described in Table 5.2.3-1.

5.3 Option 2 - Ultrafiltration /RO/Ion Exchange

Process Option 2 is depicted schematically in Figure 4.6-2. After pretreatment, the feed is passed through the ultrafilter stage, with the resulting high quality filtrate going on to reverse osmosis treatment and mixed bed ion exchange polishing. The F/HETF evaporator is expected to provide an average DF of at least 1E4, but the overheads will require filtration and ion exchange polishing to obtain maximum DF.

The decontamination factor table projects the performance of this option for the F/HETF as it applies to the decontamination of daily waste, using the present standards for yearly releases to the 200-Area seepage basins as a source term for the feed stream. Releases to the F/HETF of 1000 Ci from first cycle feed (1AF) and high activity waste (HAW) are also treated (Table 4.6-2).

Again, the average decontamination factor provided by this process depends on the source of contamination in the feed. Table C-5.3.2 illustrates the decontamination efficiency of selective ion exchange as it might be used in this option instead of regenerable mixed bed ion exchange. Decontamination of heavy metals is essentially the same as with the Option 1 process, (Table 5.2.3-1). The mass flow relationships given in the process schematic are for a 140 gpm process feed rate, and are derived from the Tables in Section 4.6.

5.4 Option 3 - Tubular Precoat Filtration/Cartridge Filtration/Selective Ion Exchange

Process Option 3 consists of the reference process, (Option 1) without reverse osmosis. After pretreatment, the feed is passed through a filtration stage, just as in Option 1, with the resulting filtrate going on to selective ion exchange. The F/HETF evaporator is eliminated, along with any polishing steps.

Because some kinds of radionuclides are not removed by a selective adsorption process, the average decontamination factors (Table C-5.4.1) projected for the F/HETF using this kind of media are high but still less than those of Options 1 and 2. For this reason, Option 3 may be unacceptable, even for the decontamination of daily waste. Releases of 1000 Ci from first cycle feed (1AF) and high activity waste (HAW) would require more treatment, possibly the use of additional, less selective, ion exchange columns.

The average decontamination factor provided by this process depends heavily on the source of contamination in the feed. Only those radionuclides which are selectively retained can be removed by this system. Decontamination of heavy metals less efficient than the Option 1 process.

5.5 Option 4 - Multiple Deep Bed Filtration/RO/Mixed Bed Ion Exchange

Option 4 is essentially the early "reference process." The pretreatment stage is followed by four separate filters. These would be a graded density, multiple media mixed bed; an iron removal filter; a carbon bed; and a backpulsable submicron filter. A more complete description of the filtration system is given in Section 4.2.

After filtration, the feed stream passes through reverse osmosis, followed by mixed bed ion exchange. The estimated decontamination efficiency of Option 4 is described in Table C-5.5.1. As with the options described previously, modifications to the ion exchange system are possible, and could be applied without affecting the front end of the treatment system. The impact of such changes can be estimated from similar changes which are described for other process options.

The backflush water from the filters is expected to be from 0.5 to 2 wt % as suspended solids. Therefore, dewatering of this stream will be necessary to minimize waste volume. The choice for equipment to do this is between tubular ultrafiltration and the older filter technology, involving filter presses and moving belt filters. This relatively low volume stream could be handled either way, but the ultrafilter would be a single stage, and would produce a filtrate that could be sent to reverse osmosis without further treatment.

5.6 Option 5 - Filtration/Ion Exchange (Nonselective)

One of the first options that was considered for the F/HETF was based on ion exchange.[1] It has the advantage of being relatively simple to operate, and works well on relatively dilute streams. The disadvantages of ion exchange include its dependence upon filtration to remove neutral species and the fact that more waste is produced in the operation of the decontamination process than is concentrated by it from the original waste stream. Ion exchange regenerant waste is typically 3 to 5 wt %, not including resin washes and rinses, which occur on each cycle. Concentration of ion exchange regenerant for disposal normally involves evaporation, and is quite expensive. The decontamination efficiency of ion exchange can be very good for highly dissociated species. However, radionuclides which form neutral and insoluble compounds, or which are adsorbed on particulate material, must be removed by filtration. The combination of good filtration with a well designed ion exchange system can be effective in removing radioactivity.

The decontamination efficiency of a nonselective ion exchange process depends on the way it is operated. Multiple beds are typically placed in series, with a cation exchange bed followed by anion exchange. The effluent from these is often fed into a mixed bed column to provide the highest product quality possible. This is a reasonable approach to ion exchange in any of the nonselective F/HETF options. The benefit of using this approach includes higher decontamination efficiency and more efficient operation. Working efficiency comes from performing in-column dual bed regeneration to recover most of the waste, which reduces the frequency of resin transfer and other procedures peculiar to mixed bed operation.

The decontamination efficiency of Option 5 is estimated in Tables C-5.6.1 and C-5.6.2 for simple mixed bed and dual column operation. Both Tables are based on the assumption that regeneration is performed to a moderate level, consistent with the waste volume estimates in Section 4.6. The accuracy of these estimates, and the DF provided by more sophisticated ion exchange combinations will depend heavily on the degree of particulate removal by the filtration system.

SECTION 5 REFERENCE

1. J. R. Cadieux, Memorandum to J. R. Wiley, Decontamination of Cooling Water by Ion Exchange, DPST-82-855, September 14, 1982.

TABLE 5.2.3-1

Hazardous Metal Decontamination

Metals	Filtration (Df)	Reverse Osmosis (Df)	Ion Exchange (Df)	System (Df)	Feed Average (ppm)	Effluent Average (ppb)
Cu	1	20	100	2000	0.22	0.110
Cr	1	10	200	2000	0.043	0.021
Hg	2	10	100	2000	0.053	0.026
Pb	5	20	100	10000	0.16	0.016
Zn	5	20	200	20000	1.5	0.075
Cd	5	20	200	20000	0.001	0.000
Ni	2	20	200	8000	0.12	0.015

6.0 FUNCTIONAL DESCRIPTION OF EQUIPMENT

6.1 Shielding

6.1.1 Activity Retention

The F/HETF will require shielding to prevent the exposure of operating personnel to gamma radiation and x-rays. Equipment design and orientation will determine the amount of shielding the system will require to handle a given level of activity safely. However, the level of activity in the various parts of the process will depend on several factors, including feed activity, chemical concentration and system performance. The materials and equipment with the greatest potential for concentrating activity are presented in Table 6.1-1. Estimates of the amount of activity they could contain during normal operations are given along with the approximate geometry of the activity sources. The equipment geometry in the Table is taken from an experimental design for the F/HETF which is to be tested and demonstrated at a process rate of 40 gpm (i.e., the ECWPF).

The basis for calculating the activities in Table 6.1-1 was the guideline for releases to the seepage basins (i.e., 1000 d/m/ml). The actual measurement would be c/m/ml, which is a lower value for a given level of activity, but the estimates in the table are a linear function of the feed activity, and may be adjusted accordingly. The distribution of activity in the table comes from that of the seepage basin release guides (see Table 2.2-1). The geometry of this equipment will change upon scale-up, and shielding calculations will have to be adjusted accordingly.

For the purpose of making shielding calculations, the concentrating efficiency of each piece of equipment is assumed to be the maximum expected for its operation under all conditions, including instances of inadequate or nonexistent performance of the previous stage (i.e., unfilterable activity or equipment bypass). Therefore, although a Df of 10 is assumed for filtration when evaluating the activities associated with filtration equipment, the entire activity load of the feed is also presumed to be capable of reaching the reverse osmosis equipment (filtration Df=0). The activity levels in the reverse osmosis pressure vessels and concentrate stream will actually be lower than predicted by Table 6.1-1 if the filtration system works as well as projected (see Appendix C).

The activity that will be contained in the nondisposable filtration equipment and materials was estimated using distribution coefficients that were measured in the laboratory (Table 6.1-2). For the purposes of these estimates, distribution ratios (K_d) remain nearly constant over the range of chemistry and activity that will be going to the F/HETF. The adsorption mechanism appears to be mainly ion exchange, as less than 50% of the adsorbed activity could be rinsed off of the filter media.

Cartridge filter activity was conservatively estimated on the basis of a presumed feed activity level (1000 d/m/ml), a high filter cake loading (10% by volume), and a phase distribution of activity like garnet, which favors adsorption by 500:1. Activity on the Mott pneumatic hydropulse filter is calculated the same way, except that the filter cake is estimated to be only 3 mm thick over the entire filter area. The activity associated with tubular precoat filtration is derived from decontamination factors, solids loading, and backwash cycle times, that have been measured in the laboratory.

The type of membrane that is used appears to make a significant difference as to the retention of activity by the reverse osmosis modules. Tests have shown that there is a considerable affinity between Cs-137 and both B-9 and B-10 aramid membrane fiber (Permasep Products Division, Du Pont). Thin film composite membranes (Filmtec Corp.) adsorbed far less Cs-137 in batch equilibration tests, even taking their relatively lower specific surface area into account. This is also born out by material balance relationships from rdioactive performance testing. The shielding calculations are intended to represent the Filmtec thin film composite membrane and its high pressure containment,

The activity that is contained by the ion exchange columns is calculated using two bases. As a worst case, the highest activity level presently allowed to go to the seepage basins would be contained in the lowest conductivity waste that has been observed so far (from H Area). The specific activity on the column would therefore be relatively high. The expected value is calculated from average radioactivity and ionic concentrations.

6.1.2 Shielding

The activity levels described in the preceding section were combined with their respective geometries. These were then used to calculate the amount of shielding that would be required to achieve acceptable dose rates for operators working around the 40 gpm scale demonstration unit.[1] The results of these calculations are given in Table 6.1-3.

6.2 Waste Handling

6.2.1 Salt Concentrate

The waste concentrate from the F/HETF evaporator is expected to behave in much the same fashion as the salt supernate in the Tank Farms. It will be essentially a sodium nitrate salt solution, and most of the insoluble minor constituents will have been removed by filtration. The only solids would be precipitates formed during the evaporation process, consisting mainly of calcium and ferric silicates, carbonates and sulfates.

At 30 wt %, sodium nitrate is a 4.33 Formal solution with a density of 1.23. Its kinematic viscosity is 1.31 CS, and ~370 grams of salt are contained in each liter of solution.

6.2.2 Filter Concentrate

The concentrate from filtration will contain the feed solids, plus any material added in the filtration process. Slurry pumps and continuous agitation will be required to prevent the filter cake from settling and possibly blocking transfer lines. Automatic rinsing must precede any shutdown to eliminate the possibility of solid cake formation in the lines and hold tanks. This is especially important in the handling of diatomeceous earth filter cake backwash, as it settles rapidly and tends to form a solid mass if left undisturbed.

6.2.3 Organic Waste

The potential problem of a two-phase (organic/aqueous) feed stream was also alluded to in the pretreatment section. Up to 500 ppm of organic carbon was measured in weekly composite samples of the 200-Area effluents. In the current reference process, this condition would be addressed primarily by using a skimmer to collect any organics which may be floating on the surface. The skimmed material would then be channelled into the filter concentrate stream, going directly to the burial ground solidification facility.

In addition to the skimmers, activated carbon or a similar adsorbent will still be required to prevent residual organic contaminants from reaching the reverse osmosis system. And, whether the adsorbent is used in the form of a column or as part of the filter precoat formula, it will require disposal once it becomes exhausted. In either case, it should be quite compatible with the filter concentrate stream.

If the option is exercized to use ultrafiltration instead of tubular precoat filtration, the use of activated carbon might be eliminated entirely, as ultrafiltration is well suited for removing organics from water. The skimmers could probably be eliminated from the pretreatment process as well, since phase separation could be handled by the ultrafilter alone. Again, the filter concentrate would contain the organic material from the feed stream, and this would go directly to the waste solidification facility.

6.2.4 Nonpumpable Solids

As described in the section covering pretreatment, the front end of the process will be protected by a screen filter. This screen should be on the order of 100 mesh to protect the process feed pumps. The high pressure ultrafilter pumps, if used, would require a screen between 100 and 200 mesh. The trapped solids would be drained and then packed in drums with vermiculite or some other absorbent material for disposal in the burial ground (classified) as nonhazardous radioactive waste.

6.3 Chemical Feed

6.3.1 Liquids

The liquids that will be used in the operation of the F/HETF include technical grade caustic and nitric acid. These will both be used in pH adjustment and ion exchange regeneration and should be ordered, received and handled as they are elsewhere at SRP. Holding and dilution tanks will be required for these. Neutralization will require at least 600 lb/day of 40 wt % for processing 200 gpm of feed at a pH of 2.6. However, about 2400 lbs/day would be needed to neutralize the same volume of pH 2 feed.

Acidity measurements as high as 1050 were recorded in weekly composite samples of H-Area waste. The equivalent free acid pH for this acidity is ~1.7, and about 1 pound of 40 wt % caustic would be required to neutralize 60 gallons.

Feeding 2000 ppm sodium nitrate through reverse osmosis at 200 gal/min, the ion exchange regeneration process will consume an average of 560 lb of 40 wt % caustic and 380 lb of 67 wt % nitric acid in 24 hours of operation.

Proprietary cleaning solutions will also be used to remove scale and organic film from the reverse osmosis membranes and as a minor feed additive to prevent membrane fouling. These will consist of phosphate detergents, polyphosphates, citric acid and surfactants. Storage and makeup tanks should be sized to permit the useage of up to 200 gallons per day of three different solutions.

6.3.2 Solids

A dry location near the tubular precoat filtration equipment is needed to store filter aid. The diatomeceous earth filter aid that will be used in the precoat filter will come in 100 lb bags. Two or more bags will be loaded into the precoat tank daily makeup tank on each day shift. This action will normally be required about once per day, depending on the nature of the feed. However, process feed that is very high in suspended solids (e.g., storm water) will require more frequent additions. Therefore, filter aid addition to the day tank should be mechanized as much as possible. A hood and proper ventilation should also be built in to prevent the aspiration of dust by the operator.

6.4 Climate

The process equipment of the F/HETF should be operated at a reasonably constant temperature. It should not be exposed to freezing temperatures or direct summer sun. The membranes of the reverse osmosis equipment will perform best at a constant temperature of 35-40°C. Colder temperatures reduce their productivity, and hotter temperatures can damage them. Electronic monitoring and control systems also require climate control.

SECTION 6 REFERENCE

1. G. W. Earle, SRP HP Memorandum to W. W. Collins, September 20, 1984).

TABLE 6.1-1

Inventory of Radioactivity (Calculated for the Experimental Contaminated Waste Processing Facility)

	Wall Geometry				Total	Alpha	Cs-137	Ru-106
Vessels		Dia (in)	Ht (in)	Volume	B-G (mCi)	(mCi)	(mCi)	(mCi)
UF Conc/Feed Tank	1/4" SS	72	96	1500 gal	230.00	1.15	53.36	44.62
RO Conc Hold Tank	1/4" SS	48	60	500 gal	17.00	0.09	3.94	3.30
IXG Columns	1/4" SS	30	90	25 cu ft	106.00	0.53	24.59	20.56
Mott PHP Filter	1/4" SS	24	106	4E5 cm^2 x 3 mm	7.78	0.04	1.80	1.51
Iron Removal Filter	1/4" SS	42	78	26 cu ft	276.69	1.38	64.00	53.68
Multi-Media	1/4" SS	48	60	34 cu ft	64.85	0.32	15.00	12.58
Bypass Cartridge	1/4" SS	9.25	39.25	10%	0.30	0.00	0.07	0.06
RO Pressure Vessel	1/8" SS	8	204	100%	1.52	0.01	0.35	0.29
UF Containment	1/8" SS	8	240	20%	1.60	0.01	0.37	0.31
Streams								
					d/dm/mL	d/dm/mL	d/dm/mL	d/dm/mL
Feed					1000	5	232	194
UF Concentrate					90000	450	20880	17460
RO Concentrate					20000	100	4640	3880
IXG Regenerant					750000	3750	174000	145500
(Expected IXG REGN)					(29000)	(145)	(6728)	(5626)

TABLE 6.1-2

Distribution Coefficients of Strontium and Cesium on Filter Media

Adsorbent	Sr-85	Cs-137
Garnet 40	87	451
Iron Removal	1725	1366
Graphite	167	245
Act Carbon	115	15
Garnet 25	30	319

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* $K_d = C_s/C_L$ where Cs and C_L are the concentrations of analyte in the solid and liquid phases respectively (g/g).

TABLE 6.1-3

Shielding Requirements for the Treatment of Normal Daily Waste (calculated for the Experimental Contaminated Water Processing Facility)

Process Unit	Unshielded Radiation Level (mR/hr) @ 1**	Unshielded Radiation Level (mR/hr) @ 3**	Shielding Requirements* Lead (inch)	Shielding Requirements* Concrete (inch)
UF Conc/Feed Tank	12	5	0.8	9
RO Conc Hold Tank	1	0.5	None	None
IX Columns	21	7	1.0	10
MOTT PHP Filter**	0.5	<0.5	None	None
Iron Removal Filter	60	15	1.4	13
Multimedia	12	3	0.6	7
Bypass Cartridge	<0.5	<0.5	None	None
RO Pressure Vessel	<0.5	<0.5	None	None
UF Containment	1.5	<0.5	None	None

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* Lead and concrete shield thickness requirements to limit personnel dose rates to <0.5 mrems/hr at 3' (91 cm) and <5 mrems/hr at 1'(30) cm).

** Without precoat

7.0 NUCLEAR AND PROCESS SAFETY

7.1 Criticality

There is no potential for a critical mass of fissile material to accumulate in the F/HETF process as a result of processing daily waste. The entire yearly output in effluents from the separations areas contains less than 10 mCi of fissile isotopes (see Section 2 and Appendix A for Analytical Summaries). This would ultimately be solidified in about 400 tons of waste concrete.

A serious spill involving the release of fissile material has never occurred, and is considered to be an almost zero probability event. However, even if it were to occur, the contaminated stream would not be diverted to the F/HETF until activity levels were measured, and the risk of criticality was completely evaluated. Part of the safety analysis and procedures that will be written before the F/HETF can be operated will include an assessment of the amount of activity that can be handled safely.

8.0 HAZARDS ANALYSIS

8.1 Explosion Potential

The possibility of explosion at the F/HETF could only arise if the ion exchange columns were heated or allowed to heat up in the presence of nitric acid. Experience within Du Pont and throughout the history of SRP has shown that ion exchange regeneration with nitric acid can be performed safely as long as proper procedures are followed and the design includes adequate pressure relief. These procedures normally assure moderately low operating temperatures. Static conditions are generally avoided when nitric acid is in contact with ion exchange resin in order to eliminate heat buildup. Furthermore, anion exchange resin must not be stored or allowed to dry out when in the nitrate form. Provisions in the design of the F/HETF are needed for a low volume temperature regulated flow to be recirculated through anion ion exchange columns that may be stored in the nitrate form. Ion exchange regeneration will be performed according to current SRP procedures.[1]

8.2 Radiation Exposure

The primary concern in the design and operation of the F/HETF is to minimize the exposure of operating personnel to ionizing radiation while producing a clean effluent that is uncontaminated with long-lived radionuclides. The decontamination process that is recommended here is amenable to these goals. With the proper degree of automation and shielding, the doses received by operators of the F/HETF would be extremely low, and may be almost undetectable on a routine basis. However, measurable exposure could occur during work performed near the concentrated waste storage area, or as a result of service work on contaminated equipment. Therefore, pumps and other high maintenance equipment in the F/HETF must be compatible with low level radioactive service, they should be easily decontaminated, easily maintained, and should be located away from concentrated radioactivity to provide safe access.

8.3 Chemical Exposure

There will be no carcinogenic substances used in the operation and maintenence of the F/HETF. Potentially corrosive substances, such as nitric acid, sodium hydroxide, sodium citrate, sodium hexametaphosphate, and sodium bisulfite may be used in cleaning the reverse osmosis membranes.

Ozone may be used as a pretreatment chemical to destroy biological activity in the F/HETF, and to oxidize organic material and iron for better treatability. It has been widely used in water treatment systems, and is typically generated and applied as a gas. Ozone gas is toxic, and affects the central nervous system at 75 minutes exposure at a concentration of 1.86 ppm in air. A concentration of 1 ppm produces a disagreeable sulfur-like odor, and may cause headache and irritation of the upper respiratory tract. These affects are temporary, and symptoms leave after removal from exposure. A concentration of 0.015 ppm produces a barely detectable odor.[2]

The use of diatomeceous earth filter aids, as called for in the reference process, may expose operators to a certain amount of dust. This dust has the potential for causing fibrosis of the lungs, but is less potent than SiO_2 in this respect. Proper design and the use of protective equipment when handling this material will eliminate this potential hazard.[2]

SECTION 8 REFERENCES

1. DPSOL 245-H-105, Rev. 17, Regenerating 100-Area Resin.

2. N. I. Sax, "Dangerous Properties of Industrial Materials," 6th Ed., VanNostrand, Reinhold Company, New York, NY (1984).

9.0 ENVIRONMENTAL

9.1 General

The purpose of the F/HETF is to reduce the concentration of long-lived radionuclides and hazardous metals in the effluents of the 200 Areas to well below the levels of concern. Such levels can be judged in many ways, but the most appropriate criteria seem to be the Offsite Dose Commitment related to maximum releases from the F/HETF, the NEPA Guidelines for hazardous chemical releases, and the absolute change with respect to current operating conditions and guidelines. Table 9.1-1 lists some of the most important radionuclides and describes the impact of the F/HETF on their concentrations in the Savannah River.

9.2 Offsite Dose Commitment

The SRP, in conjunction with SRL, operates some of the most sensitive radiochemical detection systems in the world. These are used constantly to measure the effect that SRP operations have on the surrounding environment. The information that is obtained from these systems is processed by a computer program (LADTAP2) that calculates the dose that could be received by the most vulnerable individuals, as well as that received by the population as a whole. Changes in SRP processes and waste management procedures can thus be evaluated quite objectively on the basis of their environmental impact. This technique has been applied to the effluents projected for the F/HETF. The results of this analysis are listed in Tables 9.2-1 and 9.2-2.

The presence of tritium complicates the assessment of cost to benefit for the F/HETF, because it is the major contributor to offsite dose, and it is not removed by the F/HETF. Therefore, although tritium is relatively short-lived, some measures are necessary to reduce the amount of tritium reaching the environment in order to have a substantial effect on off-site dose. Proposed methods include the segregation of tritiated waste prior to the F/HETF, and recycling or containing F/HETF effluents, which, except for tritium, would be quite pure.

9.3 NEPA Guidelines

The guideline concentrations that have been proposed for hazardous substances in the F/HETF effluents are listed in Table 9.3-1. These are based on dilution in Upper Three Runs Creek, which has a flow rate of 117 cfs. Standards for Four Mile Creek would be ~20 times more stringent owing to a reduction in dilution credit. The reference process is expected to provide the decontamination efficiency needed to permit the release of F/HETF effluents to either outfall location (See Section 5.2).

9.4 Present Release Guidelines for Radioactivity

The SRP is presently operating under guidelines which have been set by DOE for the release of radionuclides to the environment. These guidelines are based on offsite dose, as discussed in Section 9.2, and are designed to limit normal releases to about 1% of those allowed by federal regulation. The guidelines presently limit releases to Four Mile Creek to 35 mCi/yr of radiostrontium, 75 mCi/yr of radiocesium, and 150 mCi/yr of all other radioactivity.

TABLE 9.1-1

Radionuclide Releases to Savannah River

	1983	F/HETF - Routine Releases							
	Releases	No Treatment		Filtration		Filtration-Zeolite		Filtration-RO-IX	
Radionuclide	Ci	Ci	% Increase	Ci	% Increase	Ci	% Increase	Ci	% Increase
Co-60	0.0019	1	52000	1	52000	0.1	5200	5E-4	26
Sr-90	0.31	1.4	450	1.2	390	0.0013	0.4	7E-5	0.02
Cs-137	0.152	13	8600	11.8	7800	0.012	8	6E-4	0.4
Other									
Beta-Gamma*	0.024	0.7	2900	0.035	150	0.0035	15	3.5E-6	0.01

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* Excluding tritium

TABLE 9.2-1

Comparison of Offsite Doses — F/HETF Routine Releases

	Yearly Maximum Individual Dose, mrem	% of Total SRP Dose	Yearly Population Dose Person-rem	% of Total SRP Dose
DOE Guide	500			
EPA drinking water standard	4			
SRP technical standard	10			
1983 SRP releases				
Atmospheric	1.88		83	
Liquid	0.28(0.008)*		7(0.4)	
Total	2.16	100	90	100
1983 200 Areas - liquid	0.19(0.08)	9	4.5(0.4)	5
1983 200 Area seepage basins Sr-90 migration to creek**	0.068	3	1.6	2
F/HETF routine liquid releases**				
No treatment	11(0.8)	510	47(12)	50
Filtration	9(0.8)	420	35(12)	40
Filtration/zeolite	0.031(0.8)	1.4	0.17(12)	0.2
Filtration/RO/MB IX	0.00052(5E-5)	0.024	0.0022(6E-4)	0.002

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* Numbers in ( ) are thyroid dose - primarily due to I-129, 131

** Based on effective body dose calculation and average Savannah River flow and assuming no change in tritium releases

TABLE 9.2-2

Comparison of Offsite Doses — F/HETF Nonroutine Releases

	Maximum Individual Dose, mrem	% of Total SRP Dose	Population Dose Person-rem	% of Total SRP Dose
DOE Guide	500			
EPA drinking water standard	4			
SRP technical standard	10			
1983 SRP releases	2.16	100	90	100
F/HETF release*				
1000 Ci canyon release**				
No treatment	40	1850	140	160
Filtration	15	690	70	78
Filtration/zeolite	0.68	32	1.7	1.9
Filtration/RO/MB IX	0.0016	0.074	0.0088	0.0098
1000 Ci tank farm release				
No treatment	680	32000	2100	2300
Filtration	620	29000	1900	2100
Filtration/zeolite	0.62	29	1.9	2.1
Filtration/RO/MB IX	0.033	1.5	0.1	0.11

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* Based on effective body dose calculation and average Savannah River flow.

** First cycle feed

10.0 ENERGY CONSERVATION

10.1 General

The F/HETF will have a rated capacity of 200 gal/min or 1090 m^3/day, and is expected to operate at about 70% of capacity throughout the year. In addition to being much less expensive to install than total evaporation, the reference process will use less energy, and only a fraction of the energy required to evaporate using the prevailing evaporator design. The evaporators that are presently used to concentrate high level waste at the tank farms consume about 1.6 pounds of steam for every pound of overheads they produce. The F/HETF is expected to see at least 6E8 pounds of water per year, all of which would go to evaporation. This is represents an energy expendature of about 6.8 million dollars per year for steam, or roughly 12 million dollars per year if electric power were used ($0.045/KWh, 990 KWh per m^3 of feed).

The alternatives which were examined for the F/HETF included more efficient evaporators, reverse osmosis, and ion exchange. The conclusion of this investigation was that reverse osmosis would require less energy to concentrate waste to about 4 wt % solids, than even the most sophisticated evaporator. The energy cost for going up to about 30 wt % would make total evaporation more competitive, depending on the design of the F/HETF evaporator. Again, depending on the energy efficiency of the F/HETF evaporator, reverse osmosis will outperform regenerable ion exchange, especially for more concentrated feeds, by producing less waste volume and a smaller quantity of waste salts.

10.2 Reverse Osmosis vs. Evaporation

The F/HETF will provide decontamination efficiency equal or superior to that obtained by even the most sophisticated evaporation systems, at a lower energy cost. There are several efficient designs for evaporators, generally falling into three catagories. These are Multi-stage Flash Distillation, Multiple Effect Distillation (vertical and horizontal tube evaporators), and Vapor Recompression. The energy consumption of these systems in large scale seawater desalination systems ranges from 15 to as little as 8 KWh of power per m^3 of distilled water produced, with Ambient Temperature Vapor Recompression being the most efficient (Ref. Distillation, Bulletin 205, p. 3, Permasep Engineering Manual, December 1, 1982). Evaporation without energy recovery uses at least a pound of steam for each pound of overheads produced, or 620 KWh/m^3.

Total evaporation was considered as one of the primary alternatives for the F/HETF. However, preliminary cost estimates were at least double those of the other candidate processes.

Furthermore, problems were forseen with feeds that contain a significant amount of suspended solids and organic material, and with changes in feed composition.

Assuming a pump efficiency of 62%, reverse osmosis can desalinate sea water at an energy consumption of about 6.7 KWh/m^3 of product, and 3000 mg/L feed can be desalinated for about 4 KWh/m^3 (sea water membranes, concentrate staging to >90% recovery).

In the current reference process, the evaporator receives up to 10% of the feed volume, in the form of reverse osmosis concentrate. An additional volume reduction of up to about 10:1 will be obtained through the evaporation process, at a cost of 2-6 KWh of additional power per m^3 of F/HETF feed depending on the design of the F/HETF Evaporator. However, the same degree of volume reduction would also result in higher operating costs for a total evaporation process by forcing the brine stream concentration to go up to about 30 wt % at the waste concentrate outlet.

10.3 Ion Exchange vs. Reverse Osmosis

As shown in the waste generation tables in Section 5, ion exchange produces waste concentrate (regenerant) equal to about 11% of the initial feed volume. This concentrate would go to the F/HETF evaporator. This volume is projected on the basis of average feed concentrations, and an even larger volume would be produced if the feed concentration were increased.

Reverse osmosis is expected to recover about 95% of the initial feed water, generating a waste concentrate volume equal to 5.6% of the initial feed, including ion exchange polishing. Therefore, about 5.4% of the initial feed volume would be prevented from going to evaporation, saving the incremental power cost. Reverse osmosis and the nececessary pretreatment equipment need about 6 KWh/m^3 to operate, and ion exchange requires at least 0.1 KWh/m^3. Using these numbers and the concentration factors above, ion exchange and reverse osmosis break even energetically when the evaporator uses about 93 KWh/m^3.

Reverse osmosis becomes more and more favorable as evaporation costs increase. Furthermore, evaporation costs would be equivalent for reverse osmosis and ion exchange, even if reverse osmosis were to operate at only 90% recovery. The electrical energy cost of operating reverse osmosis in the F/HETF for one year, at the rate of 6 KWh/m^3, is about $75,000.

APPENDICES

A. Annual Guidelines and Normal Practices for the Release of Radioactivity to the 200-Area Seepage Basins

Table A-1. Radioactivity Released to Basins in F Area
Table A-2. Radioactivity Released to Basins in H Area

B. WMETF Feed Chemistry

Table B-1. F-Area Effluents (Trebler Monitor Analyses)
Table B-2. F-Area Effluent Point Source Analyses
Table B-3. H-Area Effluents (Trebler Monitor Analyses)
Table B-4. H-Area Effluent Point Source Analyses

Explanation of Data Tables:

B.1 Format
B.2 Symbols
B.3 Analytical Detection

C. System Decontamination Factors

C-5.2.1. Tubular Precoat Filtration (50 ppm body feed) with Reverse Osmosis and Ion Exchange
C-5.2.2. Tubular Precoat Filtration (5000 ppm body feed) Reverse Osmosis and Mixed Bed Ion Exchange
C-5.3.1. Ultrafiltration, Reverse Osmosis, and Mixed Bed Ion Exchange
C-5.3.2. Ultrafiltration, Reverse Osmosis, and Selective Ion Exchange
C-5.4.1. Tubular Precoat Filtration (50 ppm body feed) and Selective Ion Exchange
C-5.4.2. Tubular Precoat Filtration (5000 ppm body feed) and Selective Ion Exchange
C-5.5.1. Multiple Deep Bed Filtration, Reverse Osmosis, and Mixed Bed Ion Exchange
C-5.6.1. Tubular Precoat Filtration and Mixed Bed Ion Exchange
C-5.6.2. Tubular Precoat Filtration, Cation Exchange, and Anion Exchange

D. WMETF Feed Analysis Updates

D-1. F-Area Effluents
D-2. H-Area Effluents

E. Silt Density Index (SDI) Measurement

APPENDIX A

ANNUAL GUIDELINES AND NORMAL PRACTICE FOR THE RELEASE OF RADIOACTIVITY TO THE 200-AREA SEEPAGE BASINS

TABLE A-1

Radioactivity Released to Basins in F Area

Nuclide	Annual Guidelines (1984) Normal Release* (Ci/yr)	Total Volume (L/yr)	Maximum Allowed Average Concentration (pCi/L)**	4 mrem/yr Drinking Water Std. (pCi/L)
Sr-89	0.2 <0.05	6.5×10^7 to 1.3×10^8	3,080	20
Sr-90	0.4 <0.1	6.5×10^7 to 1.3×10^8	6,200	8
Zr-95	4.0 4.0	6.5×10^7 to 1.3×10^8	62,000	200
Nb-95	4.0 4.0	6.5×10^7 to 1.3×10^8	62,000	300
Ru-103	2 2	6.5×10^7 to 1.3×10^8	30,800	200
Ru-106	20 5	6.5×10^7 to 1.3×10^8	308,000	30
I-131	0.8 1	6.5×10^7 to 1.3×10^8	12,320	3
Cs-134	0.3 <0.01	6.5×10^7 to 1.3×10^8	4,650	20,000
Cs-137	4.0 <1.0	6.5×10^7 to 1.3×10^8	62,000	200
Ce-141	0.1 <0.01	6.5×10^7 to 1.3×10^8	1,540	300
Ce-144	1.0 <0.01	6.5×10^7 to 1.3×10^8	1,540	30
Pm-147	0.5 <0.1	6.5×10^7 to 1.3×10^8	7,690	600

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*Maximum reported during 1982 and 1983

** Based on guideline release levels and lower range of the volume estimate

TABLE A-1, Contd

Nuclide	Annual Guidelines (1984) Normal Release* (Ci/yr)	Total Volume (L/yr)	Maximum Allowed Average Concentration (pCi/L)**	4 mrem Drinking Water Std. (pCi/L)
Other β/γ	0.5 <0.1*	6.5×10^7 to 1.3×10^8	7,690	1500
Am-241	0.02 0.02	6.5×10^7 to 1.3×10^8	308	5
Cm-242	0.01 0.01	6.5×10^7 to 1.3×10^8	154	5
U-235, U-238	0.2 0.2	6.5×10^7 to 1.3×10^8	2,080	5
Pu-238	0.02 0.02	6.5×10^7 to 1.3×10^8	308	5
Pu-239	0.02 0.02	6.5×10^7 to 1.3×10^8	308	5
Total α	0.2 0.2	6.5×10^7 to 1.3×10^8	3,080	15

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* Maximum released during 1982 and 1983

** Based on guideline release levels

TABLE A-2

Radioactivity Released to Basins in H Area

Nuclide	Annual Guidelines (1984) Normal Release* (Ci/yr)	Total Volume (L/yr)	Maximum Allowed Average Concentration (pCi/L)**	4 mrem Drinking Water Std. (pCi/L)
Cr-51	5.0 4	1.5×10^{-8} to 1.3×10^{-8}	33,300	6,000
Co-58	1.0 <0.03	6.5×10^{-8} to 1.3×10^{-8}	6,670	9,000
Co-60	1.0 <0.5	6.5×10^{-8} to 1.3×10^{-8}	6,670	100
Zn-65	0.8 <0.1	6.5×10^{-8} to 1.3×10^{-8}	5,336	300
Sr-89	0.4 0.1	6.5×10^{-8} to 1.3×10^{-8}	2,640	20
Sr-90	1.0 <0.5	6.5×10^{-8} to 1.3×10^{-8}	6,670	8
Zr-95	1.0 <0.2	6.5×10^{-8} to 1.3×10^{-8}	6,670	200
Nb-95	1.5 <0.3	6.5×10^{-8} to 1.3×10^{-8}	10,000	300
Ru-103	1.5 <0.2	6.5×10^{-8} to 1.3×10^{-8}	10,000	200
Ru-106	7.5 <3.0	6.5×10^{-8} to 1.3×10^{-8}	50,000	30
Sb-124 Sb-125	0.2 0.15	6.5×10^{-8} to 1.3×10^{-8}	1,333	60
I-131	0.4 <0.03	6.5×10^{-8} to 1.3×10^{-8}	2,667	3
Cs-134	1.5 <0.1	1.5×10^{-8} to 2.0×10^{-8}	10,000	20,000
Cs-137	9.0 <2.5	1.5×10^{-8} to 2.0×10^{-8}	60,000	200

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* Maximum released during 1982 and 1983

** Based on the guideline release levels

TABLE A-2, Contd

Nuclide	Annual Guidelines (1984) Normal Release* (Ci/yr)	Total Volume (L/yr)	Maximum Allowed Average Concentration (pCi/L)**	4 mrem Drinking Water Std. (pCi/L)
Ce-141	0.4 0.01	1.5×10^{-8} to 2.0×10^{-8}	3,333	300
Ce-144	2.6 0.4	1.5×10^{-8} to 2.0×10^{-8}	17,333	30*
Pm-147	1.0 <0.5	1.5×10^{-8} to 2.0×10^{-8}	10,000	600
Other β-γ	0.8 <0.2	1.5×10^{-8} to 2.0×10^{-8}	5,333	1500*
Alpha				
Am-241	0.002	1.5×10^{-8} to 2.0×10^{-8}	13	5
Cm-242 Cm-244	0.001	1.5×10^{-8} to 2.0×10^{-8}	6.7	5
U-235 U-238	0.005	1.5×10^{-8} to 2.0×10^{-8}	33	5
Pu-238	0.009	1.5×10^{-8} to 2.0×10^{-8}	60	5
Pu-239	0.006	1.5×10^{-8} to 2.0×10^{-8}	40	5
Total Alpha	0.2	1.5×10^{-8} to 2.0×10^{-8}	1,333	15

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*Maximum released during 1982 and 1983.

**Based on the guideline release levels.

APPENDIX B

F/HTF FEED CHEMISTRY

APPENDIX B. EXPLANATION OF DATA TABLES

B.1 Format

The Data Tables are divided into four major sections of ten pages each. The sections represent the results of two separate sampling programs in each of the two separations areas as follows:

Table B.1. Trebler samples from F Area. These represent composites of all effluents to the F-Area seepage basins for the week ending on the sample date (normally Friday).

Table B.2. Trebler samples from H Area. These also represent a one-week composite of the effluents to the seepage basins.

Table B.3. F-Area composite samples. These were taken in the second half of the sampling program, and represent the composition of the waste water from individual sources in F Area. Evaporator samples were taken from the overheads, not the feed stream. Samples were taken proportionally from each batch, over a one-week period.

Table B.4. H-Area composite samples are one-week composite samples of effluent wastewater from H Area.

All four tables are divided as follows:

Page 1 — Summarizes the analysis of each sample, including charge balance, percent error in charge balance, and the impact of pH on the analysis. Two pH measurements are reported if available, the first taken at SRL, and the second as reported by Envirodyne Engineers. A pH was also calculated by assuming that inaccuracies in the charge balance may be accounted for by pH variability for samples outside the 3-11 pH range.

Page 2 — Conductivity, oxidation-reduction potential vs. SCE (E_h), total inorganic carbon (TIC), total organic carbon (TOC), ammonia (NH_4), anionic total inorganic carbon (as ppm of carbon x total charge frequency, acidity (phenolphthalien), alkalinity (methyl orange), and the fraction of TIC present as the monovalent and divalent anions are reported.

Page 3 — Mercury (Hg), potassium (K), nitrite (NO_2), fluoride (F), chloride (Cl), sulfate (SO_4), phosphate (PO_4), and nitrate (NO_3) are reported in parts per million. The ADD sample numbers are also reported for these analyses (by atomic absorption and ion chromatography) for archival purposes.

Page 4 — Metals analyses are reported in parts per million, including sodium (Na), calcium (Ca), magnesium (Mg), total iron (Fe), total phosphorus (P), aluminum (Al), total silicon (Si), dissolved silicon smaller than 0.45 μm (Si (Si(sol)), nickel (Ni), manganese (Mn), and zinc (Zn). The ADD sample number is also recorded for these and other analyses that were performed on the same sample by inductively coupled plasma, but the ADD sample number for the dissolved silicon concentration is not reported here.

Pages 5-6 — These pages report the rest of the metal concentrations which were measured in acid-stabilized samples by inductively coupled plasma. All units are parts per million (mg/L).

Page 7 — Tritium, gross alpha and nonvolatile beta-gamma are reported all in units of counts per minute recorded for a 1.0 mL sample. I-129, I-127, and Tc-99 analyses are reported in parts per million, as measured by neutron activation analysis. Sr-90 was not measured. Cs-137 and Co-60 were analyzed by gamma pulse height analysis (with WPTD/WDTD counting equipment) and the results are reported in units of μCi/L (or nCi/mL).

Pages 8-10 — Reports other gamma emitters detected by gamma pulse height analysis in nCi/mL (or μCi/L).

B.2 Symbols and Abbreviations

Blanks - represent no sample available or the analysis was not performed.

Na - synonymous with a blank. Used to prevent errors in computer calculations.

< - Analyte was not detected by the analytical method and procedure used.

Formality conversion - molecular, atomic or ionic weight. Used in calculations of ion balance.

Si (sol) - also Si(filt). The amount of silicon in an unstabilized (no acid) sample which passes through a 0.45 μm filter.

[Cr] addnl contr - chromium is a significant factor in the charge balance equation and is treated as a monovalent anion.

B.2 Symbols and Abbreviations, Contd

Norm (+) - moles/liter of positive (cationic charge) calculated value.

Norm (-) - moles/liter of negative (anionic) charge, calculated.

Trebler monitor - A sampling station designed to monitor the waste water going into the seepage basins. There are two, one in F Area and one in H Area.

ARU - Acid recovery (or recycle) units. Large evaporators in both separations areas for the purpose of concentrating nitric acid.

GP - general purpose (evaporators).

RBOF-TARG - (CLNG and RNS) cleaning and rinse solutions from tritium target cleaning.

Resin class - (and REGEN) solutions from resin classification and regeneration after reactor area service.

B.3 Analytical Detection

Following are some of the estimated detection limits for the methods and procedures described above.

Ammonium	<1 ppm
TIC/TOC	<3 ppm
Hg	estimate 20% accurate at 10 ppb (sensitive to about 0.5 ppb)
K	<10 ppb
NO_2	<2 ppm
F	<1 ppm
Cl	<1 ppm
SO_4	<2 ppm
PO_4	<2 ppm
NO_3	<1 ppm

Metals — see values in Data Tables

Radionuclides —
Tritium - background variable from 20-200 c/m/mL
Gross alpha - <1 c/m/mL (recorded as d/m/mL)
Beta-gamma - <1 c/m/mL (recorded as d/m/mL)

QA Analytical Precision

Method	Analyte	N	RSD (%)	Concentration Measured (ppm)
ICO	Ca	5	2.9	8.8
ICP	Na	5	1.5	116
ICP	Sr	5	4.8	0.15
IC	NO_3	4	2.9	314
IC	Cl	4	38.0	11.5
IC	NO_2	4	47.0*	13.1

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* Variation of relative standard deviation expected due to systematic loss of nitrite to oxidation.

TABLE B-1

F-Area Effluents (Trebler Monitor Analyses)

SAMPLE	DATE (sample)	NORM+	NORM-	CHG BAL	%ERROR	pH (1ST)	pH (2ND)	pH (Calc)	H3O+	OH-
F-AREA TREBLER	9-23-83	3.52E-2	4.10E-2	-5.80E-3	15.2	1.52		1.44	3.02E-2	3.31E-13
F-AREA TREBLER	9-30-83	Error	Error	Error	Error	Na		Error	Error	Na
F-AREA TREBLER	10-14-83	3.74E-2	3.97E-2	-2.31E-3	6.0	2.55		2.29	2.82E-3	3.55E-12
F-AREA TREBLER	10-21-83	1.93E-2	2.42E-2	-4.94E-3	22.7	2.36	2.36	2.03	4.37E-3	2.29E-12
F-AREA TREBLER	10-28-83	Na	Na	Na	Na	12.24		Error	5.75E-13	1.74E-2
F-AREA TREBLER	11-4-83	8.20E-2	1.51E-2	6.69E-2	137.8	11.92	12.84	12.88	1.20E-12	8.32E-3
F-AREA TREBLER	11-11-83	1.76E-2	8.61E-3	9.04E-3	68.9	11.60	12.07	12.11	2.51E-12	3.98E-3
F-AREA TREBLER	12-9-83	1.55E-2	1.56E-2	-1.41E-4	0.9	2.76		2.73	1.74E-3	5.73E-12
F-AREA TREBLER	12-16-83	3.09E-2	2.78E-2	3.02E-3	10.3	6.02		6.0***	9.55E-7	1.04E-8
AVEARAGE F-AREA (TO 12/16)		3.40E-2	2.46E-2	9.39E-3	3.74E+1	2.93			4.89E-3	3.71E-3
MAXIMUM VALUE		8.20E-2	4.10E-2	6.69E-2	1.38E+2	12.24	12.84	12.88	3.02E-2	8.32E-3
MINIMUM VALUE		1.55E-2	8.61E-3	-5.80E-3	9.08E-1	1.52	2.36	1.44	1.20E-12	3.31E-13
SAMPLE	DATE (sample)	NORM+	NORM-	CHG BAL	%ERROR	pH	pH (HIST)	pH (calc)	H3O+	OH-

TABLE B-1, Contd

SAMPLE	DATE (sample)	COND	Eh	TIC	TOC	NH4	TIC (ANIONIC)	ACIDITY as CaCO3 ppm	ALKALINITY as CaCO3 ppm	CO3/TIC	HCO3/TIC
Formality conversion		UND	UND	12	12	17	12.00	100.09	100.09		
F-AREA TREBLER	9-23-83	12900	587.0	29	0		4.32E-4	Na	Na	1.95E-9	1.49E-5
F-AREA TREBLER	9-30-83	UND	UND	50	0		UND	Na	Na	UND	UND
F-AREA TREBLER	10-14-83	5500	541.0	18	0	28	2.87E-3	Na	Na	2.09E-8	1.60E-4
F-AREA TREBLER	10-21-83	4600	462.0	15	25		1.55E-3	Na	Na	1.35E-8	1.03E-4
F-AREA TREBLER	10-28-83	15500	24.0	Na	Na	Na	Na	Na	Na	9.90E-1	9.66E-3
F-AREA TREBLER	11-4-83	7800	-288.0	17	513	30	3.37E+1	0	402.5	9.80E-1	2.00E-2
F-AREA TREBLER	11-11-83	2280	-273.5	15	215	14	2.94E+1	0	70	9.59E-1	4.08E-2
F-AREA TREBLER	12-9-83	2500	235.0	29	6	9	7.51E-3	Na	Na	3.40E-8	2.59E-4
F-AREA TREBLER	12-16-83	2200	43.6	36	5		1.15E+1	Na	Na	6.18E-5	3.20E-1
AVEARAGE F-AREA (TO 12/16)		6.66E+3	1.66E+2								
MAXIMUM VALUE		1.55E+4	5.87E+2	3.60E+1	5.13E+2	3.00E+1	3.37E+1				
MINIMUM VALUE		2.20E+3	-2.88E+2	1.50E+1	0.0	9.00E+0	4.32E-4				
SAMPLE	DATE (sample)	COND	Eh	TIC	TOC	NH4	TIC	ACIDITY	ALKALINITY		

UNITS=MILLIGRAMS/LITER

TABLE B-1, Contd

SAMPLE	DATE (sample)	ADD#	Hg (PPM)	K	ADD#	NO2	F	Cl	SO4	PO4	NO3
Formality conversion			200.59	39.1		46	19	35.5	96	95	62
F-AREA TREBLER	9-23-83	39862	5.00E-3	1.06E-1	39848	0.0	0.0	0.0	0.0	0.0	2.54E+3
F-AREA TREBLER	9-30-83	40915	<.0001		40899	0.0	0.0	0.0	0.0	0.0	6.74E+3
F-AREA TREBLER	10-14-83	41392	<.0001		41387	0.0	0.0	0.0	0.0	0.0	2.46E+3
F-AREA TREBLER	10-21-83	41497	<.0007		41492	0.0	0.0	0.0	0.0	0.0	1.50E+3
F-AREA TREBLER	10-28-83	41774	1.20E-2		41769	1.57E+1	0.0	0.0	0.0	0.0	3.13E+2
F-AREA TREBLER	11-4-83	42643	1.10E-2		42636	0.0	0.0	9.61E+0	2.65E+0	0.0	2.26E+2
F-AREA TREBLER	11-11-83	42734	<.001	1.11E+0	42727	0.0	1.24E+1	0.0	3.26E+0	0.0	9.02E+1
F-AREA TREBLER	12-9-83	43867	2.80E-3	6.91E-1	43861	0.0	0.0	0.0	3.08E+1	0.0	9.27E+2
F-AREA TREBLER	12-16-83	44135	3.00E-3	7.84E-1	44129	0.0	0.0	0.0	0.0	0.0	1.67E+3
AVEARAGE F-AREA (TO 12/16)			4.22E-3	6.73E-1		1.96E+0	1.55E+0	1.20E+0	4.59E+0	0.0	1.22E+3
MAXIMUM VALUE			1.20E-2	1.11E+0	4.41E+4	1.57E+1	1.24E+1	9.61E+0	3.08E+1	0.0	6.74E+3
MINIMUM VALUE			0.0	1.06E-1	3.98E+4	0.0	0.0	0.0	0.0	0.0	9.02E+1
SAMPLE	DATE (sample)	ADD#	Hg	K	ADD#	NO2	F	Cl	SO4	PO4	NO3

TABLE B-1, Contd

SAMPLE	DATE (sample)	ADD#	Sodium	Ca	Mg	Fe	P	Al	Si	Si(sol)	Ni	Mn	Zn
Formality conversion			23	40.1	24.3	55.8	31	26.98	28.1	28.1	58.7	54.94	65.37
F-AREA TREBLER	9-23-83	39860	1.10E+2	4.10E-1	5.00E-2	3.45E+0	3.28E+0	2.73E-1	6.10E-1	4.10E-1	<0.05	<.01	3.00E-2
F-AREA TREBLER	9-30-83	40913	7.92E+2	4.50E-1	6.00E-2	2.40E+1	3.40E+0	1.13E+0	3.70E+0	UND	<	4.00E-2	2.46E-1
F-AREA TREBLER	10-14-83	41391	7.54E+2	7.53E-1	7.20E-2	7.47E-1	1.81E+0	1.00E+0	1.58E+0	1.62E+0	<.05	1.53E-2	3.00E-2
F-AREA TREBLER	10-21-83	41496	3.42E+2	3.62E-1	5.40E-2	8.64E-1	4.40E+0	2.55E-1	6.60E-1	5.50E-1	5.00E-2	2.50E-2	1.00E-2
F-AREA TREBLER	10-28-83	41773	1.90E+3	0.0	0.0	0.0	1.36E+0	9.62E-1	3.86E+1	2.24E+1	<.05	<.1	6.86E-1
F-AREA TREBLER	11-4-83	42642	1.84E+3	0.0	0.0	0.0	9.20E-1	0.0	7.61E+0	7.41E+0	<	<	1.16E+0
F-AREA TREBLER	11-11-83	42733	3.83E+2	4.90E-1	7.40E-3	2.30E-1	1.34E+0	1.01E+0	2.87E+0	2.56E+0	2.17E-1	<	6.53E-2
F-AREA TREBLER	12-9-83	43868	2.95E+2	5.53E-1	1.41E-1	6.10E+0	3.17E+0	7.56E-1	3.11E+0	3.11E+0	<	4.16E-2	9.05E-2
F-AREA TREBLER	12-16-83	44134	7.00E+2	1.78E+0	1.55E-1	2.44E+0	1.59E+0	1.99E+0	2.16E+0	2.12E+0	4.31E-1	4.23E-2	2.87E-1
AVEARAGE F-AREA (TO 12/16)			7.90E+2	5.43E-1	5.99E-2	1.73E+0	2.23E+0	7.81E-1	7.15E+0	5.02E+0	8.72E-2	1.55E-2	2.95E-1
MAXIMUM VALUE			1.90E+3	1.78E+0	1.55E-1	2.40E+1	4.40E+0	1.99E+0	3.86E+1	2.24E+1	4.31E-1	4.23E-2	1.16E+0
MINIMUM VALUE			1.10E+2	0.0	0.0	0.0	9.20E-1	0.0	6.10E-1	4.10E-1	0.0	0.0	1.00E-2
SAMPLE	DATE (sample)	ADD#	Sodium	Ca	Mg	Fe	P	Al	Si	Si(Sol)	Ni	Mn	Zn

UNITS=MILLIGRAMS/LITER

TABLE B-1, Contd

SAMPLE	DATE (sample)	Cr	Ba	Cu	Pb	Cd	Co	Sr	Zr	Yb	La	Li	Be
Formality conversion		51.996	137.3	63.5	207.2	112.4	58.9	87.6	91.2	88.9	138.9	6.94	9.01
F-AREA TREBLER	9-23-83	<.01	<.003	<.01	<.03	<.01	<.01	4.40E-3	4.20E-2	<.01	<.005	<.005	<.003
F-AREA TREBLER	9-30-83	2.80E-2	<.003	<.01	2.70E-1	<.01	<.01	4.90E-3	<.005	1.20E-2	<.005	1.30E-2	3.70E-3
F-AREA TREBLER	10-14-83	<.01	4.90E-3	<.01	<.03	<.01	<.01	4.70E-3	<.005	<.01	<.005	<.005	<.003
F-AREA TREBLER	10-21-83	1.00E-2	1.03E-2	9.00E-3	1.03E-1	0.0	0.0	4.30E-3	4.70E-3	2.14E-2	3.00E-3	0.0	0.0
F-AREA TREBLER	10-28-83	<.01	<.03	<.01	<.03	<.01	<.02	1.84E-2	<.005	<.01	<.005	<.005	<.003
F-AREA TREBLER	11-4-83	<	4.90E-2	<	<	<	<	<	<	<	<	<	<
F-AREA TREBLER	11-11-83	1.60E-2	1.50E-2	2.75E-2	2.65E-1	<	<	<	1.40E-2	6.70E-2	1.44E-2	1.27E-2	<
F-AREA TREBLER	12-9-83	<	<	<	<	<	<	3.00E-3	<	<	<	<	<
F-AREA TREBLER	12-16-83	7.54E-2	2.16E-2	4.26E-2	5.49E-1	<	1.84E-2	1.00E-2	2.25E-2	1.14E-1	1.75E-2	1.44E-2	<
AVEARAGE F-AREA (TO 12/16)		1.27E-2	1.26E-2	9.89E-3	1.15E-1	0.0	2.30E-3	5.60E-3	1.04E-2	2.53E-2	4.36E-3	3.39E-3	0.0
MAXIMUM VALUE		7.54E-2	4.90E-2	4.26E-2	5.49E-1	0.0	1.84E-2	1.84E-2	4.20E-2	1.14E-1	1.75E-2	1.44E-2	3.70E-3
MINIMUM VALUE		0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
SAMPLE	DATE (sample)	Cr	Ba	Cu	Pb	Cd	Co	Sr	Zr	Yb	La	Li	Be

TABLE B-1, Contd

SAMPLE	DATE (sample)	B	Ti	U	V	Y
Formality conversion		10.8	47.9	238	50.9	88.9
F-AREA TREBLER	9-23-83	2.30E-2	<.003	1.16E+0	<.01	<.01
F-AREA TREBLER	9-30-83	<.005	6.50E-3	1.19E+0	1.21E-2	<.01
F-AREA TREBLER	10-14-83	005	<.003	7.19E-1	<.01	<.01
F-AREA TREBLER	10-21-83	0.0	3.00E-3	1.56E+0	7.50E-3	1.00E-3
F-AREA TREBLER	10-28-83	4.15E+0	<.03	<.5	<.01	<.01
F-AREA TREBLER	11-4-83	<	<	<	<	<
F-AREA TREBLER	11-11-83	<	1.15E-2	.72(1.2)	1.30E-2	<
F-AREA TREBLER	12-9-83	<	<	<	<	<
F-AREA TREBLER	12-16-83	1.78E-2	1.60E-2	8.47E-1	3.28E-2	<
AVEARAGE F-AREA (TO 12/16)		5.24E-1	3.81E-3	5.36E-1	6.66E-3	1.25E-4
MAXIMUM VALUE		4.15E+0	1.60E-2	1.56E+0	3.28E-2	1.00E-3
MINIMUM VALUE		0.0	0.0	0.0	0.0	0.0
SAMPLE	DATE (sample)	B	Ti	U	V	Y

TABLE B-1, Contd

SAMPLE	DATE (sample)	ADD#	T	å	β-G	I-129	I-127	Tc-99	Sr-90	Cs-137	Co-60
Formality conversion			3	d/m/ml	d/m/ml	(PPM)	PPM	PPM	90	137	60
F-AREA TREBLER	9-23-83	39854		7.00E+0	2.30E+1						
F-AREA TREBLER	9-30-83	41222	2.18E+5								
F-AREA TREBLER	10-14-83	41396		1.80E+1	1.16E+2						
F-AREA TREBLER	10-21-83	41501	1.28E+5	1.90E+1	1.85E+2	<0.03		<0.145			
F-AREA TREBLER	10-28-83	41778	1.83E+5	1.20E+1	3.60E+1	<.01	1.30E-1				
F-AREA TREBLER	11-4-83	42641	3.66E+5	0.0	3.20E+1	<0.03		<0.148			
F-AREA TREBLER	11-11-83	42732	1.48E+5	7.60E+1	4.80E+1	<0.03	Na	<0.221			
F-AREA TREBLER	12-9-83	43865	8.03E+4	1.20E+1	5.40E+1					1.43E-3	
F-AREA TREBLER	12-16-83	44133	1.79E+5	0.0	4.80E+1		<.01	0.0		3.60E-3	<
AVEARAGE F-AREA (TO 12/16)			1.81E+5	1.80E+1	6.78E+1	0.0	Na	0.0		2.51E-3	0.0
MAXIMUM VALUE			3.66E+5	7.60E+1	1.85E+2	0.0	Na	0.0	0.0	3.60E-3	0.0
MINIMUM VALUE			8.03E+4	0.0	2.30E+1	0.0	Na	0.0	0.0	1.43E-3	0.0
SAMPLE	DATE (sample)	ADD#	T	å	β-G	I-129	I-127	Tc-99	Sr-90	Cs-137	Co-60

TABLE B-1, Contd

SAMPLE	DATE (sample)	Ru-106	Sr-89	Zr-95	Nb-95	Ru-103	I-131	Cs-134	Ce-141
Formality conversion	=	106	89	95	95	103	131	134	141
F-AREA TREBLER	9-23-83								
F-AREA TREBLER	9-30-83								
F-AREA TREBLER	10-14-83								
F-AREA TREBLER	10-21-83								
F-AREA TREBLER	10-28-83								
F-AREA TREBLER	11-4-83								
F-AREA TREBLER	11-11-83								
F-AREA TREBLER	12-9-83	1.05E-2		7.77E-3	7.16E-3	2.90E-3			
F-AREA TREBLER	12-16-83	7.92E-3	<	1.27E-2	1.21E-2	1.87E-3	<	<	
AVEARAGE F-AREA (TO 12/16)		9.21E-3	0.0	1.02E-2	9.63E-3	2.38E-3	0.0	0.0	0.0
MAXIMUM VALUE		1.05E-2	0.0	1.27E-2	1.21E-2	2.90E-3	0.0	0.0	0.0
MINIMUM VALUE		7.92E-3	0.0	7.77E-3	7.16E-3	1.87E-3	0.0	0.0	0.0
SAMPLE	DATE (sample)	Ru-106	Sr-89	Zr-95	Nb-95	Ru-103	I-131	Cs-134	Ce-141

TABLE B-1, Contd

SAMPLE	DATE (sample)	Ce-144	Pm-147	U-235	K-40	Ra-228	Nb-97	Sr-85	Kr-85	Zn-65	Am-241	Xe-133	Co-58
Formality conversion		144	147	235	40								
F-AREA TREBLER	9-23-83												
F-AREA TREBLER	9-30-83												
F-AREA TREBLER	10-14-83												
F-AREA TREBLER	10-21-83												
F-AREA TREBLER	10-28-83												
F-AREA TREBLER	11-4-83												
F-AREA TREBLER	11-11-83												
F-AREA TREBLER	12-9-83												
F-AREA TREBLER	12-16-83				2.46E-3								
AVEARAGE F-AREA (TO 12/16)		0.0	0.0	0.0	2.46E-3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
MAXIMUM VALUE		0.0	0.0	0.0	2.46E-3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
MINIMUM VALUE		0.0	0.0	0.0	2.46E-3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
SAMPLE	DATE (sample)	Ce-144	Pm-147	U-235	K-40	Ra-228	Nb-97	Sr-85	Kr-85	Zn-65	Am-241	Xe-133	Co-58

TABLE B-1, Contd

SAMPLE	DATE (sample)	Mn-54	Cr-51	Fe-59	Ar-41	Bi-214	Sc-46	Sr-92	Ag-110	Sn-113	Eu-154	Na-22
Formality conversion												
F-AREA TREBLER	9-23-83											
F-AREA TREBLER	9-30-83											
F-AREA TREBLER	10-14-83											
F-AREA TREBLER	10-21-83											
F-AREA TREBLER	10-28-83											
F-AREA TREBLER	11-4-83											
F-AREA TREBLER	11-11-83											
F-AREA TREBLER	12-9-83											
F-AREA TREBLER	12-16-83					1.05E-3						
AVEARAGE F-AREA (TO 12/16)		0.0	0.0	0.0	0.0	1.05E-3	0.0	0.0	0.0	0.0	0.0	0.0
MAXIMUM VALUE		0.0	0.0	0.0	0.0	1.05E-3	0.0	0.0	0.0	0.0	0.0	0.0
MINIMUM VALUE		0.0	0.0	0.0	0.0	1.05E-3	0.0	0.0	0.0	0.0	0.0	0.0
SAMPLE	DATE (sample)	Mn-54	Cr-51	Fe-59	Ar-41	Bi-214	Sc-46	Sr-92	Ag-110	Sn-113	Eu-154	Na-22

TABLE B-2

F-Area Effluents (Point Source Analyses)

F-AREA SAMPLES Formality conversion	DATE (sample) *	NORM+	NORM-	CHG BAL	%ERROR	pH	pH (2nd)	pH (calc)	H3O+	OH-
F-AREA ARU (TANK#614)	12-10-83	7.57E-2	6.64E-2	9.32E-3	13.1	1.13		1.19	7.41E-2	1.35E-13
"	1-12-84	Na	6.95E-2			1.57			2.69E-2	3.72E-13
"	1-29-84					1.94				
F-AREA GP EVAP #1 (706-1/707-1)	12-10-83	9.70E-1	Na			12.20			6.31E-13	1.58E-2
F-AREA GP EVAP #2 (706-2/707/2)	12-10-83	2.18E-2	Na			11.10			7.94E-12	1.26E-3
" (#162)	1-12-84	Na	3.63E-1			0.82			1.51E-1	6.61E-14
"	1-29-84	Na	6.74E-5			7.14				
C-13 HYDRATE EVAPORATOR	12-22-83	8.92E-2	8.14E-2	7.81E-3	9.2	1.05		1.09	8.91E-2	1.12E-13
"	1-12-84	Na	7.22E-2			1.31			4.90E-2	2.04E-13
"	1-29-84	Na	1.11E-1							
C-1-8 OVERHEADS	12-22-83	Na	7.34E-2			1.44			3.63E-2	2.75E-13
241-F EVAPORATOR	11-2-83	Na	2.63E-5			6.30	•		5.01E-7	2.00E-8
"	11-11-83	5.99E-3	Na			9.27	9.55		5.37E-10	1.86E-5
1-EU	12-22-83	3.09E-2	2.29E-2	8.07E-3	30.0	1.51		1.64	3.09E-2	3.24E-13
"	1-12-84	Na	3.33E-2			1.81			1.55E-2	6.46E-13
"	1-29-84	Na	Na							
1-CU	12-10-83	3.90E-2	7.10E-2	-3.20E-2	58.3	1.41		1.15	3.89E-2	2.57E-13
"	1-12-84	Na	5.88E-2			1.80			1.58E-2	6.31E-13
"	1-29-84	Na	2.33E-2			1.92				
F-AREA LAUNDRY WASTE	11-18-83	2.24E-3	1.94E-3	2.92E-4	14.0	7.70	(see 1st)		2.00E-8	5.01E-7
"	12-16-83	Na	Na			8.17			6.76E-9	1.48E-6
"	12-22-83	3.34E-3	6.92E-3	-3.58E-3	69.9	9.47			3.39E-10	2.95E-5
SAMPLE	DATE (sample)	NORM+	NORM-	CHG BAL	%ERROR	pH	pH (2nd)		H3O+	OH-

TABLE B-2, Contd

SAMPLE Formality conversion	DATE (sample)	COND und	Eh UND	NH4 17	TOC 12	TIC 12	ACIDITY 100.09	ALKALINITY 100.09	CO3/TIC	HCO3/TIC	TIC (NORMALITY OF FREE ANIONS)
F-AREA ARU (TANK#614)	12-10-83	30500	329.6	26	69	81	3715	0	7.96E-10	6.07E-6	4.10E-8
"	1-12-84	21500	299.2	Na	7	10			2.19E-9	1.67E-5	1.39E-8
"	1-29-84	8200	-23.4								
F-AREA GP EVAP #1 (706-1/707-1)	12-10-83	11500	-317.0			Na	0	130	9.89E-1	1.06E-2	Na
F-AREA GP EVAP #2 (706-2/707/2)	12-10-83	1200	-253.0	0	16	Na	0	130	8.81E-1	1.19E-1	Na
" (#1&2)	1-12-84	>50000	44.9	Na	111	19			3.90E-10	2.97E-6	4.71E-9
"	1-29-84	24	-333.4								
C-1-3 HYDRATE EVAPORATOR	12-22-83	34000	334.0	0	215	65	4390	0	6.62E-10	5.05E-6	2.74E-8
"	1-12-84	42000	314.8	Na	32	5			1.20E-9	9.19E-6	3.83E-9
"	1-29-84										
C-1-8 OVERHEADS	12-22-83	25550	8.0	Na	16	7			1.62E-9	1.24E-5	7.23E-9
241-F EVAPORATOR	11-2-83	10	42.0	Na	7	0	Na	0	1.18E-4	4.73E-1	0.0
"	11-11-83	65	-136.0	58	17	11	0	20	9.90E-2	9.00E-1	1.01E-3
1-EU	12-22-83	1950	308.0	0	98	2	1385	0	1.91E-9	1.46E-5	2.43E-9
"	1-12-84	11500	-14.4	Na	81	2			3.81E-9	2.91E-5	4.84E-9
"	1-29-84										
1-CU	12-10-83	16000	314.0	0	19	81	2075	0	1.52E-9	1.16E-5	7.81E-8
"	1-12-84	11000	-13.5		75	8			3.72E-9	2.84E-5	1.89E-8
"	1-29-84	8800	-19.1								
F-AREA LAUNDRY WASTE	11-18-83			0	80	10	0	59.3	8.65E-3	9.77E-1	8.28E-4
"	12-16-83	190	-82.0	Na	Na	Na			Na	Na	Na
"	12-22-83	220	-157.0	0	185	55	0	110	1.48E-1	8.51E-1	5.26E-3
SAMPLE	DATE (sample)	COND	Eh	NH4	TOC	TIC	ACIDITY	ALKALINITY	CO3/TIC	HCO3/TIC	TIC

TABLE B-2, Contd

SAMPLE Formality conversion	DATE (sample)	ADD#	Hg 200.59	K 39.1	ADD#	NO2 46	F 19	Cl 35.5	SO4 96	PO4 95	NO3 62
F-AREA ARU (#614)	12-10-83	44483	1.80E-2	1.80E-2	44478	1.86E+1	4.71E+0	4.87E+0	0.0	0.0	4.08E+3
"	1-12-84	45424	2.80E-2	1.70E-2	45411	0.0	0.0	9.52E+1	0.0	0.0	4.14E+3
"	1-29-84	46735	1.29E-1	2.80E-2	46730	0.0	52(ID?)	0.0	0.0	0.0	2.33E+3
F-AREA GP EVAP #1 (706-1/707-1)	12-10-83	44437	4.60E-2	9.08E+0	44432	0.0	0.0	6.53E+0	1.33E+1	0.0	0.0
F-AREA GP EVAP #2 (706-2/707/2)	12-10-83	44476	9.00E-1	2.55E+0	44470	0.0	0.0	5.96E+0	0.0	0.0	3.12E+2
" (#162)	1-12-84	45441	5.80E-2	4.50E-2	45434	9.20E+1	1.06E+1	0.0	0.0	0.0	2.24E+4
"	1-29-84	46725	2.20E-2	2.50E-2	46720	0.0	0.0	0.0	0.0	0.0	4.18E+0
C-13 HYDRATE EVAPORATOR	12-22-83	44451	1.00E-3	1.20E-2	44446	0.0	0.0	0.0	0.0	0.0	5.05E+3
"	1-12-84	45449	1.20E-3	5.60E-3	44485	0.0	0.0	0.0	0.0	0.0	4.48E+3
"	1-29-84				46738	0.0	0.0	0.0	0.0	0.0	6.87E+3
C-1-8 OVERHEADS	12-22-83	45410	9.00E-4	3.00E-3	45403	0.0	0.0	4.06E+1	0.0	0.0	4.48E+3
241-F EVAPORATOR	11-2-83		Na	Na	42667	0.0	0.0	0.0	0.0	0.0	1.63E+0
"	11-11-83	42674	<.001	3.60E-1		Na	Na	Na	Na	Na	Na
1-EU	12-22-83	44429	3.00E-3	2.00E-2	44417	0.0	0.0	0.0	0.0	0.0	1.42E+3
"	1-12-84	45433	1.30E-3	2.80E-2	45426	0.0	3.85E+1	4.05E+1	0.0	0.0	2.00E+3
"	1-29-84	46729	2.70E-3	2.50E-2							
1-CU	12-10-83	Na(EST K+)	Na	2.00E-2	44463	0.0	0.0	0.0	0.0	0.0	4.40E+3
"	1-12-84	45402	1.20E-3	0.0	45395	2.44E+1	0.0	0.0	0.0	0.0	3.61E+3
"	1-29-84	46748	2.70E-3	1.97E-2	46743	0.0	0.0	0.0	0.0	0.0	1.44E+3
F-AREA LAUNDRY WASTE	11-18-83	42991	<.001	9.50E+0	42986	0.0	0.0	7.35E+0	0.0	0.0	9.98E+0
"	12-16-83		Na		44121	0.0	5.80E-1	4.32E+0	8.02E+0	0.0	0.0
"	12-22-83	44127	3.00E-4	2.56E+0	44441	0.0	0.0	6.53E+0	1.33E+1	0.0	0.0
SAMPLE	DATE (sample)	ADD#	Hg	K	ADD#	NO2	F	Cl	SO4	PO4	NO3

TABLE B-2, Contd

SAMPLE	DATE (sample)	ADD#	Sodium	Ca	Mg	Fe	P	Al	Si	Si(Sol)	Ni	Mn	Zn
Formality conversion			23	40.1	24.3	55.8	31	26.98	28.1	28.1	58.7	54.94	65.37
F-AREA ARU	12-10-83	44482	1.71E-1	6.28E-2	0.0	2.27E-2	9.64E+0	1.31E-1	<.01	<.01	1.75E-1	<	8.15E-2
"	1-12-84	45418	<	<	<	8.79E-2	6.94E+0	<	<	<	<	3.30E-2	<
"	1-29-84	46734	1.32E-1	<	1.07E-1	1.27E-1	4.43E-1	<	<	<	<	<	6.62E-2
F-AREA GP EVAP #1 (706-1/707-1)	12-10-83	44433	2.21E+4	2.21E-1	0.0	4.74E-1	1.63E+1	7.57E+1	9.28E-1	8.57E-1	2.42E-1	5.69E-2	1.37E-1
F-AREA GP EVAP #2 (706-2/707/2)	12-10-83	44475	3.99E+2	1.40E+1	1.79E+0	3.09E+1	9.87E+0	2.27E+1	1.23E+0	4.08E-1	2.72E+0	4.31E+0	8.54E-1
" (#162)	1-12-84	45440	4.84E+0	5.49E-2	<	2.81E-1	4.41E+0	<	<	<	<	4.15E-2	<
"	1-29-84	46724	1.52E+0	<	<	8.40E-2	4.34E+0	<	<	<	<	1.02E-2	5.38E-2
C-13 HYDRATE EVAPORATOR	12-22-83	44447	2.81E-1	1.16E+0	9.50E-2	1.14E-1	6.94E+0	2.24E-1	<.01	<.01	4.32E-1	<	1.34E-1
"	1-12-84	45448	<	<	<	5.07E-2	5.87E+0	<	<	<	<	<	<
"	1-29-84	46739	<	<	<	1.03E-1	1.35E+0	3.34E-2	<	<	<	<	6.99E-2
C-1-8 OVERHEADS	12-22-83	45409	0.0	0.0	0.0	4.05E-2	2.91E+0	0.0	<	<	<	3.08E-2	<
241-F EVAPORATOR	11-11-83	42668	1.01E+0	1.08E+0	7.62E-2	0.0	4.62E-2	8.89E-1	2.04E+0	2.06E+0	<	<	3.62E-2
"	11-11-83	42673	1.16E+0	4.69E+1	4.50E-1	9.50E-2	1.02E-1	1.25E+0	2.37E+0	ACIDSAMP	1.57E-1	<	5.65E+0
1-EU	12-22-83	44428	0.0	1.14E-1	0.0	2.59E-2	3.86E+1	2.94E-1	<.087	<.089	1.34E-1	<	1.33E-1
"	1-12-84	45432	<	1.17E-1	<	1.35E-2	1.41E+1	1.89E-1	<	<	1.51E-1	2.87E-2	<
"	1-29-84	46728	<	<	<	8.39E-2	1.25E+0	<	<	<	<	<	6.28E-2
1-CU	12-10-83	44464	1.98E-1	1.69E-1	0.0	5.18E-2	9.60E+0	2.49E-1	<.021	<.021	2.60E-1	1.24E-2	9.30E-2
"	1-12-84	45396	<.05	1.74E-1	<	2.35E-2	1.22E+1	2.29E-1	<	<	2.49E-1	4.15E-2	<
"	1-29-84	46747	<	<	<	<	1.19E+1	1.89E-1	<.077	<	6.92E-2	<	6.18E-2
F-AREA LAUNDRY WASTE	11-18-83	42987	3.79E+1	5.43E-1	2.64E-1	5.63E-1	1.23E+0	2.49E+0	1.07E+1	1.05E+1	<	1.41E-2	1.77E-1
"	12-16-83	44122	6.32E+1	1.63E+0	9.61E-1	3.59E-1	2.83E+0	3.95E-1	1.65E+1	1.65E+1	1.01E-1	1.15E-2	1.84E-1
"	12-22-83	44442	7.06E+1	1.48E+0	6.00E-1	4.74E-1	1.03E+0	5.48E-1	1.64E+1	1.64E+1	2.60E-1	1.03E-2	1.71E-1
SAMPLE	DATE (sample)	ADD#	Sodium	Ca	Mg	Fe	P	Al	Si	Si(Filt)	Ni	Mn	Zn

TABLE B-2, Contd

SAMPLE Formality conversion	DATE (sample)	Cr 51.996	Ba 137.3	Cu 63.54	Pb 207.19	Cd 112.4	Co 58.93	Sr 87.62	Zr 91.22	Yb 88.91	La 138.91	Li 6.939	Be 9.012
F-AREA ARU	12-10-83	2.05E-2	1.21E-2	1.22E-2	1.86E-1	<	1.20E-2	<	<	4.53E-2	6.10E-3	1.51E-2	<
"	1-12-84	<	1.16E-2	<	<	<	<	2.06E-2	<	2.03E-2	3.45E-2	<	7.90E-3
"	1-29-84	<	1.16E-2	<	<	<	<	<	<	<	<	<	<
F-AREA GP EVAP #1 (706-1/707-1)	12-10-83	2.55E-1	1.21E-2	2.54E-2	3.79E-1	<	1.39E-2	<	6.30E-3	5.42E-2	6.40E-3	1.05E-1	<
F-AREA GP EVAP #2 (706-2/707/2)	12-10-83	6.68E-1	2.67E-1	4.03E-1	5.57E+0	2.37E-2	9.23E-2	1.20E-1	1.50E-1	5.10E-1	6.75E-2	6.02E-2	7.90E-3
GP 1&2	1-12-83	<	1.16E-2	<	<	<	<	1.53E-2	<	2.03E-2	2.13E-2	<	5.10E-3
"	1-29-84	<	5.80E-3	<	<	<	<	<	<	<	<	<	<
C-13 HYDRATE EVAPORATOR	12-22-83	4.87E-2	1.21E-2	1.57E-2	3.17E-1	<	1.60E-2	3.70E-3	<	5.73E-2	7.80E-3	1.51E-2	<
"	1-12-84	<	<	<	<	<	<	6.50E-3	<	<	8.10E-3	<	<
"	1-29-84	2.20E-2	<	<	8.32E-2	<	<	<	<	<	<	<	<
C-1-8 OVERHEADS	12-22-83	<	5.80E-3	<	<	<	<	1.83E-2	<	2.90E-2	4.20E-2	<	7.10E-3
241-F EVAPORATOR	11-11-83	<	<	<	5.50E-2	<	<	3.30E-3	5.00E-3	3.12E-3	6.10E-3	<	<
"	11-11-83	<	1.00E-2	<	1.11E-1	<	<	2.92E-2	6.70E-3	3.41E-1	1.00E-2	<	<
1-EU	12-22-83	3.91E-2	<	1.57E-2	3.80E-1	<	<	<	<	3.00E-2	<	<	<
"	1-12-84	3.83E-2	1.16E-2	<	3.61E-1	<	<	2.38E-2	1.87E-2	5.27E-2	3.62E-2	<	7.10E-3
"	1-29-84	<	<	<	<	<	<	<	<	<	<	<	<
1-CU	12-10-83	3.12E-2	1.21E-2	2.27E-2	3.72E-1	<	1.59E-2	<	7.10E-3	6.32E-2	1.02E-2	1.50E-2	<
"	1-12-84	4.77E-2	1.75E-2	<	4.66E-1	<	1.24E-2	6.96E-2	2.42E-2	9.93E-2	7.92E-2	<	6.30E-3
"	1-29-84	2.63E-2	<	<	2.61E-1	<	<	<	8.00E-3	<	<	<	<
F-AREA LAUNDRY WASTE	11-18-83	<	4.70E-3	<	<	<	<	<	<	<	<	1.40E-2	<
"	12-16-83	1.23E-2	1.08E-2	1.72E-2	1.56E-1	<	<	7.10E-3	7.80E-3	<	7.56E-3	1.44E-2	<
"	12-22-83	2.43E-2	1.82E-2	2.63E-2	3.42E-1	<	2.00E-2	6.90E-3	8.90E-3	7.25E-2	1.33E-2	1.51E-2	<
SAMPLE	DATE (sample)	Cr	Ba	Cu	Pb	Cd	Co	Sr	Zr	Yb	La	Li	Be

TABLE B-2, Contd

SAMPLE	DATE (sample)	B	Ti	U	V	Y
Formality conversion		10.81	47.9	238.03	50.94	173.04
F-AREA ARU	12-10-83	2.65E-2	5.80E-3	<	1.05E-2	<
"	1-12-84	<	<	<	1.04E-2	<
"	1-29-84	<	<	<	<	<
F-AREA GP EVAP #1 (706-1/707-1)	12-10-83	8.50E-2	1.07E-2	2.97E+0	2.78E-2	<
F-AREA GP EVAP #2 (706-2/707/2)	12-10-83	1.19E-1	1.37E-1	4.48E+0	2.62E-1	2.51E-2
"	1-12-84	<	3.30E-3	<	<	<
"	1-29-84	1.41E-2	<	<	<	<
C-13 HYDRATE EVAPORATOR	12-22-83	5.07E-2	9.40E-3	<	1.44E-2	<
"	1-12-84	<	<	<	<	<
"	1-29-84	<	<	1.05E+0	<	<
C-1-8 OVERHEADS	12-22-83	<	<	<	<	1.02E-2
241-F EVAPORATOR	11-11-83	<	<	<	<	<
"		<	5.80E-3	<	<	<
1-EU	12-22-83	8.21E-2	4.80E-3	4.85E+0	2.16E-2	<
"	1-12-84	<	9.10E-3	4.87E+0	3.14E-2	<
"	1-29-84	<	<	6.51E-1	<	<
1-CU	12-10-83	3.48E-2	9.40E-3	1.16E+0	1.91E-2	<
"	1-12-84	3.58E-2	1.07E-2	5.37E+0	3.12E-2	1.39E-2
"	1-29-84	<	<	4.28E+0	1.27E-2	<
F-AREA LAUNDRY WASTE	11-18-83	3.79E-2	1.66E-2	<	<	<
"	12-16-83	5.66E-2	3.50E-3	<	<	<
"	12-22-83	7.14E-2	1.53E-2	<	1.82E-2	<
SAMPLE	DATE (sample)	B	Ti	U	V	Y

TABLE B-2, Contd

SAMPLE Formality conversion	DATE (sample)	ADD#	T 3	å d/m/ml	β-G d/m/ml	I-129 (PPM)	Tc-99 PPM
F-AREA ARU	12-10-83	44484	2.20E+5	2.00E+1	4.00E+1		
"	1-12-84	45415	1.65E+5	0.0	9.50E+1		
"	1-29-84	46737	1.82E+4	0.0	5.10E+1		
F-AREA GP EVAP #1 (706-1/707-1)	12-10-83	44438	8.65E+6	4.00E+0	1.30E+2		
F-AREA GP EVAP #2 (706-2/707/2)	12-10-83	44477	1.79E+7	9.20E+1	6.06E+2		
" (#162)	1-12-84	45438	2.17E+4	0.0	0.0		
"	1-29-84	46727	1.20E+5	0.0	0.0		
C-13 HYDRATE EVAPORATOR	12-22-83	44452	3.30E+3	6.00E+0	1.20E+1		
"	1-12-84	45446	1.90E+2	0.0	0.0		
"	1-29-84	46742	9.00E+1				
C-1-8 OVERHEADS	12-22-83	45407	1.60E+2	0.0	2.00E+0		
241-F EVAPORATOR	11-2-83	42672	2.28E+5	2.00E+0	5.20E+1	<0.03	<0.155
"	11-11-83						
1-EU	12-22-83	44430	2.84E+3	0.0	2.00E+0		
"	1-12-84	45430	4.00E+1	4.00E+0	0.0		
"	1-29-84						
1-CU	12-10-83	44467	1.18E+5	0.0	5.00E+0		
"	1-12-84	45398		0.0	0.0		
"	1-29-84	46750	2.00E+1				
F-AREA LAUNDRY WASTE	11-18-83	42993	<BKGD	2.00E+0	6.00E+0	<0.006	<0.029
"	12-16-83	44125	2.40E+2	0.0	3.00E+0		
"	12-22-83	44445	9.49E+2	6.00E+0	1.00E+0		
SAMPLE	DATE (sample)	ADD#	T	å	β-G	I-129	Tc-99

TABLE B-2, Contd

SAMPLE Formality conversion	DATE (sample) *	Cs-137 (nCi/ml)	Co-60 (nCi/ml)	Ru-106 (nCi/ml)	Sr-89 (nCi/ml)	Zr-95 (nCi/ml)	Nb-95 (nCi/ml)	Ru-103 (nCi/ml)	I-131 (nCi/ml)	Cs-134 (nCi/ml)	Ce-141 (nCi/ml)
F-AREA ARU	12-10-83	<	<	<	<	8.49E-2	8.15E-2	1.61E-3	<	<	<
"											
"	1-29-84	<	<	<	<	2.44E-1	1.58E-1	<	<	<	<
F-AREA CP EVAP #1 (706-1/707-1)	12-10-83	2.43E-3	6.43E-3	5.29E-2	<	7.00E-2	9.69E-2	7.15E-3	<	<	<
F-AREA CP EVAP #2 (706-2/707/2)	12-10-83	<	4.54E-2	1.92E-1	<	4.41E-1	5.65E-1	3.04E-2	<	<	3.57E-3
" (#1&2)	1-12-84	<	<	<	<	2.79E-3	4.04E-3	<	<	<	<
"	1-29-84	<	<	<	<	9.56E-3	1.01E-2	6.75E-4	3.55E-4	<	<
C-13 HYDRATE EVAPORATOR	12-22-83	1.08E-3	<	<	<	<	<	<	<	<	<
"	1-12-84	<	<	<	<	<	<	7.06E-4	<	<	<
"	1-29-84										
C-1-8 OVERHEADS	12-22-83	<	<	<	<	<	<	6.88E-4	<	<	<
241-F EVAPORATOR	11-2-83										
"	11-11-83										
1-EU	12-22-83	8.80E-4	<	9.75E-3	<	<	<	<	<	<	<
"	1-12-84	<2.52E-4	<	<	<	<	<3.72E-4	<	<	<	<
"	1-29-84	<	<	<	<	<	<	<	<	<	<
1-CU	12-10-83	<	<	2.96E-3	<	<	<	<	<	<	<
"	1-12-84	<	<	<	<	<	5.19E-4	<	<	<	<
"	1-29-84										
F-AREA LAUNDRY WASTE	11-18-83	<	<	<	<	<	<	<	<	<	<
"	12-16-83	4.45E-4	<	<	<	<	<	<	<	<	<
"	12-22-83	<	<	<	<	<	<	<	<	<	<
SAMPLE	DATE (sample)	Cs-137	Co-60	Ru-106	Sr-89	Zr-95	Nb-95	Ru-103	I-131	Cs-134	Ce-141

TABLE B-2, Contd

SAMPLE Formality conversion	DATE (sample)	Ce-144 (nCi/ml)	Pm-147 (nCi/ml)	U-235 (nCi/ml)	K-40 (nCi/ml)	Ra-228 (nCi/ml)	Nb-97 (nCi/ml)	Sr-85 (nCi/ml)	Kr-85 (nCi/ml)	Zn-65 (nCi/ml)	Am-241 (nCi/ml)	Xe-133 (nCi/ml)	Co-58 (nCi/ml)
F-AREA ARU (TANK#614)	12-10-83	<	<	<	<	<	<	<	<	<	<	<	<
"	1-29-84	<	<	<	<	4.93E-4	<	<	<	<	<	<	<
F-AREA GP EVAP #1 (706-1/707-1)	12-10-83	9.76E-3	<	<	<	<	<	<	<	<	<	<	<
F-AREA GP EVAP #2 (706-2/707/2)	12-10-83	8.98E-2	<	<	<	<	<	<	<	<	1.04E-2	1.65E-3	3.13E-3
" (#1&2)	1-12-84	<	<	<	<	<	<	<	<	<	<	<	<
"	1-29-84	<	<	<	4.02E-2	<	<	<	<	<	<	<	<
C-13 HYDRATE EVAPORATOR	12-22-83	<	<	<	3.35E-3	<	<	<	<	<	<	<	<
"	1-12-84	<	<	<	<	4.82E-4	<	<	<	<	<	<	<
"	1-29-84												
C-1-8 OVERHEADS	12-22-83	<	<	<	<	<	<	<	<	<	<	<	<
241-F EVAPORATOR	11-2-83												
"	11-11-83												
1-EU	12-22-83	<	<	<	1.93E-3	<	<	<	<	<	<	<	<
"	1-12-84	<	<	<	<	<	<	<	<	<	<	<	<
"	1-29-84	<	<	<	<	<	<	<	<	<	<	<	<
1-CU	12-10-83	<	<	<	4.224-2	<	<	<	<	<	<	<	<
"	1-12-84	<	<	<	<	<	<	<	<	<	<	<	<
"	1-29-84												
F-AREA LAUNDRY WASTE	11-18-83	<	<	<	<	<	<	<	<	<	<	<	<
"	12-16-84	<	<	<	<	<	<	<	<	<	<	<	<
"	12-22-83	<	<	<	<	<	<	<	<	<	<	<	<
SAMPLE	DATE (sample)	Ce-144	Pm-147	U-235	K-40	Ra-228	Nb-97	Sr-85	Kr-85	Zn-65	Am-241	Xe-133	Co-58

TABLE B-2, Contd

SAMPLE Formality conversion	DATE (sample)	Mn-54 (nCi/ml)	Cr-51 (nCi/ml)	Fe-59 (nCi/ml)	Ar-41 (nCi/ml)	Bi-214 (nCi/ml)	Sc-46 (nCi/ml)	Sr-92 (nCi/ml)	Ag-110 (nCi/ml)	Sn-113 (nCi/ml)	Eu-154 (nCi/ml)	Na-22 (nCi/ml)
F-AREA ARU (TANK#614)	12-10-83	<	<	<	<	<	<	<	<	<	<	<
"	1-29-84	<	<	<	<	<	<	<	<	<	<	<
F-AREA GP EVAP #1 (706-1/707-1)	12-10-83	<	<	<	<	<	<	<	<	<	<	<
F-AREA GP EVAP #2 (706-2/707/2)	12-10-83	1.18E-7	<	<	<	<	<	<	<	<	<	<
" (#162)	1-12-84	<	<	<	<	<	<	<	<	<	<	<
"	1-29-84	<	<	<	<	<	<	<	<	<	<	<
C-13 HYDRATE EVAPORATOR	12-22-83	1.09E-3	<	1.83E-3	1.82E-3	<	<	<	<	<	<	<
"	1-12-84	<	<	<	<	<	<	<	<	<	<	<
"	1-29-84											
C-1-8 OVERHEADS	12-22-83	<	<	<	<	1.12E-3	<	<	<	<	<	<
241-F EVAPORATOR	11-2-83											
"	11-11-83											
1-EU	12-22-83	<	<	<	<	<	<	<	<	<	<	<
"	1-12-84	<	<	<	<	<	<	<	<	<	<	<
"	1-29-84	<	<	<	<	<	<	<	<	<	<	<
1-CU	12-10-83	<	<	<	<	9.37E-3	<	<	<	<	<	<
"	1-12-84	<	<	<	<	<	<	<	<	<	<	<
"	1-29-84											
F-AREA LAUNDRY WASTE	11-18-83	<	<	<	<	<	<	<	<	<	<	<
"	12-16-84	<	<	<	<	<	<	<	<	<	<	<
"	12-22-83	<	<	<	<	<	<	<	<	<	<	<
SAMPLE	DATE (sample)	Mn-54	Cr-51	Fe-59	Ar-41	Bi-214	Sc-46	Sr-92	Ag-110	Sn-113	Eu-154	Na-22

TABLE B-3

H-Area Effluents (Trebler Monitor Analyses)

SAMPLE	DATE (sample)	NORM+	NORM-	CHG BAL	%ERROR	pH (1ST)	pH (2ND)	pH (Calc)	H3O+	OH-
H-AREA TREBLER	9-23-83	1.36E-2	5.83E-3	7.80E-3	80.2	1.96	*(SEE 1ST)	2.50	1.10E-2	9.12E-13
H-AREA TREBLER	9-30-83	Error	Error	Error	Error	UND		Error	Error	Error
H-AREA TREBLER	10-7-83	Error	Error	Error	Error	UND		Error	Error	Error
H-AREA TREBLER	10-14-83	1.17E-2	3.15E-2	-1.97E-2	91.3	2.25	2.35	1.60	5.62E-3	1.78E-12
H-AREA TREBLER	10-21-83	4.97E-3	8.49E-3	-3.52E-3	52.3	2.36		2.10	4.37E-3	2.29E-12
H-AREA TREBLER	10-28-83	4.21E-3	5.37E-3	-1.16E-3	24.2	2.44		2.32	3.63E-3	2.75E-12
H-AREA TREBLER	11-4-83	2.02E-3	2.24E-3	-2.22E-4	10.4	5.48	4.80	3.65	3.31E-6	3.02E-9
H-AREA TREBLER	11-11-83	6.74E-3	8.65E-3	-1.91E-3	24.8	2.36	1.62	2.20	4.37E-3	2.29E-12
H-AREA TREBLER	11-18-83	2.28E-2	Na	Na	Na	2.02	1.08	Error	9.55E-3	1.04E-12
H-AREA TREBLER	12-2-83	7.04E-3	1.40E-2	-6.92E-3	65.9	2.43		1.97	3.72E-3	2.68E-12
H-AREA TREBLER	12-9-83	2.59E-3	2.09E-3	4.99E-4	21.3	2.76	2.65	2.91	1.74E-3	5.73E-12
H-AREA TREBLER	12-16-83	3.85E-3	8.22E-3	-4.37E-3	72.4	2.49		2.12	3.24E-3	3.08E-12
AVERAGE H-AREA (TO 12/16)		6.22E-3	9.05E-3	9.05E-3	9.05E-3	2.37		2.32	4.24E-3	3.80E-10
MAXIMUM VALUE		1.36E-2	3.15E-2	3.15E-2	3.15E-2	5.48	4.80	3.65	1.10E-2	3.02E-9
MINIMUM VALUE		2.02E-3	2.09E-3	2.09E-3	2.09E-3	1.96	1.08	1.60	3.31E-6	9.12E-13

TABLE B-3, Contd

SAMPLE	DATE (sample)	COND	Eh	TIC	TOC	NH4	TIC (ANIONIC)	ACIDITY as CaCO3 ppm	ALKALINITY as CaCO3 ppm	CO3/TIC	HCO3/TIC
Formality conversion	•			12	12	17	12	100.09	100.09		
H-AREA TREBLER	9-23-83	2000	530.0	4	1	28	1.64E-4	772	0	5.38E-9	4.10E-5
H-AREA TREBLER	9-30-83	UND	UND	4	3	10	Error	Na	Na	Error	Error
H-AREA TREBLER	10-7-83	UND	UND	7	2	10	Error	Na	Na	Error	Error
H-AREA TREBLER	10-14-83	5600	545.0	16	1		1.28E-3	Na	Na	1.05E-8	8.00E-5
H-AREA TREBLER	10-21-83	2400	462.0	3	6		3.09E-4	Na	Na	1.35E-8	1.03E-4
H-AREA TREBLER	10-28-83	2000	510.0				0.0	Na	Na	1.62E-8	1.24E-4
H-AREA TREBLER	11-4-83	100	91.0	0	5	2	0.0	0	1.3	1.78E-5	1.20E-1
H-AREA TREBLER	11-11-83	1085	269.0	0	4	2	0.0	350	0	1.35E-8	1.03E-4
H-AREA TREBLER	11-18-83	3600	292.0	8	10	2	3.77E-4	1050	0	6.18E-9	4.71E-5
H-AREA TREBLER	12-2-83	4100	272.2	42	26	10	5.09E-3	550	0	1.59E-8	1.21E-4
H-AREA TREBLER	12-9-83	850	235.6	10	10	2	2.59E-3	127	0	3.40E-8	2.59E-4
H-AREA TREBLER	12-16-83	1650	250.0	10	12		1.39E-3	Na	Na	1.82E-8	1.39E-4
AVERAGE H-AREA (TO 12/16)		1.96E+3	3.62E+2								
MAXIMUM VALUE		5.60E+3	5.45E+2	1.60E+1	1.20E+1	2.80E+1	2.59E-3				
MINIMUM VALUE		1.00E+2	9.10E+1	0.0	1.00E+0	2.00E+0	0.0				

TABLE B-3, Contd

SAMPLE	DATE (sample)	ADD#	Hg (PPM)	K	ADD#	NO2	F	Cl	SO4	PO4	NO3
Formality conversion	-		200.59	39.1		46	19	35.5	96	95	62
H-AREA TREBLER	9-23-83	39863	2.80E-2	7.98E-1	39849	0.0	0.0	0.0	0.0	0.0	3.56E+2
H-AREA TREBLER	9-30-83	40916	7.30E-2		40900	0.0	0.0	0.0	0.0	0.0	3.31E+2
H-AREA TREBLER	10-7-83	41236	2.80E-1		41231	0.0	0.0	0.0	0.0	0.0	8.39E+2
H-AREA TREBLER	10-14-83	41402	<.0001		41397	0.0	0.0	0.0	0.0	0.0	1.95E+3
H-AREA TREBLER	10-21-83	41487	3.20E-2		41482	0.0	0.0	1.30E+0	3.91E+0	0.0	4.88E+2
H-AREA TREBLER	10-28-83	41764	4.00E-2		41759	0.0	1.07E+0	1.96E+0	6.32E+0	0.0	3.18E+2
H-AREA TREBLER	11-4-83	42718	<.001	1.44E+0	42711	7.79E+0	0.0	4.02E+0	1.19E+1	0.0	8.04E+1
H-AREA TREBLER	11-11-83	42726	<.001	8.50E-1	42719	0.0	0.0	4.15E+0	1.19E+1	0.0	4.93E+2
H-AREA TREBLER	11-18-83	42883	1.00E-3	1.14E+0	42878	Na	Na	Na	Na	Na	Na
H-AREA TREBLER	12-2-83	43605	2.30E-3	1.67E+0	43597	0.0	0.0	0.0	0.0	0.0	7.31E+2
H-AREA TREBLER	12-9-83	43836	1.68E-2	6.89E-1	43830	0.0	0.0	0.0	8.47E+0	0.0	6.69E+1
H-AREA TREBLER	12-16-83	44144	3.97E-2	6.33E-1	44138	0.0	0.0	8.40E-1	0.0	2.70E+2	2.70E+2
AVERAGE H-AREA (TO 12/16)			4.27E-2	1.03E+0		7.08E-1	9.73E-2	1.12E+0	3.87E+0	2.45E+1	5.38E+2
MAXIMUM VALUE			2.80E-1	1.67E+0		7.79E+0	1.07E+0	4.15E+0	1.19E+1	2.70E+2	1.95E+3
MINIMUM VALUE			0.0	6.33E-1		0.0	0.0	0.0	0.0	0.0	6.69E+1

TABLE B-3, Contd

SAMPLE	DATE (sample)	ADD#	Sodium	Ca	Mg	Fe	P	Al	Si	Si(sol)	Ni	Mn	Zn
Formality conversion	-		23	40.1	24.3	55.8	31	26.98	28.1	28.1	58.7	54.94	65.37
H-AREA TREBLER	9-23-83	39861	1.83E+1	1.52E+0	2.70E-1	6.40E-1	6.60E-1	6.94E-1	4.27E+0	4.32E+0	<.05	1.50E-1	4.00E-2
H-AREA TREBLER	9-30-83	40914	6.10E+0	2.30E+0	3.00E-1	1.29E+0	7.90E-1	9.50E-1	2.80E+0	UND	<	2.50E-1	3.44E-1
H-AREA TREBLER	10-7-83	41235	1.17E+1	1.44E+1	3.33E+0	2.21E+1	8.00E-1	1.12E+1	1.31E+1	1.33E+1	1.60E-1	1.72	1.86E+0
H-AREA TREBLER	10-14-83	41401	6.15E+1	1.59E+1	4.45E+0	2.54E+1	1.05E+0	1.24E+1	1.63E+1	1.63E+1	1.08E-1	3.20E+0	1.60E+0
H-AREA TREBLER	10-21-83	41486	8.72E+0	2.37E+0	3.40E-1	8.60E-1	5.30E-1	4.50E-1	2.78E+0	2.82E+0	0.0	3.50E-1	1.70E-1
H-AREA TREBLER	10-28-83	41763	9.88E+0	1.62E+0	2.75E-1	5.64E-1	4.50E-1	2.53E-1	3.75E+0	4.75E+0	<.05	5.10E-2	6.54E-2
H-AREA TREBLER	11-4-83	42712	3.55E+1	5.90E+0	3.36E-1	0.0	8.50E-2	0.0	4.73E+0	4.88E+0	1.67E-1	2.15E-1	1.75E-1
H-AREA TREBLER	11-11-83	42720	1.04E+1	3.30E+1	6.09E-1	7.28E-1	2.89E-1	5.87E-1	4.77E+0	4.62E+0	1.88E-1	4.67E-2	3.90E+0
H-AREA TREBLER	11-18-83	42882	1.59E+1	2.39E+2	2.56E+0	1.34E+0	5.50E-1	2.45E+0	5.05E+0	4.75E+0	2.10E-1	1.77E-1	2.65E+1
H-AREA TREBLER	12-2-83	43604	1.25E+1	1.64E+1	2.63E+0	7.21E+0	7.80E-1	7.73E+0	1.14E+1	1.13E+1	3.81E-1	1.76E+0	1.98E+0
H-AREA TREBLER	12-9-83	43837	1.13E+1	2.15E+0	2.04E-1	3.87E-1	3.24E-1	7.71E-1	2.88E+0	2.70E+0	1.37E-1	1.44E-1	1.13E-1
H-AREA TREBLER	12-16-83	44143	9.15E+0	1.25E+0	1.48E-1	3.50E-1	1.23E+0	1.01E+0	3.73E+0	3.74E+0	2.98E-1	3.21E-1	1.10E-1
AVERAGE H-AREA (TO 12/16)			1.76E+1	2.80E+1	1.29E+0	5.07E+0	6.28E-1	3.21E+0	6.30E+0	6.12E+0	1.37E-1	5.55E-1	3.07E+0
MAXIMUM VALUE			6.15E+1	2.39E+2	4.45E+0	2.54E+1	1.23E+0	1.24E+1	1.63E+1	1.63E+1	3.81E-1	3.20E+0	2.65E+1
MINIMUM VALUE			6.10E+0	1.25E+0	1.48E-1	0.0	8.50E-2	0.0	2.78E+0	2.70E+0	0.0	0.0	4.00E-2

UNITS=MILLIGRAMS/LITER

TABLE B-3, Contd

SAMPLE	DATE (sample)	Cr	Ba	Cu	Pb	Cd	Co	Sr	Zr	Yb	La	Li	Be
Formality conversion	=	51.996	137.3	63.5	207.2	112.4	58.9	87.6	91.2	88.9	138.9	6.94	9.01
H-AREA TREBLER	9-23-83	<.01	1.25E-2	1.08E-2	<.03	<.01	<.01	7.00E-3	<.005	1.38E-2	<.005	<.005	<.003
H-AREA TREBLER	9-30-83	1.20E-2	3.80E-2	<.01	<.03	<.01	<.01	9.30E-3	<.005	<.01	<.005	6.30E-3	<.003
H-AREA TREBLER	10-7-83	3.50E-1	4.10E-1	2.80E-1	5.40E-1	9.00E-3	6.90E-2	9.99E-2	1.50E-2	1.10E-1	2.70E-2	2.40E-2	1.20E-2
H-AREA TREBLER	10-14-83	3.55E-1	2.49E-1	2.26E-1	5.32E-1	<.01	6.84E-2	6.10E-2	1.46E-2	1.09E-1	3.60E-2	2.35E-2	9.70E-3
H-AREA TREBLER	10-21-83	2.00E-2	2.00E-2	1.70E-2	0.0	1.00E-4	5.00E-4	9.70E-3	0.0	8.40E-3	7.00E-4	0.0	4.00E-4
H-AREA TREBLER	10-28-83	<.01	<.003	<.01	<.03	<.01	<.01	6.80E-3	<5E-3	<.01	<.005	<.005	<.003
H-AREA TREBLER	11-4-83	<	1.51E-2	1.19E-2	1.71E-1	<	<	8.80E-3	9.30E-3	8.21E-2	1.12E-2	1.27E-2	<
H-AREA TREBLER	11-11-83	<	1.50E-2	2.10E-2	1.87E-1	<	<	2.40E-2	9.70E-3	2.63E-1	1.10E-2	1.27E-2	<
H-AREA TREBLER	11-18-83	<	1.90E-2	1.47E-2	9.00E-2	<	<	1.31E-1	<	1.26E+0	7.00E-3	<	<
H-AREA TREBLER	12-2-83	7.53E-2	2.09E-1	2.07E-1	5.29E-1	<	7.24E-2	6.26E-2	2.92E-2	1.74E-1	4.80E-2	2.74E-2	7.60E-3
H-AREA TREBLER	12-9-83	1.94E-2	6.10E-3	1.08E-2	5.56E-2	<	<	8.90E-3	<	2.11E-2	<	1.55E-2	<
H-AREA TREBLER	12-16-83	3.69E-2	2.16E-2	2.72E+0	3.17E-1	<.01	1.47E-2	5.70E-3	1.51E-2	7.37E-2	1.03E-2	1.44E-2	<
AVERAGE H-AREA (TO 12/16)		7.24E-2	8.46E-2	2.93E-1	2.02E-1	7.58E-4	1.88E-2	3.62E-2	7.74E-3	1.76E-1	1.26E-2	1.14E-2	2.48E-3
MAXIMUM VALUE		3.55E-1	4.10E-1	2.72E+0	5.40E-1	9.00E-3	7.24E-2	1.31E-1	2.92E-2	1.26E+0	4.80E-2	2.74E-2	1.20E-2
MINIMUM VALUE		0.0	0.0	0.0	0.0	0.0	0.0	5.70E-3	0.0	0.0	0.0	0.0	0.0

TABLE B-3, Contd

SAMPLE	DATE (sample)	B	Ti	U	V	Y
normality conversion	-	10.8	47.9	238	50.9	88.9
H-AREA TREBLER	9-23-83	<.005	<.003	<.5	<.01	<.01
H-AREA TREBLER	9-30-83	<.005	<.003	<.5	<.01	<.01
H-AREA TREBLER	10-7-83	0.0		7.10E-2	2.70E-2	8.20E-2
H-AREA TREBLER	10-14-83	2.33E-2	2.94E-2	<.5	5.65E-2	7.76E-2
H-AREA TREBLER	10-21-83	0.0		0.0	0.0	2.30E-3
H-AREA TREBLER	10-28-83	2.06E+C	<.003	<.5	<.01	<.01
H-AREA TREBLER	11-4-83	<	4.70E-3	<	<	<
H-AREA TREBLER	11-11-83	<	6.70E-3	<	<	<
H-AREA TREBLER	11-18-83	<	1.00E-2	<	<	2.60E-2
H-AREA TREBLER	12-2-83	5.30E-2	1.45E-2	<	2.34E-2	1.00E-1
H-AREA TREBLER	12-9-83	9.90E-3	5.30E-3	<	1.25E-2	<
H-AREA TREBLER	12-16-83	1.35E-2	9.40E-3	<0.5	1.97E-2	<.01
AVERAGE H-AREA (TO 12/16)		1.80E-1	8.00E-3	5.92E-3	1.16E-2	2.40E-2
MAXIMUM VALUE		2.06E+0	2.94E-2	7.10E-2	5.65E-2	1.00E-1
MINIMUM VALUE		0.0	0.0	0.0	0.0	0.0

TABLE B-3, Contd

SAMPLE	DATE (sample)	ADD#	T	å	β-G	I-129	I-127	Tc-99	Sr-90	Cs-137	Co-60
Formality conversion	•		3	d/m/ml	d/m/ml	(PPM)	PPM	PPM	90	137	60
H-AREA TREBLER	9-23-83			7.00E+0	1.90E+1						
H-AREA TREBLER	9-30-83	41406	4.47E+5			<0.03		<0.155			
H-AREA TREBLER	10-7-83	41219	3.33E+5			<0.03		<0.162			
H-AREA TREBLER	10-14-83	41406	6.48E+5	4.20E+1	4.20E+1	<0.03		<0.141			
H-AREA TREBLER	10-21-83	41491	1.33E+5	0.0	1.00E+1	<0.03		<0.210			
H-AREA TREBLER	10-28-83	41768	2.76E+5	3.20E+1	5.60E+1	<.01	9.00E-2				
H-AREA TREBLER	11-4-83	42716	6.09E+4	3.20E+1	6.00E+0	<0.03	Na	<0.193			
H-AREA TREBLER	11-11-83	42724	1.58E+5	<BKGD	6.00E+0	<0.03	Na	<0.234			
H-AREA TREBLER	11-18-83	42885	1.34E+5	<BKGD	1.20E+1	<0.005	Na	<0.023		1.15E-2	<
H-AREA TREBLER	12-2-83	43603	2.96E+5	3.90E+1	4.30E+1					2.85E-2	<2.41E-4
H-AREA TREBLER	12-9-83	43834	1.49E+5	3.10E+1	3.00E+1					2.39E-2	<2.7E-4
H-AREA TREBLER	12-16-83	44142	3.28E+5	3.00E+0	4.00E+1					4.33E-2	<
AVERAGE H-AREA (TO 12/16)			2.69E+5								
MAXIMUM VALUE			6.48E+5	4.20E+1	5.60E+1	0.0				4.33E-2	0.0
MINIMUM VALUE			6.09E+4	0.0	6.00E+0	0.0				2.39E-2	0.0

TABLE B-3, Contd

SAMPLE	DATE (sample)	Ru-106	Sr-89	Zr-95	Nb-95	Ru-103	I-131	Cs-134	Ce-141
Formality conversion	*	106	89	95	95	103	131	134	141
H-Area Trebler	9-23-83								
H-Area Trebler	9-30-83								
H-AREA TREBLER	10-7-83								
H-AREA TREBLER	10-14-83								
H-AREA TREBLER	10-21-83								
H-AREA TREBLER	10-28-83								
H-AREA TREBLER	11-4-83								
H-AREA TREBLER	11-11-83								
H-AREA TREBLER	11-18-83	2.88E-3	<	<	<	<	<	<	<
H-AREA TREBLER	12-2-83	<2.13E-3	<	<	<	<	<	8.24E-4	<
H-AREA TREBLER	12-9-83	4.70E-3	<	<3.52E-4	<2.33E-4	<2.52E-4	<2.74E-4	6.33E-4	<3.62E-4
H-AREA TREBLER	12-16-83	<	<	<	<	<	<	8.78E-4	<
AVERAGE H-AREA (TO 12/16)									
MAXIMUM VALUE		4.70E-3	0.0	0.0	0.0	0.0	0.0	8.78E-4	0.0
MINIMUM VALUE		0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

TABLE B-3, Contd

SAMPLE	DATE (sample)	Ce-144	Pm-147	U-235	K-40	Ra-228	Nb-97	Sr-85	Kr-85	Zn-65	Am-241	Xe-133	Co-58
Formality conversion	-	144	147	235	40								
H-Area Trebler	9-23-83												
H-Area Trebler	9-30-83												
H-AREA TREBLER	10-7-83												
H-AREA TREBLER	10-14-83												
H-AREA TREBLER	10-21-83												
H-AREA TREBLER	10-28-83												
H-AREA TREBLER	11-4-83												
H-AREA TREBLER	11-11-83												
F-AREA TREBLER	11-18-83	<	<	<	3,21E-3	<	<	<	<	<	<	<	<
H-AREA TREBLER	12-2-83	<	<	<	4.91E-3	5.12E-4	<	<	<	3.22E-3	<	<	<
H-AREA TREBLER	12-9-83	<1.54E-3	<	<3.61E-4	<3.83E-3	4.10E-4	<	<	<	<	<	<	<
H-AREA TREBLER	12-16-83	<	<	<	<	<	<	<	<	<	<	<	<
AVERAGE H-AREA (TO 12/16)													
MAXIMUM VALUE		0.0	0.0	0.0	4.91E-3	5.12E-4	0.0	0.0	0.0	3.22E-3	0.0	0.0	0.0
MINIMUM VALUE		0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

TABLE B-3, Contd

SAMPLE	DATE (sample)	Mn-54	Cr-51	Fe-59	Ar-41	Bi-214	Sc-46	Sr-92	Ag-110	Sn-113	Eu-154	Na-22
H-Area Trebler	9-23-83											
H-Area Trebler	9-30-83											
H-AREA TREBLER	10-7-83											
H-AREA TREBLER	10-14-83											
H-AREA TREBLER	10-21-83											
H-AREA TREBLER	10-28-83											
H-AREA TREBLER	11-4-83											
H-AREA TREBLER	11-11-83											
F-AREA TREBLER	11-18-83	<	<	<	<	<	<	<	<	<	<	<
H-AREA TREBLER	12-2-83	<	<	<	<	<	<	<	<	<	<	<
H-AREA TREBLER	12-9-83	<	<	<	<	<	<	<	<	<	<	<
H-AREA TREBLER	12-16-83	<	<	<	<	<	<	<	<	<	<	<
AVERAGE H-AREA (TO 12/16)												
MAXIMUM VALUE		0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
MINIMUM VALUE		0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

TABLE B-4

H-Area Effluents (Source Analyses)

H-AREA SAMPLES	DATE (sample)	NORM+	NORM-	CHG BAL	%ERROR	pH (1st)	pH (2nd)	pH (calc)	H3O+	OH-
H-AREA ARU (211-H)	11-11-83	6.93E-2	4.30E-2	2.63E-2	46.8	1.20	0.74	1.43	6.31E-2	1.58E-13
"	11-18-83									1.00E-14
H-AREA GP (211-H)	11-2-83	4.19E-4	1.91E-4	2.28E-4	74.7	6.95	4.53		1.12E-7	8.91E-8
"	11-11-83	3.27E-2	6.42E-2	-3.15E-2	65.0	12.76		12.42	1.74E-13	5.75E-2
"	11-18-83									
H-AREA 242-H (1H) EVAPORATOR	11-4-83	3.76E-4	1.58E-7	3.76E-4	199.8	7.20			6.31E-8	1.58E-7
"	11-11-83	1.82E-3	1.59E-3	2.33E-4	13.7	7.50	7.40		3.16E-8	3.16E-7
"	11-18-83	9.64E-2	2.48E-2	7.16E-2	118.2	1.02	(see 1st)	1.62	9.55E-2	1.05E-13
"	11-29-83									
242-28H (2H) EVAPORATOR	11-11-83	1.87E-3	5.33E-4	1.34E-3	111.3	8.95	9.25		1.12E-9	8.91E-6
"	11-18-83	1.62E-3	1.12E-3	5.01E-4	36.5	9.29			5.13E-10	1.95E-5
"	11-29-83									

SAMPLE	DATE (sample)	NORM+	NORM-	CHG BAL	%ERROR	pH (1ST)			H3O+	OH-
RBOF-TARG CLNG+RNS #11265	12-9-83	8.20E-2	7.58E-2	-1.57E-2	19.9	1.42		1.27	3.80E-2	2.63E-13
FILTER BACKFLUSH (FB#11266)	12-9-83	1.30E-1	1.78E-1	-5.03E-2	32.7	12.40			3.98E-13	2.51E-2
RESIN CLASS RBOF	12-9-83	7.44E-3	5.12E-3	2.25E-3	35.8	11.28		11.62	5.25E-12	1.91E-3
RESIN REGEN RBOF	12-9-83	4.19E-1	2.90E-1	1.29E-1	36.4	12.77		13.27	1.70E-13	5.89E-2
DEIONIZER RINSE	12-9-83	2.16E-2	1.77E-2	3.86E-3	19.7	12.24		12.33	5.75E-13	1.74E-2

TABLE B-4, Contd

H-AREA SAMPLES Formality conversion	DATE (sample)	COND UND	Eh UND	NH4 17	TOC 12	TIC 12	ACIDITY 100.09	ALKALINITY 100.09	CO3/TIC	HCO3/TIC	TIC (NORMALITY OF FREE ANIONS)
H-AREA ARU (211-H)	11-11-83	8500	307.0	0	63	20	2200	0	9.35E-10	7.13E-6	1.19E-8
"	11-18-83			0	271	69					
H-AREA GP (211-H)	11-2-83	7	23.0	1	7	0	0	.1	5.26E-4	8.00E-1	0.0
"	11-11-83	12800	-349.0	35	31	0			9.97E-1	2.94E-3	0.0
"	11-18-83			0	56	0	0	15	1.00E-0		
H-AREA 242-H (1H) EVAPORATOR	11-4-83	15	-20.2	2	6	0			9.34E-4	8.76E-1	0.0
"	11-11-83	88	-32.7	4	30	10	0	46	1.86E-3	9.33E-1	7.80E-4
"	11-18-83	Na	Na	7	14	10	1200	0	6.18E-10	4.71E-6	3.93E-9
"	11-29-83										
242-28H (2H) EVAPORATOR	11-11-83	48	-118.2	27	22	6	0	73.5	5.00E-2	9.48E-1	5.24E-4
"	11-18-83	105	-147.0	23	69	12	0	72.9	1.03E-1	8.96E-1	1.10E-3
"	11-29-83										

SAMPLE	DATE (sample)	COND	Eh	NH4	TOC	TIC	ACIDITY	ALKALINITY	CO3/TIC	HCO3/TIC	TIC (free -)
RBOF-TARG CLNG-RNS #11265	12-9-83	17000	312.0	Na	Na	Na	Na	Na	Na	Na	Na
FILTER BACKFLUSH (FB#11266)	12-9-83	5500	-327.0	Na	Na	Na	Na	Na	Na	Na	Na
RESIN CLASS RBOF	12-9-83	408	263.0	Na	Na	Na	Na	Na	Na	Na	Na
RESIN REGEN RBOF	12-9-83	10300	-351.0	Na	Na	Na	Na	Na	Na	Na	Na
DEIONIZER RINSE	12-9-83	3700	-320.0	Na	Na	Na	Na	Na	Na	Na	Na

TABLE B-4, Contd

H-AREA SAMPLES Formality conversion	DATE (sample)	ADD#	Hg 200.59	K 39.1	ADD#	NO2 46	F 19	Cl 35.5	SO4 96	PO4 95	NO3 62
H-AREA ARU (211-H)	11-11-83	42665	1.00E-3	8.00E-2	42658	0.0	0.0	0.0	0.0	0.0	2.67E+3
"	11-18-83	43000	5.00E-2	3.90E-1	42995	0.0	0.0	0.0	0.0	0.0	2.05E+4
H-AREA GP (211-H)	11-2-83	42710	<.001	7.00E-2	42703	5.50E+0	0.0	0.0	1.02E+0	0.0	3.10E+0
"	11-11-83	43844	2.75E-1	9.37E-1	43838	0.0	0.0	0.0	1.83E+1	0.0	3.86E+2
"	11-18-83	42983	<.001	1.00E-1	42978	0.0	6.01E-1	3.99E+0	0.0	0.0	1.84E+0
H-AREA 242-H (1H) EVAPORATOR	11-4-83	42682	2.00E-3	7.30E-1	42675	0.0	0.0	0.0	0.0	0.0	0.0
"	11-11-83	42694	<.001	6.70E-1	42687	0.0	0.0	9.92E-1	1.62E+1	6.04E+0	2.75E+1
"	11-18-83	43008	2.00E-2	6.30E-1	43003	0.0	0.0	0.0	0.0	0.0	1.54E+3
"	11-29-83	43201	2.90E-1								
242-28H (2H) EVAPORATOR	11-11-83	42702	0.0	5.30E-1	42695	0.0	0.0	0.0	0.0	0.0	0.0
"	11-18-83	43852	6.00E-4	3.57E-1	43846	0.0	0.0	0.0	0.0	0.0	0.0
"	11-29-83	43200	3.10E-1								

SAMPLE	DATE (sample)	ADD#	Hg (PPM)	K	ADD#	NO2	F	Cl	SO4	PO4	NO3
RBOF-TARG CLNG+RNS #11265	12-9-83	43859	8.00E-4	6.53E-1	43853	0.0	0.0	1.74E+0	1.44E+1	3.44E+4	0.0
FILTER BACKFLUSH (FB#11266)	12-9-83	43875	8.00E-4	4.44E-1	43869	0.0	1.38E+1	1.07E+2	2.02E+2	6.72E+3	2.02E+2
RESIN CLASS RBOF	12-9-83	44105	3.00E-4	1.25E+0	44100	0.0	0.0	2.76E+0	5.67E+0	1.33E+2	1.38E+1
RESIN REGEN RBOF	12-9-83	44112	1.00E-4	5.33E+1	44107	0.0	0.0	0.0	2.44E+3	0.0	1.12E+4
DEIONIZER RINSE	12-9-83	44120	2.00E-4	1.40E-1	44114	0.0	0.0	0.0	2.31E+0	0.0	1.64E+1

TABLE B-4, Contd

H-AREA SAMPLES Formality conversion	DATE (sample)	ADD#	Sodium 23	Ca 40.1	Mg 24.3	Fe 55.8	P 31	Al 26.98	Si 28.1	Si(Sol) 28.1	Ni 58.7	Mn 54.94	Zn 65.37
H-AREA ARU (211-H)	11-11-83	42664	2.56E-1	1.20E+2	8.73E-1	3.22E-1	4.61E+0	8.69E-1	2.72E-1	2.40E-1	1.00E-1	1.67E-1	2.08E+1
"	11-18-83	42996	1.49E+1	8.70E-2	0.0	2.48E-1	5.84E+0	0.0	0.0	<.01	0.0	7.08E-1	6.00E-2
H-AREA GP (211-H)	11-2-83	42656	1.05E+0	4.40E+0	6.39E-1	4.56E-1	0.0	2.15E-1	0.0	0.0	0.0	2.80E-2	7.28E+0
"	11-11-83	43846	7.02E+2	2.89E-1	0.0	1.06E-1	7.49E+0	5.41E-1	2.34E-1	.304*	3.05E-1	7.05E-2	1.60E-2
"	11-18-83	42982	1.30E+0	4.51E+1	4.36E-1	4.79E-1	1.82E-1	0.0	0.0	<.01	0.0	<.01	5.40E-2
H-AREA 242-H (1H) EVAPORATOR	11-4-83	42677	1.68E+0	3.00E+0	2.04E-1	0.0	8.36E-2	0.0	2.28E+0	2.60E+0	1.39E-1	<	6.68E-2
"	11-11-83	42688	3.28E+1	2.59E+0	1.81E-1	0.0	2.06E+0	0.0	2.45E+0	2.48E+0	9.86E-2	<	2.85E-1
"	11-18-83	43004	3.53E+0	1.51E+0	3.25E-1	2.66E-1	0.0	1.51E+0	2.74E+0	2.63E+0	<	<	1.82E-1
"	11-29-83	43202	8.78E+0	2.67E-1	4.64E-2	1.26E-1	5.40E-2	2.33E+0	4.09E+0	Na	1.65E-1	<	2.51E-2
242-28H (2H) EVAPORATOR	11-11-83	42696	1.31E+0	1.54E+0	5.90E-2	5.90E-2	<	1.14E+0	2.73E+0	2.51E+0	2.14E-1	<	2.06E-2
"	11-18-83	43847	3.51E+0	3.47E-1	3.44E-2	2.29E-2	1.85E-1	7.86E-1	2.53E+0	2.49E+0	1.24E-1	<	2.56E-2
"	11-29-83	43199	3.76E+0	3.70E-1	6.36E-2	6.64E-2	<	1.10E+0	1.78E+0	Na	1.46E-1	<	3.40E-2

SAMPLE	DATE (sample)	ADD#	Sodium	Ca	Mg	Fe	P	Al	Si	Si(sol)	Ni	Mn	Zn
RBOF-TARG CLNG+RNS #11265	12-9-83	43854	6.44E+2	3.31E+0	2.53E-1	2.97E+0	9.41E+3	1.41E+2	1.40E+1	1.37E+1	<	<	2.02E+0
FILTER BACKFLUSH (FB#11266)	12-9-83	43870	2.94E+3	0.0	0.0	1.63E+0	8.84E+2	1.49E+1	3.16E+0	8.59E-1	<	<	1.15E+0
RESIN CLASS RBOF	12-9-83	44101	1.56E+2	4.49E-1	4.91E-2	6.24E+0	4.01E+1	3.38E+0	1.62E+0	8.89E-1	<	3.23E-2	1.15E-1
RESIN REGEN RBOF	12-9-83	44111	8.35E+3	1.09E+3	0.0	0.0	3.11E-1	5.91E-1	3.91E+0	4.11E+0	2.78E+0	<	8.60E-1
DEIONIZER RINSE	12-9-83	44115	4.95E+2	1.84E-1	0.0	1.10E-1	9.41E+0	2.74E-1	2.38E-2	3.60E-2	<	<	4.72E-2

TABLE B-4, Contd

H-AREA SAMPLES Formality conversion	DATE (sample)	Cr 51.996	Ba 137.3	Cu 63.54	Pb 207.19	Cd 112.4	Co 58.93	Sr 87.62	Zr 91.22	Yb 88.91	La 138.91	Li 6.939	Be 9.012
H-AREA ARU (211-H)	11-11-83	2.13E-2	5.00E-3	<	<	<	<	6.49E-2	<	7.21E-1	8.40E-3	<	<
"	11-18-83	<	<	<	<	<	<	<	<	<	<	<	<
H-AREA GP (211-H)	11-2-83	<	5.00E-3	<	<	<	<	3.60E-2	<	<	<	<	<
"	11-11-83	4.11E-2	1.14E-2	2.50E-2	4.91E-1	<	<	4.10E-3	2.04E-2	7.41E-2	1.46E-2	1.52E-2	<
"	11-18-83	<.01	<.003	<.01	<.03	<.01	<.01	<.003	<.005	<.01	<.005	<.005	<.003
H-AREA 242-H (1H) EVAPORATOR	11-4-83	<	4.90E-3	<	1.36E-1	<	<	6.30E-3	7.50E-3	5.68E-2	8.70E-3	<	<
"	11-11-83	<	5.00E-3	<	9.12E-2	<	<	1.94E-1	6.30E-3	4.77E-2	1.11E-2	2.53E-2	<
"	11-18-83	0.0	0.0	0.0	0.0	0.0	0.0	3.34E-2	0.0	0.0	0.0	0.0	0.0
"	11-29-83	1.69E-2	9.50E-3	1.00E-2	1.25E-1	<.01	<	4.00E-3	9.10E-3	1.69E-2	<	<	<
242-28H (2H) EVAPORATOR	11-11-83	<	1.50E-2	1.65E-2	2.35E-1	<	<	4.80E-3	1.00E-2	5.60E-2	1.25E-2	<	<
"	11-18-83	<	<	<	1.58E-1	<	<	3.90E-3	6.20E-3	3.58E-2	8.10E-3	1.52E-2	<
"	11-29-83	1.20E-2	9.50E-3	<	7.50E-2	<	<	8.20E-3	8.10E-3	2.43E-2	<	<	3.40E-3

SAMPLE	DATE (sample)	Cr	Ba	Cu	Pb	Cd	Co	Sr	Zr	Yb	La	Li	Be
RBOF-TARG CLNG+RNS #11265	12-9-83	1.14E+3	<	<	4.11E+1	<	3.17E-1	<	<	<	<	<	<
FILTER BACKFLUSH (FB#11266)	12-9-83	1.03E+2	<	<	0.0	<	<	<	<	<	<	<	<
RESIN CLASS RBOF	12-9-83	3.49E+0	<	<	0.0	<	<	<	<	<	<	<	<
RESIN REGEN RBOF	12-9-83	1.11E+0	3.24E-1	<	1.26E+0	<	<	3.55E+0	6.60E-2	6.76E+0	8.50E-2	1.44E-1	<
DEIONIZER RINSE	12-9-83	9.95E-1	<	<	5.18E-2	<	<	<	<	<	<	<	<

TABLE B-4, Contd

H-AREA SAMPLES Formality conversion	DATE (sample)	B 10.81	Ti 47.9	U 238.03	V 50.94	Y 173.04
H-AREA ARU (211-H)	11-11-83	<	6.00E-3	<	<	<
"	11-18-83	<	<	<	<	<
H-AREA GP (211-H)	11-2-83	<	<	<	<	<
"	11-11-83	<	1.38E-2	4.38E+0	3.26E-2	<
"	11-18-83	<.005	<.003	<.5	<.01	<.01
H-AREA 242-H (1H) EVAPORATOR	11-4-83	<	3.00E-3	<	<	<
"	11-11-83	<	<	<	<	<
"	11-18-83	<	<	<	<	<
"	11-29-83	<	5.60E-3	<	<	<
242-28H (2H) EVAPORATOR	11-11-83	<	7.80E-3	<	<	<
"	11-18-83	<	8.30E-3	<	<	<
"	11-29-83	<	4.80E-3	<	<	<

SAMPLE	DATE (sample)	B	Ti	U	V	Y
RBOF-TARG CLNG+RNS #11265	12-9-83	<	4.71E-1	<	4.77E-1	<
FILTER BACKFLUSH (FB#11266)	12-9-83	<	<	<	<	<
RESIN CLASS RBOF	12-9-83	1.86E-2	2.11E-1	<	<	<
RESIN REGEN RBOF	12-9-83	1.67E-1	8.00E-2	<	1.05E-1	<
DEIONIZER RINSE	12-9-83	<	<	<	<	<

TABLE B-4, Contd

H-AREA SAMPLES UNITS	DATE (sample)	ADD#	T d/m/ml	α d/m/ml	β-G d/m/ml	I-129 (PPM)	Tc-99 (PPM)
H-AREA ARU (211-H)	11-11-83	42663	2.29E+6	0.0	2.00E+0	<0.03	<0.20
"	11-18-83	43002	1.08E+6			<0.006	<0.033
H-AREA GP (211-H)	11-2-83	42708	3.06E+4	1.60E+1	9.00E+0	<0.03	<0.162
"	11-11-83	43842	2.63E+4	4.20E+1	1.70E+1		
"	11-18-83	42985	4.10E+4	2.00E+0	<		
H-AREA 242-H (1H) EVAPORATOR	11-4-83	42680	1.51E+5	4.80E+1	6.50E+1	<0.03	<0.203
"	11-11-83	42693	1.00E+5	1.20E+1	1.08E+2	<0.03	<0.193
"	11-18-83	43010	1.18E+5			<0.006	<0.027
"	11-29-83						
242-28H (2H) EVAPORATOR	11-11-83	42700	3.49E+4	6.00E+0	1.20E+2	<0.03	<0.193
"	11-18-83	43850	2.67E+4	1.80E+1	1.28E+2		
"	11-29-83						

SAMPLE	DATE (sample)	ADD#	Tritium	α	β-G	I-129	Tc-99
RBOF-TARG CLNG+RNS #11265	12-9-83	43857	4.54E+5	0.0	1.38E+4		
FILTER BACKFLUSH (FB#11266)	12-9-83	43873	5.91E+4	1.60E+1	4.98E+3		
RESIN CLASS RBOF	12-9-83	44106	9.32E+4	0.0	1.05E+3		
RESIN REGEN RBOF	12-9-83	44113	9.16E+4	1.50E+1	1.24E+4		
DEIONIZER RINSE	12-9-83	44118	2.94E+3	1.00E+0	5.40E+1		

TABLE B-4, Contd

H-AREA SAMPLES UNITS=MICROCURIES/LITER (nCi/ml)	DATE (sample)	Cs-137 (nCi/ml)	Co-60 (nCi/ml)	Ru-106 (nCi/ml)	Sr-89 (nCi/ml)	Zr-95 (nCi/ml)	Nb-95 (nCi/ml)	Ru-103 (nCi/ml)	I-131 (nCi/ml)	Cs-134 (nCi/ml)	Ce-141 (nCi/ml)
H-AREA ARU (211-H)	11-11-83										
"	11-18-83										
H-AREA GP (211-H)	11-2-83	<2.4E-4	<2.5E-4	<1.29E-3	<	<3.84E-4	<2.36E-4	<2.12E-4	<2.34E-4	<4.35E-4	<3.48E-4
"	11-11-83	1.63E-3	<	<	<	7.33E-3	1.06E-2	<	<	<	<
"	11-18-83										
H-AREA 242-H (1H) EVAPORATOR	11-4-83										
"	11-11-83										
"	11-18-83	7.01E-2	<	7.86E-3	<	<	<	<	<	2.59E-3	<
"	11-29-83	7.47E-1	<	6.02E-2	<	<	<	<	<	2.68E-3	<
242-28H (2H) EVAPORATOR	11-11-83										
"	11-18-83	1.44E-1	<	<	<	<	<	<	<	2.40E-3	<4.41E-4
"	11-29-83	4.76E-1	<	1.33E-2	<	<	<	<	<	8.75E-3	<

SAMPLE	DATE (sample)	Cs-137	Co-60	Ru-106	Sr-89	Zr-95	Nb-95	Ru-103	I-131	Cs-134	Ce-141
RBOF-TARG CLNG+RNS #11265	12-9-83										
FILTER BACKFLUSH (FB#11266)	12-9-83	5.94E-2	1.00E-1	8.78E-3	<	4.54E-2	9.24E-2	6.04E-3	<	<	5.10E-3
RESIN CLASS RBOF	12-9-83	6.16E-3	1.59E-2	<	<	1.44E-2	2.72E-3	2.48E-3	<	5.26E-4	3.50E-3
RESIN REGEN RBOF	12-9-83	2.29E+0	5.95E-2	<	<	<	3.32E-3	<	<	1.51E-1	<
DEIONIZER RINSE	12-9-83	5.68E-3	1.95E-2	<	<	<7.95E-4	9.92E-3	<	<	<	<

TABLE B-4, Contd

H-AREA SAMPLES UNITS=MICROCURIES/LITER (nCi/ml)	DATE (sample)	Ce-144 (nCi/ml)	Pm-147 (nCi/ml)	U-235 (nCi/ml)	K-40 (nCi/ml)	Ra-228 (nCi/ml)	Nb-97 (nCi/ml)	Sr-85 (nCi/ml)	Kr-85 (nCi/ml)	Zn-65 (nCi/ml)	Am-241 (nCi/ml)	Xe-133 (nCi/ml)	Co-58 (nCi/ml)
H-AREA ARU (211-H)	11-11-83												
"	11-18-83												
H-AREA GP (211-H)	11-2-83	<1.47E-3	<	<3.3E-4	4.00E-3	<	<	<	<	<	<	<	<
"	11-11-83	<	<	<	<	<	<	<	<	<	<	<	<
"	11-18-83												
H-AREA 242-H (1H) EVAPORATOR	11-4-83												
"	11-11-83												
"	11-18-83	<	<	<	<	<	<	<	<	<	<	<	<
"	11-29-83	<	<	1.51E-3	<	8.67E-4	8.26E-3	1.34E-2	3.03E+0	<	<	<	<
242-28H (2H) EVAPORATOR	11-11-83												
"	11-18-83	<	<	<	1.06E-3	<	<	<	<	<	<	<	<
"	11-29-83	<	<	3.13E-4	<	<	<	<	<	<	<	<	<

SAMPLE	DATE (sample)	Ce-144	Pm-147	U-235	K-40	Ra-228	Nb-97	Sr-85	Kr-85	Zn-65	Am-241	Xe-133	Co-58
RBOF-TARG CLNG+RNS #11265	12-9-83												
FILTER BACKFLUSH (FB#11266)	12-9-83	7.36E-2	<	<	<	<	2.14E-2	<	<	8.94E-1	<	1.96E-3	1.48E-2
RESIN CLASS RBOF	12-9-83	2.32E-2	<	<	7.40E-4	<	2.92E-3	<	<	1.14E-1	<	4.62E-4	6.50E-4
RESIN REGEN RBOF	12-9-83	<	<	4.17E-3	<	<	2.78E-2	<	<	1.11E-1	<	<	6.35E-2
DEIONIZER RINSE	12-9-83	7.55E-3	<	<	<	<	3.45E-3	<	<	1.09E-1	<	<	3.50E-3

TABLE B-4, Contd

H-AREA SAMPLES UNITS=MICROCURIES/LITER (nCi/ml)	DATE (sample)	Mn-54 (nCi/ml)	Cr-51 (nCi/ml)	Fe-59 (nCi/ml)	Ar-41 (nCi/ml)	Bi-214 (nCi/ml)	Sc-46 (nCi/ml)	Sr-92 (nCi/ml)	Ag-110 (nCi/ml)	Sn-113 (nCi/ml)	Eu-154 (nCi/ml)	Na-22 (nCi/ml)
H-AREA ARU (211-H)	11-11-83											
"	11-18-83											
H-AREA GP (211-H)	11-2-83	<	<	<	<	<	<	<	<	<	<	<
"	11-11-83	<	<	<	<	1.06E-3	<	<	<	<	<	<
"	11-18-83											
H-AREA 242-H (1H) EVAPORATOR	11-4-83											
"	11-11-83											
"	11-18-83	<	<	<	<	<	<	<	<	<	<	<
"	11-29-83	<	<	<	<	<	<	<	<	<	<	<
242-28H (2H) EVAPORATOR	11-11-83											
"	11-18-83	<	<	<	<	<	<	<	<	<	<	<
"	11-29-83	<	<	<	<	<	<	<	<	<	<	<

SAMPLE	DATE (sample)	Mn-54	Cr-51	Fe-59	Ar-41	Bi-214	Sc-46	Sr-92	Ag-110	Sn-113	Eu-154	Na-22
RBOF-TARG CLNG-RNS #11265	12-9-83											
FILTER BACKFLUSH (FB#11266)	12-9-83	2.06E-1	2.42E-1	1.08E-1	1.07E-1	8.90E-2	1.34E-2	<	6.22E-3	1.45E-3	2.52E-3	8.46E-4
RESIN CLASS RBOF	12-9-83	1.53E-2	3.00E-1	3.00E-3	2.94E-3	8.36E-3	1.26E-3	5.02E-4	<	<	<	<
RESIN REGEN RBOF	12-9-83	2.88E-2	6.21E+0	<	<	<	<	<	<	<	<	<
DEIONIZER RINSE	12-9-83	5.38E-2	2.14E-2	2.99E-2	2.90E-2	<	<	<	<	<	<	<

APPENDIX C

SYSTEM DECONTAMINATION FACTORS

Tables C-5.2.1, C-5.2.2
C-5.3.1, C-5.3.2
C-5.4.1, C-5.4.2
C-5.5.1
C-5.6.1, C-5.6.2

These tables describe the performance that would be expected of each of the F/HETF process alternatives discussed in Sections 5.2 through 5.6 of this document. Although the values are approximate, they are based on decontamination factors that have been observed in laboratory and pilot scale equipment. As such, they may be used for purposes of comparison and to provide reasonably conservative estimates of F/HETF effluent concentrations.

TABLE C-5.2.1

Tubular Precoat Filtration (50 ppm body feed) with Reverse Osmosis and Mixed Bed Ion Exchange

Radionuclide	Release Std F (Ci/yr)	Release Std H (Ci/yr)	Pretreatment Filtration (DF)	Filtrate Activity (mCi/yr)	Reverse Osmosis (DF)	Released by RO (mCi/yr)	Polishing Mixed Bed (DF)	Released by MB IXG (mCi/yr)
Cr-51	0.0	5.0	1	5000	19	263	1000	0.3
Co-58	0.0	1.0	1	1000	19	53	100	0.5
Co-60	0.0	1.0	1	1000	19	53	100	0.5
Zn-65	0.0	0.8	1	800	17	47	1000	0.0
Sr-89	0.2	0.4	1.1	545	19	29	1000	0.0
Sr-90	0.4	1.0	1.1	1273	19	67	1000	0.1
Y-90	-	-	2	-	19		1000	
Y-91	-	-	2	-	19		1000	
Zr-95	4.0	1.0	20	250	50	5	100	0.1
Nb-95	4.0	1.5	20	275	50	6	100	0.1
Ru-103	2.0	1.5	10	350	50	7	100	0.1
Ru-106	20.0	7.5	10	2750	50	55	100	0.6
Rh-106	-	-	10	-	50		100	
Sb-124	0.0	0.2	1	200	19	11	1000	0.0
I-131	0.8	0.4	1	1200	19	63	1000	0.1
Cs-134	0.3	1.5	1.1	1636	19	86	1000	0.1
Cs-137	4.0	9.0	1.1	11818	19	622	1000	0.6
Ce-141	0.1	0.4	20	25	50	0	100	0.0
Ce-144	1.0	2.6	20	180	50	4	100	0.0
Pr-144	-	-	20	-	50	0	1000	
Pm-147	0.5	1.0	1	1500	19	79	100	0.8
Other beta-gamma	0.5	0.8	1	1300	19	68	100	0.7
Total beta-gamma	37.8	36.6	2.4	31103	20.5	1517	338.6	4.5
Non Cs/Sr beta-gamma	32.9	24.7	3.6	15830	22.2	713	194.0	3.7

TABLE C-5.2.1, Contd

Radionuclide	First Cycle Feed (1AF)* %	1000 Ci 1AF Release After filt (mCi/event)	1000 Ci 1AF Release After RO (mCi/event)	1000 Ci 1AF Release After IXG (mCi/event)	Current Guidelines (mCi/yr)
Beta-Gamma					
Cr-51	-				
Co-58	-				
Co-60	-				
Zn-65	-				
Sr-89	5.3	48182	2536	3	35/2
Sr-90	0.38	3455	182	0	35/2
Y-90	0.38	1900	100	0	
Y-91	8.75	43750	2303	2	
Zr-95	11.56	5780	116	1	
No-95	22.19	11095	222	2	
Ru-103	1.78	1780	36	0	
Ru-106	1.38	1380	28	0	
Rh-106	1.38	1380	28	0	
Sb-124	-	-	0	0	
I-131	-	-	0	0	
Cs-134	0.84	7636	402	0	75/2
Cs-137	1.13	10273	541	1	75/2
Ce-141	1.69	845	17	0	
Ce-144	19.69	9845	197	2	
Pr-144	19.69	9845	197	0	
Pm-147	2.16	21600	1137	11	
Other beta-gamma	1.72	17200	905	9	
Total beta-gamma	100	195945	8944	33	
Non Cs/Sr Beta-gamma	92	126400	5284	29	175

TABLE C-5.2.1, Contd

Radionuclide	Release Std F (Ci/yr)	Release Std H (Ci/yr)	Pretreatment Filtration (DF)	Filtrate Activity (mCi/yr)	Reverse Osmosis (DF)	Released by RO (mCi/yr)	Polishing Mixed Bed (DF)	Released by MB IXG (mCi/yr)
Alpha								
Am-241	0.020	0.002	20	1.1E+0	99	1.1E-2	100	1.1E-4
Cm-242/244	0.010	0.001	20	5.5E-1	99	5.6E-3	100	5.6E-5
U-235/238	0.200	0.005	20	1.0E+1	99	1.0E-1	100	1.0E-3
Pu-238	0.020	0.009	20	1.4E+0	99	1.5E-2	100	1.5E-4
Pu-239	0.020	0.006	20	1.3E+0	99	1.3E-2	100	1.3E-4
Pu-240	-	-	20	-	99	0.0	100	0.0
Sum alpha (OBS)	0.270	0.023	20	1.5E+1	99	1.5E-1	100	1.5E-3
Total alpha (guide)	0.5	0.2	20	3.5E+1	99	3.5E-1	100	3.5E-3
Sum alpha/ Total β-γ								

TABLE C-5.2.1, Contd

Radionuclide	First Cycle Feed (1AF)* %	1000 Ci 1AF Release After filt (mCi/event)	1000 Ci 1AF Release After RO (mCi/event)	1000 Ci 1AF Release After IXG (mCi/event)	Current Guidelines (mCi/yr)
<u>Beta-Gamma</u>					
Cr-51	-				
Co-58	-				
Co-60	-				
Zn-65	-				
Sr-89	5.3	48182	2536	3	35/2
Sr-90	0.38	3455	182	0	35/2
Y-90	0.38	1900	100	0	
Y-91	8.75	43750	2303	2	
Zr-95	11.56	5780	116	1	
No-95	22.19	11095	222	2	
Ru-103	1.78	1780	36	0	
Ru-106	1.38	1380	28	0	
Rh-106	1.38	1380	28	0	
Sb-124	-	-	0	0	
I-131	-	-	0	0	
Cs-134	0.84	7636	402	0	75/2
Cs-137	1.13	10273	541	1	75/2
Ce-141	1.69	845	17	0	
Ce-144	19.69	9845	197	2	
Pr-144	19.69	9845	197	0	
Pm-147	2.16	21600	1137	11	
Other beta-gamma	1.72	17200	905	9	
Total beta-gamma	100	195945	8944	33	
Non Cs/Sr Beta-gamma	92	126400	5284	29	175

TABLE C-5.2.1, Contd

Radionuclide	High Activity Waste (HAW) %	1000 Ci HAW Release After Filt. (mCi/event)	1000 Ci HAW Release After RO (mCi/event)	1000 Ci HAW Release After IXG (mCi/event)
Beta-Gamma				
Cr-51	0			
Co-58	0			
Co-60	0			
Zn-65	0			
Sr-89	0	0	0	0
Sr-90	6.6	60000	3158	3
Y-90	0	0	0	0
Y-91	0	0	0	0
Zr-95	5.4	2700	54	1
No-95	1.9	950	19	0
Ru-103	0.3	300	6	0
Ru-106	6.5	6500	130	1
Rh-106	0	0	0	0
Sb-124	0	0	0	0
I-131	0	0	0	0
Cs-134	3.8	34545	1818	2
Cs-137	6.7	60909	3206	3
Ce-141	0.4	200	4	0
Ce-144	68.2	34100	682	7
Pr-144	0	0	0	0
Pm-147	0	0	0	0
Other beta-gamma	0.2	2000	105	1
Total beta-gamma	100	202205	9182	18
Non Cs/Sr Beta-gamma	83	46750	1000	10

TABLE C-5.2.1, Contd

Radionuclide	High Activity Waste (HAW) Character Alpha Curie Distribution %	1000 Ci HAW Release After Filt. (mCi/event)	1000 Ci HAW Release After RO (mCi/event)	1000 Ci HAW Release After IXG (mCi/event)
Alpha				
Am-241	0	0	0	0.0
Cm-242/244	0	0	0	0.0
U-235/238	0	0	0	0.0
Pu-238	99.1	150.14	1.517	1.52E-2
Pu-239	0.43	0.65	0.007	6.58E-5
Pu-240	0.43	0.65	0.007	6.58E-5
Total alpha	3.03 Ci	151.4 mCi	0.153 mCi	0.015 mCi
Total alpha/ Total β-γ	0.00303			

TABLE C-5.2.2

Tubular Precoat Filtration (5000 ppm Body Feed) Reverse Osmosis and Mixed Bed Ion Exchange

Radionuclide	Release Std F (Ci/yr)	Release Std H (Ci/yr)	Pretreatment Filtration (DF)	Reverse Osmosis (DF)	Released by RO (mCi/yr)	Polishing Mixed Bed (DF)	Released by MB IXG (mCi/yr)	Current Guidelines (mCi/yr)
Cr-51	0.0	5.0	1	19	263	1000	0.3	
Co-58	0.0	1.0	1	19	53	100	0.5	
Co-60	0.0	1.0	1	19	53	100	0.5	
Zn-65	0.0	0.8	1	17	47	1000	0.0	
Sr-89	0.2	0.4	17	19	2	1000	0.0	35/2
Sr-90	0.4	1.0	17	19	4	1000	0.0	35/2
Y-90	-	-	10	19		1000		
Y-91	-	-	10	19		1000		
Zr-95	4.0	1.0	88	50	1	100	0.0	
No-95	4.0	1.5	88	50	1	100	0.0	
Ru-103	2.0	1.5	50	50	1	100	0.0	
Ru-106	20.0	7.5	50	50	11	100	0.1	
Rh-106	-	-	50	50		100		
Sb-124	0.0	0.2	1	19	11	1000	0.0	
I-131	0.8	0.4	1	19	63	1000	0.1	
Cs-134	0.3	1.5	17	19	6	1000	0.0	75/2
Cs-137	4.0	9.0	17	19	40	1000	0.0	75/2
Ce-141	0.1	0.4	2000	50	0	100	0.0	
Ce-144	1.0	2.6	2000	50	0	100	0.0	
Pr-144	-	-	2000	50	0	100		
Pm-147	0.5	1.0	5	19	16	100	0.2	
Other beta-gamma	0.5	0.8	1	19	68	100	0.7	
Total beta-gamma	37.8	36.6	5.0	23.2	640	258.3	2.5	
Non Cs/Sr Beta-Gamma	32.9	24.7	4.9	20.0	588	242.4	2.4	175

TABLE C-5.2.2, Contd

Radionuclide	Release Std F (Ci/yr)	Release Std H (Ci/yr)	Pretreatment Filtration (DF)	Reverse Osmosis (DF)	Released by RO (mCi/yr)	Polishing Mixed Bed (DF)	Released by MB IXG (mCi/yr)	Current Guidelines (mCi/yr)
Alpha								
Am-241	0.020	0.002	20	99	1.11E-2	100	1.11E-4	
Cm-242/244	0.010	0.001	20	99	5.56E-3	100	5.56E-5	
U-235/238	0.200	0.005	20	99	1.04E-1	100	1.04E-3	
Pu-238	0.020	0.009	20	99	1.46E-2	100	1.46E-4	
Pu-239	0.020	0.006	20	99	1.31E-2	100	1.31E-4	
Pu-240	-	-	20	99	0.0	100	0.0	
Sum alpha (OBS)	0.270	0.023	20	99	1.48E-1	100	1.48E-3	10.00
Total alpha (guide)	0.5	0.2	20	99	3.54E-1	100	3.54E-3	10.00
Sum alpha/ Total β-γ	0.007	0.001						

TABLE C-5.2.2, Contd

Radionuclide	First Cycle Feed (1AF)* %	1000 Ci 1AF Release After Filt. (mCi/event)	1000 Ci 1AF Release After RO (mCi/event)	1000 Ci 1AF Release After IXG (mCi/event)
Beta Gamma				
Cr-51	-			
Co-58	-			
Co-60	-			
Zn-65	-			
Sr-89	5.3	3118	164	1.6E-1
Sr-90	0.38	224	12	1.2E-2
Y-90	0.38	380	20	2.0E-2
Y-91	8.75	8750	461	4.6E-1
Zr-95	11.56	1314	26	2.6E-1
Nb-95	22.19	2522	50	5.0E-1
Ru-103	1.78	356	7	7.1E-2
Ru-106	1.38	276	6	5.5E-2
Rh-106	1.38	276	6	5.5E-2
Sb-124	-		0	0.0
I-131	-		0	0.0
Cs-134	0.84	494	26	2.6E-2
Cs-137	1.13	665	35	3.5E-2
Ce-141	1.69	8	0	1.7E-3
Ce-144	19.69	98	2	2.0E-2
Pr-144	19.69	98	2	2.0E-2
Pm-147	2.16	4320	227	2.3E+0
Other beta-gamma	1.72	17200	905	9.1E+0
Total beta-gamma	100	40099	1949	1.3E+1
Non Cs/Sr Beta-gamma	92	35599	1712	1.3E+1

TABLE C-5.2.2, Contd

Radionuclide	High Activity Waste (HAW) %	1000 Ci HAW Release After Filt. (mCi/event)	1000 Ci HAW Release After RO (mCi/event)	1000 Ci HAW Release After IXG (mCi/event)
Beta Gamma				
Cr-51	0			
Co-58	0			
Co-60	0			
Zn-65	0			
Sr-89	0	0	0	0.0
Sr-90	6.6	3882	204	2.0E-1
Y-90	0	0	0	0.0
Y-91	0	0	0	0.0
Zr-95	5.4	614	12	1.2E-1
Nb-95	1.9	216	4	4.3E-2
Ru-103	0.3	60	1	1.2E-2
Ru-106	6.5	1300	26	2.6E-1
Rh-106	0	0	0	0.0
Sb-124	0	0	0	0.0
I-131	0	0	0	0.0
Cs-134	3.8	2235	118	1.2E-1
Cs-137	6.7	3941	207	2.1E-1
Ce-141	0.4	2	0	4.0E-4
Ce-144	68.2	341	7	6.8E-2
Pr-144	0	0	0	0.0
Pm-147	0	0	0	0.0
Other beta-gamma	0.2	2000	105	1.1E+0
Total beta-gamma	100	14591	685	2.1E+0
Non Cs/Sr Beta-gamma	83	4533	156	1.6E+0

TABLE C-5.2.2, Contd

Radionuclide	High Activity Waste (HAW) Character Alpha Curie Distribution %	1000 Ci HAW Release After filt (mCi/event)	1000 Ci HAW Release After RO (mCi/event)	1000 Ci HAW Release After IXG (mCi/event)
Alpha				
Am-241	0	0	0	0.0
Cm-242/244	0	0	0	0.0
U-235/238	0	0	0	0.0
Pu-238	99.1	150.14	1.517	1.5E-2
Pu-239	0.43	0.65	0.007	6.6E-5
Pu-240	0.43	0.65	0.007	6.6E-5
Sum alpha (OBS)	3.03 Ci	151.4 mCi	1.53 mCi	0.153
Total alpha/ Total β-γ	0.00303			

TABLE C-5.3.1

Ultrafiltration, Reverse Osmosis and Mixed Bed Ion Exchange

Radionuclide	Release Std F (Ci/yr)	Release Std H (Ci/yr)	Pretreatment Filtration (DF)	Released in Filtrate (mCi/yr)	Reverse Osmosis (DF)	Released by RO (mCi/yr)	Polishing Mixed Bed (DF)	Released by Mixed Bed (mCi/yr)	Current Guidelines (mCi/yr)
Cr-51	0.0	5.0	1	5000	19	263	1000	0.3	
Co-58	0.0	1.0	1	1000	19	53	100	0.5	
Co-60	0.0	1.0	1	1000	19	53	100	0.5	
Zn-65	0.0	0.8	1	800	17	47	1000	0.0	
Sr-89	0.2	0.4	1.1	545	19	29	1000	0.0	35/2
Sr-90	0.4	1.0	1.1	1273	19	67	1000	0.1	35/2
Y-90	-	-	2		19		1000		
Y-91	-	-	2		19		1000		
Zr-95	4.0	1.0	20	250	50	5	100	0.1	
Nb-95	4.0	1.5	20	275	50	6	100	0.1	
Ru-103	2.0	1.5	10	350	50	7	100	0.1	
Ru-106	20.0	7.5	10	2750	50	55	100	0.6	
Rh-106	-	-	10		50		100		
Sb-124	0.0	0.2	1	200	19	11	1000	0.0	
I-131	0.8	0.4	1	1200	19	63	1000	0.1	
Cs-134	0.3	1.5	1.1	1636	19	86	1000	0.1	75/2
Cs-137	4.0	9.0	1.1	11818	19	622	1000	0.6	75/2
Ce-141	0.1	0.4	20	25	50	0	100	0.0	
Ce-144	1.0	2.6	20	180	50	4	100	0.0	
Pr-144	-	-	2		50	0	100		
Pm-147	0.5	1.0	1	1500	19	79	100	0.8	
Other beta-gamma	0.5	0.8	1	1300	19	68	100	0.7	
Total beta-gamma	37.8	36.6	2.4	31103	20.5	1517	339	4.5	
Non Cs/Sr Beta-Gamma	32.9	24.7	3.6	15830	22.2	713	194	3.7	175

TABLE C-5.3.1, Contd

Radionuclide	Release Std F (Ci/yr)	Release Std H (Ci/yr)	Pretreatment Filtration (DF)	Released in Filtrate (mCi/yr)	Reverse Osmosis (DF)	Released by RO Stage (mCi/yr)	Polishing Mixed Bed (DF)	Released by MB IXG (mCi/yr)	Current Standards (mCi/yr)
Am-241	0.020	0.002	20	1.100	99	1.1E-2	100	1.11E-4	
Cm-242/244	0.010	0.001	20	0.550	99	5.6E-3	100	5.56E-5	
U-235/238	0.200	0.005	20	10.250	99	1.0E-1	100	1.04E-3	
Pu-238	0.020	0.009	20	1.450	99	1.5E-2	100	1.46E-4	
Pu-239	0.020	0.006	20	1.300	99	1.3E-2	100	1.31E-4	
Pu-240	-	-	20	-	00	0.0	100	0.0	
Sum alpha (OBS)	0.270	0.023	20	14.650	99	1.5E-1	100	1.48E-3	100
Total alpha (guide)	0.5	0.2	20	35	99	3.5E-1	100	3.54E-3	
Sum alpha/ Total β-γ	0.007	0.001							

TABLE C-5.3.1, Contd

Radionuclide	High Activity Waste (HAW) %	1000 Ci HAW Release After filt (mCi/event)	1000 Ci HAW Release After RO (mCi/yr)	1000 Ci HAW Release After MB IXG (mCi/event)
Beta-Gamma				
Cr-51	0			
Co-58	0			
Co-60	0			
Zn-65	0			
Sr-89	0	0	0	0.0
Sr-90	6.6	60000	3158	3.2E+0
Y-90	0	0	0	0.0
Y-91	0	0	0	0.0
Zr-95	5.4	2700	54	5.4E-1
Nb-95	1.9	950	19	1.9E-1
Ru-103	0.3	300	6	6.0E-2
Ru-106	6.5	6500	130	1.3E+0
Rh-106	0	0	0	0.0
Sb-124	0	0	0	0.0
I-131	0	0	0	0.0
Cs-134	3.8	34545	1818	1.8E+0
Cs-137	6.7	60909	3206	3.2E+0
Ce-141	0.4	200	4	4.0E-2
Ce-144	68.2	34100	682	6.8E+0
Pr-144	0	0	0	0.0
Pm-147	0	0	0	0.0
Other beta-gamma	0.2	2000	105	1.1E+0
Total beta-gamma	100.0	202205	9182	1.8E+1
Non Cs/Sr Beta-Gamma	83	46750	1000	1.0E+1

TABLE C-5.3.1, Contd

Radionuclide	High Activity Waste (HAW) Character Alpha Curie Distribution %	1000 Ci HAW Release After Filt. (mCi/event)	1000 Ci HAW Release After RO (mCi/yr)	1000 Ci HAW Release After MB IXG (mCi/event)
Alpha				
Am-241	0	0	0	0.0
Cm-242/244	0	0	0	0.0
U-235/238	0	0	0	0.0
Pu-238	99.1	150.14	1.517	1.5E-2
Pu-239	0.43	0.65	0.007	6.6E-5
Pu-240	0.43	0.65	0.007	6.6E-5
Total alpha	3.03 Ci	151.4 mCi	1.53 mCi	0.153 mCi
Total alpha/ Total β-γ	0.00303			

TABLE C-5.3.1, Contd

Radionuclide	First Cycle Feed (1AF)* %	1000 Ci 1AF Release After Filt. (mCi/event)	1000 Ci 1AF Release After RO (mCi/event)	1000 Ci 1AF Release After IXG (mCi/event)
Beta Gamma				
Cr-51	-			
Co-58	-			
Co-60	-			
Zn-65	-			
Sr-89	5.3	48182	2536	2.5E+0
Sr-90	0.38	3455	182	1.8E-1
Y-90	0.38	1900	100	1.0E-1
Y-91	8.75	43750	2303	2.3E+0
Zr-95	11.56	5780	116	1.2E+0
No-95	22.19	11095	222	2.2E+0
Ru-103	1.78	1780	36	3.6E-1
Ru-106	1.38	1380	28	2.8E-1
Rh-106	1.38	1380	28	2.8E-1
Sb-124	-	-	0	0.0
I-131	-		0	0.0
Cs-134	0.84	7636	402	4.0E-1
Cs-137	1.13	10273	541	5.4E-1
Ce-141	1.69	845	17	1.7E-1
Ce-144	19.69	9845	197	2.0E+0
Pr-144	19.69	9845	197	2.0E+0
Pm-147	2.16	21600	1137	1.1E+1
Other Beta-Gamma	1.72	17200	905	9.1E+0
Total beta-gamma	100	195945	8944	3.5E+1
Non Cs/Sr Beta-Gamma	92	126400	5284	3.1E+1

TABLE C-5.3.2

Ultrafiltration, Reverse Osmosis and Selective Ion Exchange

Radionuclide	Release Std F (Ci/yr)	Release Std H (Ci/yr)	Pretreatment Filtration (DF)	Released in Filtrate (mCi/yr)	Reverse Osmosis (DF)	Released by RO (mCi/yr)	Polishing by Zeolite (DF)	Released by Filt/RO/Zeo (mCi/yr)	Current Standards (mCi/yr)
Alpha									
Am-241	0.020	0.002	20	1.10E+0	99	1.11E-2	10	1.11E-3	
Cm-242/244	0.010	0.001	20	5.50E-1	99	5.56E-3	10	5.56E-4	
U-235/238	0.200	0.005	20	1.02E+1	99	1.04E-1	10	1.04E-2	
Pu-238	0.020	0.009	20	1.45E+0	99	1.46E-2	10	1.46E-3	
Pu-239	0.020	0.006	20	1.30E+0	99	1.31E-2	10	1.31E-3	
Pu-240	-	-	20	0.0	99	0.0	10	0.0	
Sum alpha (OBS)	0.270	0.023	20	1.47E+1	99	1.48E-1	10	1.48E-2	
Total alpha (guide)	0.5	0.2	20	3.50E+1	99	3.54E-1	10	3.54E-2	
Sum alpha/ Total β-γ	0.007	0.001	20		99		10		10

TABLE C-5.3.2, Contd

Radionuclide	First Cycle Feed (1AF)* %	1000 Ci 1AF Release After Filt. (mCi/event)	1000 Ci 1AF Release After RO (mCi/event)	1000 Ci 1AF Release After Zeo (mCi/event)
<u>Beta-Gamma</u>				
Cr-51	-			
Co-58	-			
Co-60	-			
Zn-65	-			
Sr-89	5.3	48182	2536	3
Sr-90	0.38	3455	182	0
Y-90	0.38	1900	100	1
Y-91	8.75	43750	2303	23
Zr-95	11.56	5780	116	58
No-95	22.19	11095	222	111
Ru-103	1.78	1780	36	36
Ru-106	1.38	1380	28	28
Rh-106	1.38	1380	28	28
Sb-124	-		0	0
I-131	-		0	0
Cs-134	0.84	7636	402	0
Cs-137	1.13	10273	541	1
Ce-141	1.69	845	17	2
Ce-144	19.69	9845	197	20
Pr-144	19.69	9845	197	197
Pm-147	2.16	21600	1137	1137
Other Beta Gamma	1.72	17200	905	905
Total beta gamma	100	195945	8944	2548
Non Cs/Sr Beta-Gamma	92	126400	5284	2544

TABLE C-5.3.2, Contd

Radionuclide	High Activity Waste (HAW) %	1000 Ci HAW Release After Filt. (mCi/event)	1000 Ci HAW Release After RO (mCi/event)	1000 Ci HAW Release After Zeo (mCi/event)	1000 Ci HAW /1E6 gallons Df to Release
Beta Gamma					
Cr-51	0				35 mCi
Co-58	0				
Co-60	0				
Zn-65	0				
Sr-89	0	0	0	0	
Sr-90	6.6	60000	3158	3	1886
Y-90	0	0	0	0	
Y-91	0	0	0	0	
Zr-95	5.4	2700	54	27	1543
No-95	1.9	950	19	10	543
Ru-103	0.3	300	6	6	86
Ru-106	6.5	6500	130	130	1857
Rh-106	0	0	0	0	
Sb-124	0	0	0	0	
I-131	0	0	0	0	
Cs-134	3.8	34545	1818	2	1086
Cs-137	6.7	60909	3206	3	1914
Ce-141	0.4	200	4	0.4	114
Ce-144	68.2	34100	682	68	19486
Pr-144	0	0	0	0	
Pm-147	0	0	0	0	
Other beta-gamma	0.2	2000	105	105	
Total beta-gamma	100	202205	9182	355	28571
Non Cs/Sr Beta-Gamma	83	46750	1000	346	23629

TABLE C-5.4.1

Tubular Precoat Filtration (50 ppm Body Feed) and Selective Ion Exchange

Radionuclide	Release Std F (Ci/yr)	Release Std H (Ci/yr)	Pretreatment Filtration (DF)	Released by Pretreatment (mCi/yr)	Selective IXG Polish (DF)	After Select IXG Polish (mCi/yr)	Current Guidelines (mCi/yr)
Cr-51	0.0	5.0	1	5000	100	50	
Co-58	0.0	1.0	1	1000	10	100	
Co-60	0.0	1.0	1	1000	10	100	
Zn-65	0.0	0.8	1	800	100	8	
Sr-89	0.2	0.4	1.1	545	1000	1	35/2
Sr-90	0.4	1.0	1.1	1273	1000	1	35/2
Y-90	-	-	2		100	0	
Y-91	-	-	2		100	0	
Zr-95	4.0	1.0	20	250	2	125	
Nb-95	4.0	1.5	20	275	2	138	
Ru-103	2.0	1.5	10	350	1	350	
Ru-106	20.0	7.5	10	2750	1	2750	
Rh-106	-	-	10		1	0	
Sb-124	0.0	0.2	1	200	1	200	
I-131	0.8	0.4	1	1200	1	1200	
Cs-134	0.3	1.5	1.1	1636	1000	2	
Cs-137	4.0	9.0	1.1	11818	1000	12	75/2
Ce-141	0.1	0.4	20	25	10	2	
Ce-144	1.0	2.6	20	180	10	18	
Pr-144	-	-	20	0	10	0	
Pm-147	0.5	1.0	1	1500	1	1500	
Other beta-gamma	0.5	0.8	1	1300	1	1300	
Total beta-gamma	37.8	36.6	2.4	31103	4.0	7856	
Non Cs/Sr Beta-gamma	32.9	24.7	3.6	15830	2.0	7841	175

TABLE C-5.4.1, Contd

Radionuclide	Release Std F (Ci/yr)	Release Std H (Ci/yr)	Pretreatment Filtration (DF)	Released by Filtration (mCi/yr)	Selective IXG Polish (DF)	After Select IXG Polish (mCi/yr)	Current Guidelines (mCi/yr)
Alpha							
Am-241	0.020	0.002	20	1.10E+0	10	1.10E-1	
Cm-242/244	0.010	0.001	20	5.50E-1	10	5.50E-2	
U-235/238	0.200	0.005	20	1.02E+1	10	1.02E+0	
Pu-238	0.020	0.009	20	1.45E+0	10	1.45E-1	
Pu-239	0.020	0.006	20	1.30E+0	10	1.30E-1	
Pi-240	-	-	20	0.0	10	0.0	
Sum alpha (OBS)	0.270	0.023	20	1.47E+1	10	1.46E+0	10.00
Total alpha (guide)	0.5	0.2	20	3.50E+1	10	3.50E+0	10.00
Sum alpha/ Total β-γ	0.007	0.001					

TABLE C-5.4.1, Contd

Radionuclide	First Cycle Feed (1AF)* %	1000 Ci 1AF Release After Filt. (mCi/event)	1000 Ci 1AF Release Selective IXG Polish (DF)
Beta-Gamma			
Cr-51	-		
Co-58	-		
Co-60	-		
Zn-65	-		
Sr-89	5.3	48182	48
Sr-90	0.38	3455	3
Y-90	0.38	1900	38
Y-91	8.75	43750	438
Zr-95	11.56	5780	2890
Nb-95	22.19	11095	5548
Ru-103	1.78	1780	1780
Ru-106	1.38	1380	1380
Rh-106	1.38	1380	1380
Sb-124	-		0
I-131	-		0
Cs-134	0.84	7636	8
Cs-137	1.13	10273	10
Ce-141	1.69	845	84
Ce-144	19.69	9845	984
Pr-144	19.69	9845	984
Pm-147	2.16	21600	21600
Other beta-gamma	1.72	17200	17200
Total beta-gamma	100	227380	54357
Non Cs/Sr Beta-Gamma	92	157835	54288

TABLE C-5.4.1, Contd

Radionuclide	High Activity Waste (HAW) %	1000 Ci HAW Release After Filt. (mCi/event)	1000 Ci HAW Release After Select IXG Polish DF (mCi/event)
Beta Gamma			
Cr-51	0		
Co-58	0		
Co-60	0		
Zn-65	0		
Sr-89	0	0	0
Sr-90	6.6	60000	60
Y-90	0	0	0
Y-91	0	0	0
Zr-95	5.4	2700	1350
Nb-95	1.9	950	475
Ru-103	0.3	300	300
Ru-106	6.5	6500	6500
Rh-106	0	0	0
Sb-124	0	0	0
I-131	0	0	0
Cs-134	3.8	34545	35
Cs-137	6.7	60909	61
Ce-141	0.4	200	20
Ce-144	68.2	34100	3410
Pr-144	0	0	0
Pm-147	0	0	0
Other beta-gamma	0.2	2000	2000
Total beta-gamma	100	202205	14210
Non Cs/Sr Beta-Gamma	83	46750	14055

TABLE C-5.4.1, Contd

Radionuclide	High Activity Waste (HAW) Character Alpha Curie Distribution	1000 Ci HAW Release After Filt. (mCi/event)	1000 Ci HAW After Select IXG Polish (mCi/event)
Alpha			
Am-241	0	0	0.0
Cm-242/244	0	0	0.0
U-235/238	0	0	0.0
Pu-238	99.1	150.14	1.50E+1
Pu-239	0.43	0.65	6.51E-2
Pu-240	0.43	0.65	6.51E-2
Sum alpha	3.03 Ci	151	1.51E+1
Sum alpha/ Total β-γ	0.00303		

TABLE C-5.4.2

Tubular Precoat Filtration (5000 ppm body feed) and Selective Ion Exchange

Radionuclide	Release Std F (Ci/yr)	Release Std H (Ci/yr)	Pretreatment Filtration (DF)	Released by Pretreatment (mCi/yr)	Selective IXG Polish (DF)	After Select IXG Polish (mCi/yr)	Current Guidelines (mCi/yr)
Cr-51	0.0	5.0	1	5000	100	50	
Co-58	0.0	1.0	1	1000	10	100	
Co-60	0.0	1.0	1	1000	10	100	
Zn-65	0.0	0.8	1	800	100	8	
Sr-89	0.2	0.4	17	35	100	0	35/2
Sr-90	0.4	1.0	17	82	100	1	35/2
Y-90	-	-	10	-	100	0	
Y-91	-	-	10	-	100	0	
Zr-95	4.0	1.0	88	57	2	28	
Nb-95	4.0	1.5	88	62	2	31	
Ru-103	2.0	1.5	50	70	1	70	
Ru-106	20.0	7.5	50	550	1	550	
Rh-106	-	-	50	-	1	0	
Sb-124	0.0	0.2	1	200	1	200	
I-131	0.8	0.4	1	1200	1	1200	
Cs-134	0.3	1.5	17	106	100	1	75/2
Cs-137	4.0	9.0	17	765	100	8	75/2
Ce-141	0.1	0.4	2000	0	10	0	
Ce-144	1.0	2.6	2000	2	10	0	
Pr-144	-	-	2000	0	10	0	
Pm-147	0.5	1.0	5	300	1	300	
Other beta-gamma	0.5	0.8	1	1300	1	1300	
Total beta-gamma	37.8	36.6	5.9	12530	3.2	3948	
Non Cs/Sr beta-gamma	32.9	24.7	5.0	11541	2.9	3938	174

TABLE C-5.4.2, Contd

Radionuclide Alpha	Release Std F (Ci/yr)	Release Std H (Ci/yr)	Pretreatment Filtration (DF)	Released by Pretreatment (mCi/yr)	Selective IXG Polish (DF)	After Select IXG Polish (mCi/yr)	Current Guidelines (mCi/yr)
Am-241	0.020	0.002	20	1.10E+0	10	1.10E-1	
Cm-242/244	0.010	0.001	20	5.50E-1	10	5.50E-2	
U-235/238	0.200	0.005	20	1.02E+1	10	1.02E+0	
Pu-238	0.020	0.009	20	1.45E+0	10	1.45E-1	
Pu-239	0.020	0.006	20	1.30E+0	10	1.30E-1	
Pu-240	-	-	20	0.0	10	0.0	
Sum alpha (DBS)	0.270	0.023	20	1.47E+1	10	1.46E+0	
Total alpha (guide)	0.5	0.2	20	3.50E+1	10	3.50E+0	10
Sum alpha/tot β-γ	0.007	0.001					

TABLE C-5.4.2, Contd

Radionuclide	First Cycle Feed (1AF)* (%)	1000 Ci 1AF Release After Filtration (mCi/event)	1000 Ci 1AF Release After Select IXG Polish (mCi/event)
Beta-Gamma			
Cr-51	-		
Co-58	-		
Co-60	-		
Zn-65	-		
Sr-89	5.3	3118	31
Sr-90	0.38	224	2
Y-90	0.38	380	4
Y-91	8.75	8750	88
Zr-95	11.56	1314	657
Nb-95	22.19	2522	1261
Ru-103	1.78	356	356
Ru-106	1.38	276	276
Rh-106	1.38	13800	13800
Sb-124	-		0
I-131	-		0
Cs-134	0.84	494	5
Cs-137	1.13	665	7
Ce-141	1.69	8	1
Ce-144	19.69	98	10
Pr-144	19.69	98	10
Pm-147	2.16	4320	4320
Other beta-gamma	1.72	17200	17200
Total beta-gamma	100	53623	38026
Non Cs/Sr β-γ	92	49123	37981

TABLE C-5.4.2, Contd

Radionuclide	High Activity Waste (HAW) Feed (1AF)* (%)	1000 Ci HAW Release After Filtration (mCi/event)	1000 Ci HAW Release After Select IXG Polish DF (mCi/event)
Beta-Gamma			
Cr-51	0		
Co-58	0		
Co-60	0		
Zn-65	0		
Sr-89	0	0	0
Sr-90	6.6	3882	39
Y-90	0	0	0
Y-91	0	0	0
Zr-95	5.4	614	307
Nb-95	1.9	216	108
Ru-103	0.3	60	60
Ru-106	6.5	1300	1300
Rh-106	0	0	0
Sb-124	0	0	0
I-131	0	0	0
Cs-134	3.8	2235	22
Cs-137	6.7	3941	39
Ce-141	0.4	2	0
Ce-144	68.2	341	34
Pr-144	0	0	0
Pm-147	0	0	0
Other beta-gamma	0.2	2000	2000
Total beta-gamma	100	14591	3910
Non Cs/Sr β-γ	83	4533	3809

TABLE C-5.4.2, Contd

Radionuclide	High Activity Waste (HAW) Character Alpha Curie Distribution, %	1000 Ci HAW Release After Filtration (mCi/event)	1000 Ci HAW Release After Select IXG Polish (mCi/event)
Beta-Gamma			
Am-241	0	0	0.0
Cm-242/244	0	0	0.0
U-235/238	0	0	0.0
Pu-238	99.1	150.14	1.50E+1
Pu-239	0.43	0.65	6.51E-2
Pu-240	0.43	0.65	6.51E-2
Total alpha	3.03	151	1.51E+1
Total alpha/total β-γ	0.00303		

TABLE C-5.5.1

Multiple Deep Bed Filtration, Reverse Osmosis, Mixed Bed Ion Exchange

Radionuclide	Release Std F (Ci/yr)	Release Std H (Ci/yr)	Pretreatment Filtration (DF)	Released by Filtrate (mCi/yr)	Reverse Osmosis (DF)	Released by RD (mCi/yr)	Polishing Mixed Bed (DF)	Released by Mixed Bed (mCi/yr)	Current Guidelines (mCi/yr)
Cr-51	0.0	5.0	1	5000	19	2.63E+2	1000	0.3	
Co-58	0.0	1.0	1	1000	19	5.26E+1	100	0.5	
Co-60	0.0	1.0	1	1000	19	5.26E+1	100	0.5	
Zn-65	0.0	0.8	1	800	17	4.71E+1	1000	0.0	
Sr-89	0.2	0.4	1.1	545	19	2.87E+1	1000	0.0	35/2
Sr-90	0.4	1.0	1.1	1273	19	6.70E+1	1000	0.1	35/2
Y-90	-	-	1		19		1000		
Y-91	-	-	1		19		1000		
Zr-95	4.0	1.0	10	500	50	1.00E+1	100	0.1	
Nb-95	4.0	1.5	10	550	50	1.10E+1	100	0.1	
Ru-103	2.0	1.5	2	1750	50	3.50E+1	100	0.3	
Ru-106	20.0	7.5	2	13750	50	2.75E+2	100	2.8	
Rh-106	-	-	2		50		100		
Sb-124	0.0	0.2	1	200	19	1.05E+1	100	0.1	
I-131	0.8	0.4	1	1200	19	6.32E+1	1000	0.1	
Cs-134	0.3	1.5	1.1	1636	19	8.61E+1	1000	0.1	75/2
Cs-137	4.0	9.0	1.1	11818	19	6.22E+2	1000	0.6	75/2
Ce-141	0.1	0.4	10	50	50	1.00E+0	100	0.0	
Ce-144	1.0	2.6	10	360	50	7.20E+0	100	0.1	
Pr-144	-	-	10		50	0.0	100		
Pm-147	0.5	1.0	1	1500	19	7.89E+1	100	0.8	
Other beta-gamma	0.5	0.8	1	1300	19	6.84E+1	100	0.7	
Total beta-gamma	37.8	36.6	1.7	44233	24.9	1.78E+3	247	7.2	
Non Cs/Sr beta-gamma	32.9	24.7	2.0	28960	29.7	9.76E+2	153	6.4	175

TABLE C-5.5.1, Contd

Radionuclide	Release Std F (Ci/yr)	Release Std H (Ci/yr)	Pretreatment Filtration (DF)	Released by Filtrate (mCi/yr)	Reverse Osmosis (DF)	Released by RD (mCi/yr)	Polishing Mixed Bed (DF)	Released by Mixed Bed (mCi/yr)	Current Guidelines (mCi/yr)
Alpha									
Am-241	0.020	0.002	10	2	99	2.22E-2	100	2.22E-4	
Cm-242/244	0.010	0.001	10	1	99	1.11E-2	100	1.11E-4	
U-235/238	0.200	0.005	10	20	99	2.07E-1	100	2.07E-3	
Pu-238	0.020	0.009	10	3	99	2.93E-2	100	2.93E-4	
Pu-239	0.020	0.006	10	3	99	2.63E-2	100	2.63E-4	
Pu-240	-	-	10	-	99	0.0	100	0.0	
Sum alpha (DBS)	0.270	0.023	10	29.3	99	2.96E-1		2.96E-3	10.00
Total alpha (guide)	0.5	0.2	10	70	99	7.07E-1			
Sum alpha/tot β-γ	0.001	0.001							

TABLE C-5.5.1, Contd

Radionuclide	First Cycle Feed (1AF)* (%)	1000 Ci 1AF Release After Filtration (mCi/event)	1000 Ci 1AF Release After RD (mCi/event)	1000 Ci 1AF Release After IXG (mCi/event)
Beta-Gamma				
Cr-51	-			
Co-58	-			
Co-60	-			
Zn-65	-			
Sr-89	5.3		2536	3
Sr-90	0.38		182	0
Y-90	0.38		200	0
Y-91	8.75		4605	5
Zr-95	11.56		231	2
Nb-95	22.19		444	4
Ru-103	1.78		178	2
Ru-106	1.38		138	1
Rh-106	1.38		138	1
Sb-124	-		0	0
I-131	-		0	0
Cs-134	0.84		402	0
Cs-137	1.13		541	1
Ce-141	1.69		34	0
Ce-144	19.69		394	4
Pr-144	19.69		394	4
Pm-147	2.16		1137	11
Other beta-gamma	1.72		905	9
Total beta-gamma	100		12458	48
Non Cs/Sr β-γ	92		8798	45

TABLE C-5.5.1, Contd

Radionuclide Beta-Gamma	High Activity Waste (HAW) %	1000 Ci HAW Release After Filtration (mCi/event)	1000 Ci HAW Release After RD (mCi/event)	1000 Ci HAW Release After MB IXG (mCi/event)
Cr-51	0			
Co-58	0			
Co-60	0			
Zn-65	0			
Sr-89	0	0	0	0
Sr-90	6.6	60000	3158	3
Y-90	0	0	0	0
Y-91	0	0	0	0
Zr-95	5.4	5400	108	1
Nb-95	1.9	1900	38	0
Ru-103	0.3	1500	30	0
Ru-106	6.5	32500	650	6
Rh-106	0	0	0	0
Sb-124	0	0	0	0
I-131	0	0	0	0
Cs-134	3.8	34545	1818	2
Cs-137	6.7	60909	3206	3
Ce-141	0.4	400	8	0
Ce-144	68.2	68200	1364	14
Pr-144	0	0	0	0
Pm-147	0	0	0	0
Other beta-gamma	0.2	2000	105	1
Total beta-gamma	100.0	267355	10485	31
Non Cs/Sr β-γ	83	111900	2303	23

TABLE C-5.5.1, Contd

Radionuclide	High Activity Waste (HAW) Character Alpha Curie Dist. %	1000 Ci HAW Release After Filtration (mCi/event)	1000 Ci HAW Release After RD (mCi/event)	1000 Ci HAW Released by MB IXG (mCi/event)
Alpha				
Am-241	0	0	0	0.0
Cm-242/244	0	0	0	0.0
U-235/238	0	0	0	0.0
Pu-238	99.1	300.27	3.033	3.03E-2
Pu-239	0.43	1.30	0.013	1.32E-4
Pu-240	0.43	1.30	0.013	1.32E-4
Total alpha	3.03	151.4	1.53	0.153
Total alpha/tot β-γ	0.00303			

TABLE C-5.6.1

Tubular Precoat Filtration and Mixed Bed Ion Exchange

Radionuclide	Release Std F (Ci/yr)	Release Std H (Ci/yr)	Pretreatment Filtration (DF)	Released by Pretreatment (mCi/yr)	Polishing Mixed Bed (DF)	After Mixed Bed IXG (mCi/yr)	Current Guidelines (mCi/yr)
Cr-51	0.0	5.0	1	5000	1000	5	
Co-58	0.0	1.0	1	1000	100	10	
Co-60	0.0	1.0	1	1000	100	10	
Zn-65	0.0	0.8	1	800	1000	1	
Sr-89	0.2	0.4	17	35	1000	0	35/2
Sr-90	0.4	1.0	17	82	1000	0	35/2
Y-90	-	-	10	-	1000	0	
Y-91	-	-	10	-	1000	0	
Zr-95	4.0	1.0	88	57	100	1	
Nb-95	4.0	1.5	88	62	100	1	
Ru-103	2.0	1.5	50	70	100	1	
Ru-106	20.0	7.5	50	550	100	6	
Rh-106	-	-	50		100	0	
Sb-124	0.0	0.2	1	200	1000	0	
I-131	0.8	0.4	1	1200	1000	1	
Cs-134	0.3	1.5	17	106	1000	0	75/2
Cs-137	4.0	9.0	17	765	1000	1	75/2
Ce-141	0.1	0.4	2000	0	100	0	
Ce-144	1.0	2.6	2000	2	100	0	
Pr-144	-	-	2000	0	100	0	
Pm-147	0.5	1.0	5	300	100	3	
Other beta-gamma	0.5	0.8	1	1300	100	13	
Total beta-gamma	37.8	36.6	5.9	12530	11200	52	
Non Cs/Sr beta-gamma	32.9	24.7	5.0	11541	7200	51	175

TABLE C-5.6.1, Contd

Radionuclide	Release Std F (Ci/yr)	Release Std H (Ci/yr)	Pretreatment Filtration (DF)	Released by Filtration (mCi/yr)	Polishing Mixed Bed (DF)	Released by Mixed Bed (mCi/yr)	Current Standards (mCi/yr)
Alpha							
Am-241	0.020	0.002	20	1.1E+0	100	1.10E-1	
Cm-242/244	0.010	0.001	20	5.5E-1	100	5.50E-2	
U-235/238	0.200	0.005	20	1.0E+1	100	1.02E+0	
Pu-238	0.020	0.009	20	1.4E+0	100	1.45E-1	
Pu-239	0.020	0.006	20	1.3E+0	100	1.30E-1	
Pu-240	-	-	20	0.0	100	0.0	
Sum alpha (DBS)	0.270	0.023	20	1.5E+1	100	1.46E+0	
Total alpha (guide)	0.5	0.2	20	3.5E+1	100	3.50E+0	10
Sum alpha/tot β-γ	0.007	0.001					

TABLE C-5.6.1, Contd

Radionuclide	First Cycle Feed (1AF)* (%)	1000 Ci 1AF Release After Filtration (mCi/event)	1000 Ci 1AF Release After Mixed Bed IXG (mCi/event)
Beta-Gamma			
Cr-51	-		
Co-58	-		
Co-60	-		
Zn-65	-		
Sr-89	5.3	3118	3
Sr-90	0.38	224	0
Y-90	0.38	380	0
Y-91	8.75	8750	9
Zr-95	11.56	1314	13
Nb-95	22.19	2522	25
Ru-103	1.78	356	4
Ru-106	1.38	276	3
Rh-106	1.38	276	3
Sb-124	-		0
I-131	-		0
Cs-134	0.84	494	0
Cs-137	1.13	665	1
Ce-141	1.69	8	0
Ce-144	19.69	98	1
Pr-144	19.69	98	1
Pm-147	2.16	4320	43
Other beta-gamma	1.72	17200	172
Total beta-gamma	100	40099	278
Non Cs/Sr β-γ	92	35599	274

TABLE C-5.6.1, Contd

Radionuclide Beta-Gamma	High Activity Waste (HAW) (%)	1000 Ci HAW Release After Filtration (mCi/event)	1000 Ci HAW Release After Mixed Bed IXG (mCi/event)
Cr-51	0		
Co-58	0		
Co-60	0		
Zn-65	0		
Sr-89	0	0	0.0
Sr-90	6.6	3882	3.88E+0
Y-90	0	0	0.0
Y-91	0	0	0.0
Zr-95	5.4	614	6.14E+0
Nb-95	1.9	216	2.16E+0
Ru-103	0.3	60	6.00E-1
Ru-106	6.5	1300	1.30E+1
Rh-106	0	0	0.0
Sb-124	0	0	0.0
I-131	0	0	0.0
Cs-134	3.8	2235	2.24E+0
Cs-137	6.7	3941	3.94E+0
Ce-141	0.4	2	2.00E-2
Ce-144	68.2	341	3.41E+0
Pr-144	0	0	0.0
Pm-147	0	0	0.0
Other beta-gamma	0.2	2000	2.00E+1
Total beta-gamma	100	14591	5.54E+1
Non Cs/Sr β-γ	83	4533	4.53E+1

TABLE C-5.6.1, Contd

Radionuclide	High Activity Waste (HAW) Character Alpha Curie Distribution, %	1000 Ci HAW Release After Filtration (mCi/event)	1000 Ci HAW Release After IXG (mCi/event)
Beta-Gamma			
Am-241	0	0	0.0
Cm-242/244	0	0	0.0
U-235/238	0	0	0.0
Pu-238	99.1	150.14	1.50E+0
Pu-239	0.43	0.65	6.51E-3
Pu-240	0.43	0.65	6.51E-3
Total alpha	3.03	151	1.51E+0
Total alpha/total β-γ	0.00303		

TABLE C-5.6.2

Tubular Precoat Filtration, Cation Exchange and Anion Exchange

Radionuclide	Release Std F (Ci/yr)	Release Std H (Ci/yr)	Pretreatment Filtration (DF)	Released by Pretreatment (mCi/yr)	Polishing Dual Bed (DF)	After Dual Bed IXG (mCi/yr)	Current Guidelines (mCi/yr)
Cr-51	0.0	5.0	1	5000	100	50	
Co-58	0.0	1.0	1	1000	10	100	
Co-60	0.0	1.0	1	1000	10	100	
Zn-65	0.0	0.8	1	800	100	8	
Sr-89	0.2	0.4	17	35	100	0	35/2
Sr-90	0.4	1.0	17	82	100	1	35/2
Y-90	-	-	10		100	0	
Y-91	-	-	10		100	0	
Zr-95	4.0	1.0	88	57	10	6	
Nb-95	4.0	1.5	88	62	10	6	
Ru-103	2.0	1.5	50	70	10	7	
Ru-106	20.0	7.5	50	550	10	55	
Rh-106	-	-	50		10	0	
Sb-124	0.0	0.2	1	200	100	2	
I-131	0.8	0.4	1	1200	100	12	
Cs-134	0.3	1.5	17	106	100	1	75/2
Cs-137	4.0	9.0	17	765	100	8	75/2
Ce-141	0.1	0.4	2000	0	10	0	
Ce-144	1.0	2.6	2000	2	10	0	
Pr-144	-	-	2000	0	10	0	
Pm-147	0.5	1.0	5	300	10	30	
Other beta-gamma	0.5	0.8	1	1300	10	130	
Total beta-gamma	37.8	36.6	5.9	12530	24.3	516	
Non Cs/Sr Beta-Gamma	32.9	24.7	5.0	11541	22.8	506	175

TABLE C-5.6.2, Contd

Radionuclide	Release Std F (Ci/yr)	Release Std H (Ci/yr)	Pretreatment Filtration (DF)	Released by Filtration (mCi/yr)	Polishing Dual Bed (DF)	Released by Dual Bed (mCi/yr)	Current Guidelines (mCi/yr)
Alpha							
Am-241	0.020	0.002	20	1	10	1.1E-1	
Cm-242/244	0.010	0.001	20	1	10	5.5E-2	
U-235/238	0.200	0.005	20	10	10	1.0E+0	
Pu-238	0.020	0.009	20	1	10	1.4E-1	
Pu-239	0.020	0.006	20	1	10	1.3E-1	
Pu-240	-	-	20	0	10	0.0	
Sum alpha (OBS)	0.270	0.023	20	15	10	1.5E+0	10.00
Total alpha (guide)	0.5	0.2	20	35	10	3.5E+0	
Sum alpha/ Total β-γ	0.007	0.001					

TABLE C-5.6.2, Contd

Radionuclide	First Cycle Feed (1AF)* %	1000 Ci 1AF Release After filt (mCi/event)	1000 Ci 1AF Release After Mixed Bed IXG (mCi/event)
Beta-Gamma			
Cr-51	-		
Co-58	-		
Co-60	-		
Zn-65	-		
Sr-89	5.3	3118	31
Sr-90	0.38	224	2
Y-90	0.38	380	4
Y-91	8.75	8750	88
Zr-95	11.56	1314	131
Nb-95	22.19	2522	252
Ru-103	1.78	356	36
Ru-106	1.38	276	28
Rh-106	1.38	276	28
Sb-124	-		0
I-131	-		0
Cs-134	0.84	494	5
Cs-137	1.13	665	7
Ce-141	1.69	8	1
Ce-144	19.69	98	10
Pr-144	19.69	98	10
Pm-147	2.16	4320	432
Other beta-gamma	1.72	17200	1720
Total beta-gamma	100	40099	2783
Non Cs/Sr Beta-Gamma	92	35599	2738

TABLE C-5.6.2, Contd

Radionuclide	High Activity Waste (HAW) %	1000 Ci HAW Release After Filt. (mCi/event)	1000 Ci HAW Release After Dual Bed IXG (mCi/event)
Beta-Gamma			
Cr-51	0		
Co-58	0		
Co-60	0		
Zn-65	0		
Sr-89	0	0	0
Sr-90	6.6	3882	39
Y-90	0	0	0
Y-91	0	0	0
Zr-95	5.4	614	61
Nb-95	1.9	216	22
Ru-103	0.3	60	6
Ru-106	6.5	1300	130
Rh-106	0	0	0
Sb-124	0	0	0
I-131	0	0	0
Cs-134	3.8	2235	22
Cs-137	6.7	3941	39
Ce-141	0.4	2	0
Ce-144	68.2	341	34
Pr-144	0	0	0
Pm-147	0	0	0
Other beta-gamma	0.2	2000	200
Total beta-gamma	100	14591	554
Non Cs/Sr Beta-Gamma	83	4533	453

TABLE C-5.6.2, Contd

Radionuclide	High Activity Waste (HAW) Character Alpha Curie Distribution %	1000 Ci HAW Release After Filt. (mCi/event)	1000 Ci HAW Release After IXG (mCi/event)
Alpha			
Am-241	0	0	0
Cm-242/244	0	0	0
U-235/238	0	0	0
Pu-238	99.1	150.14	15
Pu-239	0.43	0.65	0
Pu-240	0.43	0.65	0
Total alpha	3.03 Ci	151	15
Total alpha/ Total β-γ	0.00303		

APPENDIX D

WMETF FEED ANALYSIS UPDATES

Tables D-1 F-Area Effluents
D-2 H-Area Effluents

TABLE D-1

F-Area Effluents (ppm)

Anions

Sample Date (1984)	F	Cl	PO_4	NO_3	NO_2	SO_4
9-3	31.5	<1		2216		39
8-9	5.6	3.8		2493	31	65
8-17	<10	124		4029	22	<50
9-28	<0.5	<1.0		1824	<5	6
10-19	<0.5	1.3		909	4.8	13
10-26	<5	<10		2631	16	25
11-2	<0.5	8.7		1594	21	13
11-9	<0.5	<1		721		12
Average	6.6	18.6		2052	12.3	27.8
Maximum	31.5	124		4029	31	65
Minimum	<0.5	<1		721	<1	6

Cations

Sample Date (1984)	Al	Ca	Cr	Fe	Mn	Na	Si	P	Pb
8-3	0.6	1.2	0.021	51	0.12	6.7	1.4	5.1	0.68
8-9	0.4	0.5	0.018	8.9	0.02	31	2.0	3.7	0.02
8-17	0.6	1.0	0.023	4.3	0.10	6.0	1.3	4.5	0.28
9-28	0.7	1.0	0.024	2.0	0.01	135	2.4	3.6	0.36
10-19	0.5	0.4	0.026	9.7	0.03	61	1.6	5.0	0.10
10-26	1.0	1.5	0.122	1.1	0.06	11	1.7	3.7	2.2
11-2	0.6	0.6	0.027	1.9	0.02	36	1.8	3.7	0.41
11-9	0.7	0.9	0.014	2.6	0.02	14	2.5	3.2	0.23
Average	0.6	0.9	0.034	10.2	0.05	37.6	1.8	4.1	0.53
Maximum	1.0	1.5	0.122	51	0.12	135	2.5	5.1	2.2
Minimum	0.4	0.4	0.014	1.1	0.01	6.0	1.3	3.2	0.02

TABLE D-2

H-Area Effluents (ppm)

Anions

Sample Date (1984)	F	Cl	PO_4	NO_3	NO_2	SO_4
8-9	1.1	10		2281	32	80
8-17	NA	99		2853	77	NA
9-28	<0.5	2.9		75	<5	8.4
10-19	<1	3.7		229	1.4	9.4
10-26	<0.2	<0.4		75	<2	10
11-2	20	<1		176	<50	<25
11-9	<1	6.4		81	<5	11
Average	3.6	21		824	28	24
Maximum	20	99		2853	77	80
Minimum	<0.2	<0.4		75	1.4	8.4

Cations

Sample Date (1984)	Al	Ca	Cr	Fe	Mg	Na	Si	P	Pb
8-9	2.8	3.3	3.4	0.43	0.29	485	17.1	24.4	0.68
8-17	3.8	1.9	2.5	4.8	0.48	862	37.3	96.3	0.63
9-28	0.31	1.7	<0.01	0.66	0.46	4.8	5.7	1.5	0.12
10-19	0.50	1.1	0.04	0.93	0.30	13	4.8	0.7	0.22
10-26	0.87	2.5	0.08	0.69	0.40	7.9	5.3	1.2	1.94
11-2	0.50	1.3	0.02	1.1	0.28	19	4.5	1.1	0.19
11-9	0.39	2.2	0.02	0.66	0.34	18	4.5	0.9	0.22
Average	1.3	2.0	0.85	1.3	0.36	201	11.3	18	0.54
Maximum	3.8	3.3	3.4	4.8	0.48	862	37.3	96	1.94
Minimum	0.3	1.1	0.01	0.43	0.28	4.8	4.5	0.7	0.12