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BEST AVAILABLE TECHNOLOGY/ ALL KNOWN AND REASONABLE METHODS OF TECHNOLOGY (BAT/AKART) ANALYSIS FOR HANFORD DECONTAMINATION LAUNDRY FACILITY PROJECT B-503

December 13, 1991

Prepared for: United State Department of Energy
and
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Enclosure 1

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EXECUTIVE SUMMARY

Westinghouse Hanford Company is in the process of design, construction, and start-up, of the Decontamination Laundry Facility (DLF). The DLF will be located in the 200 East Area of the Hanford site, and will replace the Protective Equipment Decontamination Facility (PEDF) currently in operation in the 200 West Area. Once the DLF comes on-line, it will clean protective clothing which becomes soiled through use on the Hanford Site. A process wastewater will be produced as a consequence of the laundering of the soiled protective clothing.

Incoming laundry to the DLF will be separated into regulated (soiled and potentially containing measurable radioactivity) and nonregulated (soiled only, with no potential for radioactivity) batches and washed in separate equipment. The DLF will be designed to prevent cross-contamination of laundry by providing separate areas for the regulated and nonregulated laundry processing. The process wastewater generated at the DLF will consist of washwater and rinsewater from both the regulated and nonregulated operations at the facility. The resultant DLF regulated and nonregulated process wastewaters will be collectively combined, and treated by the DLF wastewater treatment system. After treatment, a portion of the process wastewater will be recycled to the regulated washers. The remainder of the treated process wastewater will be discharged to the Treated Effluent Disposal Facility (TEDF).

The Department of Energy Richland Field Office is in the process of obtaining a wastewater discharge permit for the treatment of laundry effluents at the TEDF. Section 304 of the Clean Water Act, 33 U.S.C. Section 1251, et. seq., requires the application of "best available technology economically achievable (BAT)" effluent limits to discharges of wastewater containing toxic and non-toxic conventional pollutants. All wastewaters proposed for discharge in the State of Washington must be provided

with "all known, available, and reasonable methods of treatment (AKART)." These terms describe equivalent levels of treatment required for discharge to waters of the United States and Washington State. This document provides the BAT/AKART evaluation for the DLF that is to be included in the Engineering Report prepared under Washington Administrative Code (WAC) 173-240-130.

The generic treatment systems method described in WHC document WHC-EP-0137, Best Available Technology (economically achievable) Guidance Document for the Hanford Site (WHC 1988b), was used for the identification and documentation of BAT/AKART for the treatment of laundry effluents. In addition, a treatability study was conducted to provide data to support a decision regarding the selection of the appropriate BAT/AKART alternative for the treatment of laundry effluents. The procedure utilized for the identification of BAT/AKART treatment of laundry effluents is consistent with the information and policies contained in the Washington Department of Ecology, Water Quality Program document, Economic Reasonbleness Tests for NPDES and State Wastewater Discharge Permits, November 1991.

The optimum technologies identified during the treatability study are as follows:

- Pretreatment - lint separation, heat recovery, flow equalization;
- Suspended solids removal - membrane microfiltration;
- Dissolved solids removal - lime precipitation, zeolite exchange;
- Total dissolved solids reduction - reverse osmosis; and
- Organic removal - granular activated carbon.

These technologies have been sequentially combined to represent a range of progressive treatment, and four alternatives have been formulated. Each of the four alternatives have been assessed based upon technical merit and cost effectiveness.

Technical merit has been assessed based on the following criterion:

- Treated water quality;
- Reliability;
- Safety;
- Process development status;
- Ease of maintenance;
- Flexibility;
- Permitting;
- Interdependence;
- Secondary wastes; and
- Cost.

The BAT/AKART procedure resulted in the identification of the flowing BAT/AKART technology as the preferred alternative for the treatment of laundry effluents:

- Lint separation;
- Heat recovery;
- Flow equalization;
- Chemical treatment;
- Chemical storage;
- Membrane microfiltration;
- pH adjustment;
- Sludge handling;
- Zeolite ion exchange; and
- Activated carbon.

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1.0 INTRODUCTION

Westinghouse Hanford Company (Westinghouse Hanford) is in the process of design, construction, and start-up of the Decontamination Laundry Facility (DLF). This facility will be located in the 200 East Area of the Hanford Site, and will replace the Protective Equipment Decontamination Facility (PEDF) currently in operation in the 200 West Area. Once the DLF comes on line, it will clean protective clothing which becomes soiled through use on the Hanford Site.

Incoming laundry to the DLF will be separated into regulated (soiled and potentially containing measurable radioactivity) and nonregulated (soiled only, with no potential for radioactivity) batches and washed in separate equipment. The DLF will be designed to prevent cross-contamination of laundry by providing separate areas for the regulated and nonregulated laundry processing. The process wastewater generated at the DLF will consist of washwater and rinsewater from both the regulated and nonregulated operations at the facility. The resultant DLF regulated and nonregulated process wastewaters will be collectively combined, and treated by the DLF wastewater treatment system. After treatment, a portion of the process wastewater will be recycled to the regulated washers. The remainder of the treated process wastewater will be discharged to the Treated Effluent Disposal Facility (TEDF).

The following sections review the overall purpose of this document, the methodologies used in its preparation, and the background of the project. The remaining sections of the document provide the necessary supporting information concerning effluent management alternatives for the DLF.

1.1 BACKGROUND AND PURPOSE

The Department of Energy Richland Field Office is in the process of obtaining a wastewater discharge permit for the treatment of laundry effluents at the TEDF. Section 304 of the Clean Water Act, 33 U.S.C. Section 1251, et. seq., requires the application of "best available technology economically echievable (BAT)" effluent limits to discharges of wastewater containing toxic and non-toxic conventional pollutants. All wastewaters proposed for discharge in the State of Washington must be provided with "all known, available, and reasonable methods of treatment (AKART)." These terms describe equivalent levels of treatment required for discharge to waters of the United States and Washington State. This document provides the BAT/AKART evaluation for the DLF that is to be included in the Engineering Report prepared under Washington Administrative Code (WAC) 173-240-130.

1.2 METHODOLOGY

WHC document WHC-EP-0137, Best Available Technology (economically achievable) Guidance Document for the Hanford Site (WHC 1988b), provides a step-by-step procedure for the identification and documentation of the BAT/AKART for treatment of liquid effluents. The BAT determination procedure presented in the guidance document involves the following five steps.

- Assemble all relevant liquid effluent data;
- Determine BAT/AKART by the effluent guidelines method;

- In the absence of relevant effluent guidelines, determine BAT/AKART by the technology transfer method;

- In the absence of applicable technology transfer determine BAT/AKART by the treatability studies method; and

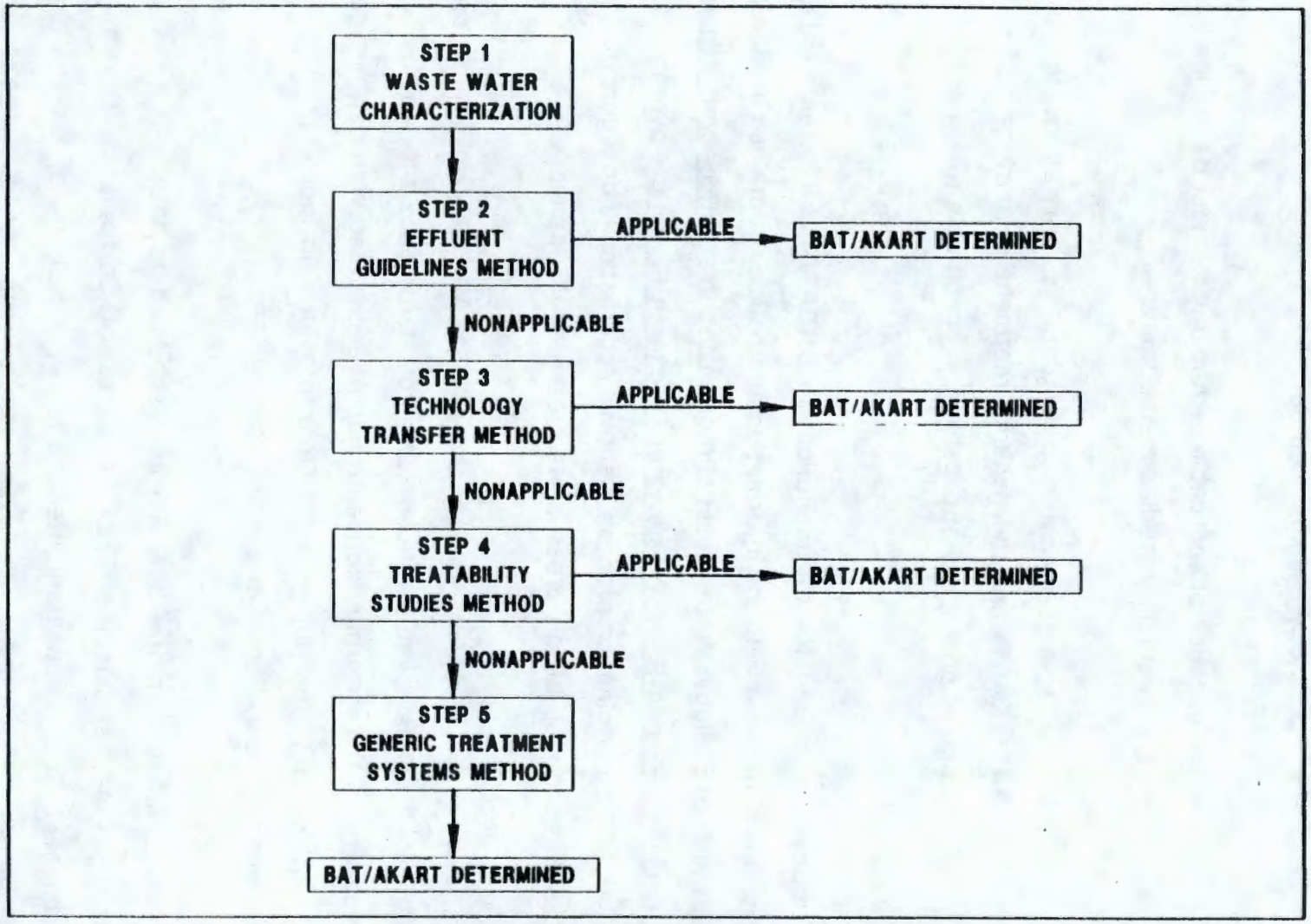
- If the treatability studies method is not adequate to establish BAT/AKART, use the generic treatment system method to identify a range of potentially applicable and acceptable treatment systems.

The procedure utilized for the identification of BAT/AKART treatment of laundry effluents is consistent with the information and policies contained in the Washington Department of Ecology, Water Quality Program document, Economic Reasonableness Tests for NPDES and State Wastewater Discharge Permits, November 1991. The BAT/AKART determination process is shown schematically on Figure 1.1. Additional details on each step of this process are presented in Appendix A.

As shown above, the first step in the BAT/AKART determination process is to assemble all relevant liquid effluent data to characterize the wastewater stream. Comparison of the maximum concentration of each wastewater stream contaminant with applicable or relevant effluent limits provides an indication of the extent of treatment required, if any, for specific contaminants.

Treated effluent from the DLF will be discharged to the TEDF. As part of the permitting process for the TEDF, a series of Comparative Levels have been established. These values are intended to serve as an initial baseline to assess the effectiveness of treatment alternatives in reducing the concentrations of contaminants

FIGURE 1.1


STEP 1
WASTE WATER
CHARACTERIZATION
STEP 2
EFFLUENT
GUIDELINES METHOD
APPLICABLE
BAT/AKART DETERMINED
NONAPPLICABLE
STEP 3
TECHNOLOGY
TRANSFER METHOD
APPLICABLE
BAT/AKART DETERMINED
NONAPPLICABLE
STEP 4
TREATABILITY
STUDIES METHOD
APPLICABLE
BAT/AKART DETERMINED
NONAPPLICABLE
STEP 5
GENERIC TREATMENT
SYSTEMS METHOD
BAT/AKART DETERMINED

of concern. The Comparative Levels for a number of species are provided in Functional Design Criteria for the 200 Area Treated Effluent Disposal System, Project W-049H (WHC 1991a), and a list of these Comparative Levels is provided in Appendix A, Attachment 1. For radionuclide species which do not have Comparative Levels, 4% of the Derived Concentration Guide (DCG) values for ingested water are used in accordance with DOE Order 5400.5 (DOE 1990).

2.0 WASTEWATER DEFINITION

This section describes the function and location of the laundry facility currently generating wastewater, and the laundry facility which will replace the present facility. Characterization data for the anticipated wastewater stream from the future laundry facility, which is based on the laundry wastewater currently generated, is also presented.

2.1 PROCESS AND STREAM DESCRIPTION

This section describes in detail the future laundry facility and the sources of the wastewater streams which will be generated at this future facility.

2.1.1 Facility Description

Presently, protective clothing which becomes soiled through use on the Hanford Site is sent to the PEDF for cleaning and decontamination. This facility, located in the 200 West Area, was constructed in the early 1950's. Since construction, the facility has undergone numerous upgrades and structural additions, resulting in the current facility arrangement.

Westinghouse Hanford plans to replace the aging PEDF with a new, more efficient laundry process facility. The new DLF will safely and economically meet the site's present and future clean laundry needs. This new facility will be located in the 200 East Area and will have a total processing capability of 4,200,000 pounds of laundry per year. Liquid effluents from the DLF will be discharged to the TEDF, which is also known as project W-049H.

2.1.2 Process Description

Soiled protective clothing at the Hanford Site is segregated into two categories based upon its use in radioactive and nonradioactive areas. Clothing worn in an area with possible exposure to radioactive contaminants is referred to as "regulated" laundry. This laundry is assumed to be contaminated. Clothing worn only in areas without radioactive contamination is classified as "nonregulated" laundry. This laundry is assumed to be free of radioactive contamination.

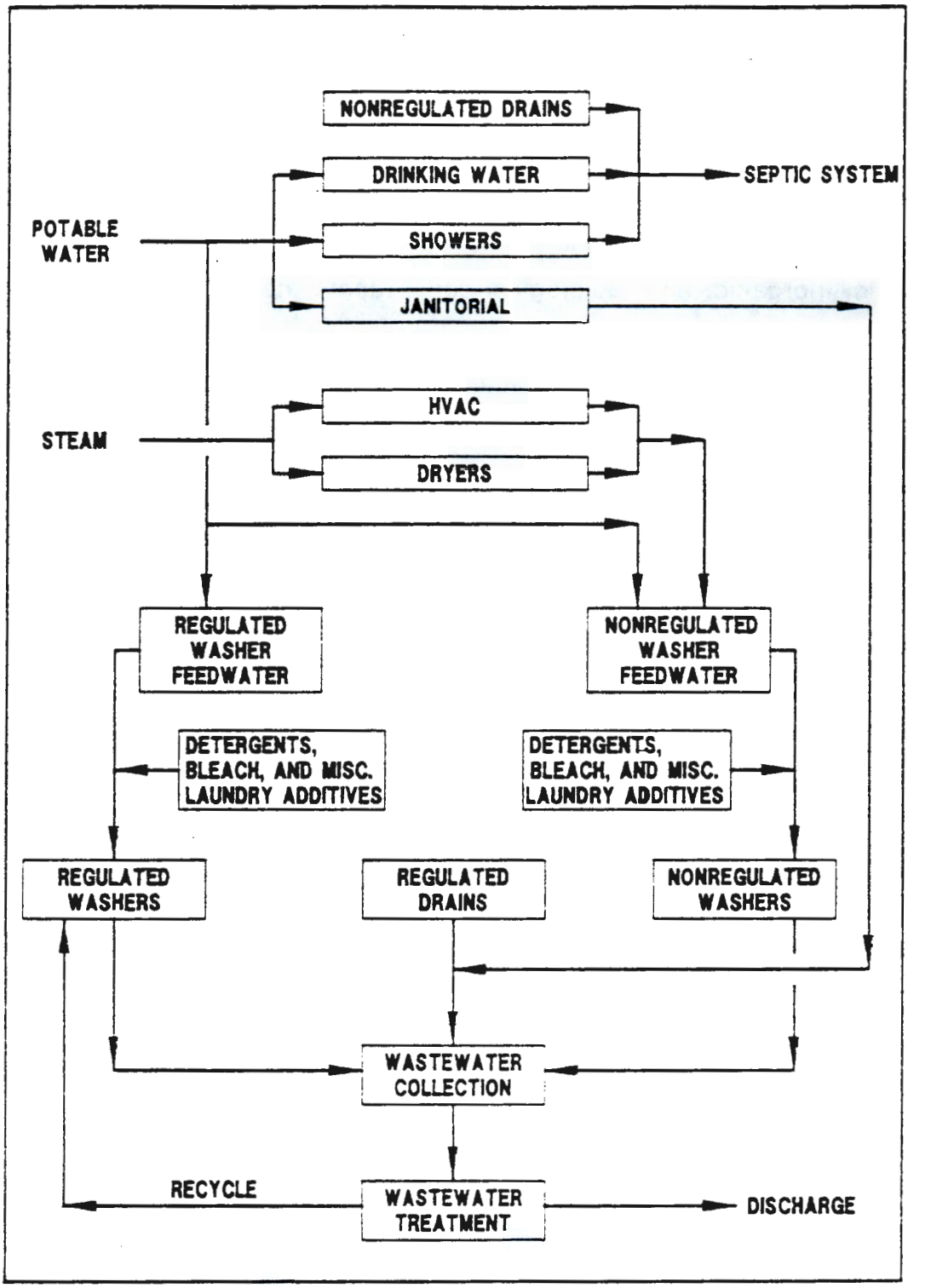
The new DLF will be designed to prevent cross-contamination of laundry by providing separate areas for the regulated and nonregulated laundry processing operations. The facility will also contain an administrative area. The DLF will be a modern, largely mechanized facility, sized and equipped to handle the design volume of soiled clothing on a two eight-hour shifts per day, five days per week basis.

Both the regulated and nonregulated sides of the DLF will produce a liquid effluent. Additional sources of liquid effluent include domestic usage, and process and non-process condensate.

2.1.3 Wastewater Source Description

The waste streams generated at the DLF will include process wastewater from the clothes washing operations, sanitary domestic waste, and air conditioning and steam condensate waters. An overall schematic of liquid waste sources within the DLF is presented in Figure 2.1. As shown, potable water will be supplied to both the regulated and nonregulated washing operations. Detergents, bleaches, and other miscellaneous laundry additives will be added to each washer load as necessary. The resultant DLF regulated and nonregulated process wastewaters will be collectively

FIGURE 2.1


NONREGULATED DRAINS
DRINKING WATER
SEPTIC SYSTEM
POTABLE WATER
SHOWERS
JANITORIAL
HVAC
STEAM
DRYERS
REGULATED WASHER FEEDWATER
NONREGULATED WASHER FEEDWATER
DETERGENTS, BLEACH, AND MISC. LAUNDRY ADDITIVES
DETERGENTS, BLEACH, AND MISC. LAUNDRY ADDITIVES
REGULATED WASHERS
REGULATED DRAINS
NONREGULATED WASHERS
WASTEWATER COLLECTION
RECYCLE
WASTEWATER TREATMENT
DISCHARGE

combined and treated. After treatment, a portion of the process wastewater will be recycled to the regulated washers. The remainder of the treated process wastewater will be discharged to the TEDF. Steam condensate waters, which will not have contacted any of the DLF waste streams, will be used to supplement the water supply to the nonregulated washers.

Contamination of the process wastewater stream is anticipated to include several organic, inorganic, and radiological constituents that can be present on the soiled clothing. Because the DLF, and therefore the wastewater treatment plant, are not yet in operation, it is not possible to collect actual process wastewater characterization data. Therefore, background on the washing processes that generate the wastewater, and the selection of a design basis process wastewater stream quality from available data, must be used to predict influent waste quality.

2.2 WASTEWATER CHARACTERISTICS

The process wastewater generated at the DLF will consist of washwater and rinsewater from the laundry operations at the facility. Wastewater volumes and characteristics will be variable depending on the activities taking place at the Hanford Site, and therefore the laundry. In addition, the concentration of contaminants in the wastewater will be dependent on the degree to which clothing has been soiled and the types of contaminants which the person wearing the clothing come in contact with. Incoming laundry in the DLF will be separated into regulated (containing radioactive components) and nonregulated (soiled only, with no radioactivity measured) batches and washed in separate equipment. Therefore the wastewater generated will not contain consistent contamination levels. In addition, wastewater will be generated in discrete quantities during the wash and rinse steps of the washing cycle yielding wastewater batches that will be different in their contaminant levels.

The volumes of process wastewater that are projected to be generated at the DLF are 51,000 gallons per day from regulated washing and 26,000 gallons per day from nonregulated washing. These volumes are based on the current operation of the PEDF and the projected amount of laundry that is expected to be processed at the DLF.

Data used to predict the characteristics of the expected process wastewater in the DLF are presented in Tables 2.1 through 2.4. Table 2.5 presents the definitions of the Contract Laboratory Program (CLP) data qualifiers shown on Table 2.3 and 2.4, and as shown in tables presented in subsequent sections of this document. The values for expected process wastewater contaminant levels in the DLF, as presented in Table 2.6, were generated from the samples collected at the PEDF, and knowledge and characterization of the PEDF process wastewaters. The rationale in developing the expected DLF wastewater treatment system influent characteristics using the PEDF as a basis is that the DLF will replace the PEDF in function, therefore the process wastewater generated at both facilities will be similar. Most of these samples were collected during the treatability testing at the PEDF, although some historical data were available.

As presented in Table 2.1, the historical data is from the 2724-W Laundry Wastewater Stream-Specific Report (WHC 1990a). The table presents the mean, the upper value of the 90 percent confidence interval, and the maximum of four data points collected for that report.

TABLE 2.1
WASTEWATER CHARACTERIZATION – HISTORICAL DATA
BEST AVAILABLE TECHNOLOGY ANALYSIS
DECONTAMINATION LAUNDRY FACILITY
WESTINGHOUSE HANFORD COMPANY, RICHLAND, WASHINGTON

		Stream Specific Report Data a/		
Analyte	Units	Mean	90 % Confidence Interval	Maximum
Miscellaneous Data				
pH	SU	8.45	9.55	9.55
Temperature	C	45.7	49.0	50.6
Conductivity	µmhos	769	1,040	1,010
Alkalinity	µg/l	257,000	364,000	436,000
Total Dissolved Solids	µg/l	495,000	702,000	751,000
Total Suspended Solids	µg/l	153,000	281,000	385,000
Oil and Grease	µg/l	–	–	–
Inorganic Species				
Aluminum	µg/l	1,760	3,818	5,510
Ammonia	µg/l	18,200	27,200	32,700
Arsenic	µg/l	6.25	8.3	10.0
Arsenic (EP Toxic)	µg/l	<500	<500	<500
Barium	µg/l	544	1,260	1,860
Barium (EP Toxic)	µg/l	<1,000	<1,000	<1,000
Boron	µg/l	126	194	213
Cadmium	µg/l	10.5	21.9	31.0
Cadmium (EP Toxic)	µg/l	<100	<100	<100
Calcium	µg/l	21,300	27,400	31,800
Chloride	µg/l	15,100	28,700	39,700
Chromium	µg/l	32.0	64.3	91.0
Chromium (EP Toxic)	µg/l	<500	<500	500
Copper	µg/l	223	471	678
Cyanide	µg/l	26.5	38.3	44.5
Fluoride	µg/l	715	1,070	1,160
Hydrazine	µg/l	53.2	72.5	75.0
Iron	µg/l	5,060	11,700	17,200
Lead	µg/l	108	226	319
Lead (EP Toxic)	µg/l	<500	<500	<500
Lithium	µg/l	445	1,070	1,590
Magnesium	µg/l	5,980	7,660	7,570
Manganese	µg/l	66.5	134	190
Mercury	µg/l	0.310	0.512	0.650
Mercury (EP Toxic)	µg/l	<40.0	<72.8	<100
Nickel	µg/l	48.5	111	163
Nitrate (as Nitrogen)	µg/l	1,370	2,110	2,600
Phosphate	µg/l	93,100	144,000	183,000
Potassium	µg/l	9,340	15,800	18,200
Selenium (EP Toxic)	µg/l	<500	< 500	<500

TABLE 2.1 (continued)
WASTEWATER CHARACTERIZATION – HISTORICAL DATA
BEST AVAILABLE TECHNOLOGY ANALYSIS
DECONTAMINATION LAUNDRY FACILITY
WESTINGHOUSE HANFORD COMPANY, RICHLAND, WASHINGTON

		Stream Specific Report Data a/		
Analyte	Units	Mean	90 % Confidence Interval	Maximum
Silicon	µg/l	27,200	36,900	39,700
Silver (EP Toxic)	µg/l	<500	< 500	<500
Sodium	µg/l	109,000	145,000	142,000
Strontium	µg/l	111	151	183
Sulfate	µg/l	17,700	21,900	23,000
Sulfide	µg/l	1,400	1,800	1,970
Titanium	µg/l	180	378	542
Vanadium	µg/l	8.00	12.9	17.0
Zinc	µg/l	608	1,230	1,730
Organic Species				
Acetone	µg/l	14.0	19.8	23.0
Benzoic Acid	µg/l	154	278	280
Benzyl Alcohol	µg/l	143	242	322
Bis(2–ethylhexyl)phthalate	µg/l	71.5	96.3	100
Butylbenzyl phthalate	µg/l	39.5	61.1	78.0
Chloroform (trichloromethane)	µg/l	33.2	67.4	95.0
Di–n–octyl–phthalate	µg/l	111	163	186
Phenol	µg/l	12.0	14.9	24.0
Total Organic Carbon	µg/l	48,600	70,100	87,100
Total Carbon	µg/l	110,000	128,000	136,000
Total Organic Halides (TOX)	µg/l	421	863	1,230
Radionuclides				
Gross alpha	pCi/l	209	451	632
Gross beta	pCi/l	1,660	3,240	3,700
Americium–241	pCi/l	44.1	116	120
Curium–244	pCi/l	0.605	2.10	1.09
Cobalt–60	pCi/l	293	545	576
Cesium–137	pCi/l	170	357	502
Hydrogen–3	pCi/l	1,270	3,640	3,780
Manganese–54	pCi/l	40.4	74.5	61.8
Lead–210	pCi/l	1.22	2.03	2.63
Plutonium–238	pCi/l	17.6	33.9	36.1
Plutonium–239/240	pCi/l	204	395	416
Total radium	pCi/l	0.751	1.19	1.41
Radium–228	pCi/l	250	–	250
Ruthenium–106	pCi/l	32.7	59.8	77.9
Strontium–90	pCi/l	1,460	3,220	4,560

TABLE 2.1 (continued)
WASTEWATER CHARACTERIZATION – HISTORICAL DATA
BEST AVAILABLE TECHNOLOGY ANALYSIS
DECONTAMINATION LAUNDRY FACILITY
WESTINGHOUSE HANFORD COMPANY, RICHLAND, WASHINGTON

		Stream Specific Report Data a/		
Analyte	Units	Mean	90 % Confidence Interval	Maximum
Uranium–234	pCi/l	58.4	142	212
Uranium–235	pCi/l	5.96	15.3	23.1
Uranium–238	pCi/l	66.0	163	243
Total Uranium	pCi/l	423	548	<100

Notes
a/ Concentration data taken from WHC–EP–0342 Addendum 11, "2724–W Laundry Wastewater Stream–Specific Report".

TABLE 2.2
WASTEWATER CHARACTERIZATION – TREATABILITY STUDY BATCH SAMPLES a/
BEST AVAILABLE TECHNOLOGY ANALYSIS
DECONTAMINATION LAUNDRY FACILITY
WESTINGHOUSE HANFORD COMPANY, RICHLAND, WASHINGTON

Analyte	Units	n	Mean b/	90 % Confidence Interval	Maximum
Miscellaneous Data					
Alkalinity	µg/l	6	380,000	385,407	388,000
Total Dissolved Solids	µg/l	6	1,263,333	1,330,902	1,370,000
Total Suspended Solids	µg/l	6	181,667	243,060	320,000
Oil and Grease	µg/l	6	239,000	286,233	332,000
Inorganic Species					
Aluminum	µg/l	6	1,325	1,630	1,980
Ammonia	µg/l	6	7,445	10,137	8,900
Arsenic	µg/l	6	40	78	100
Barium	µg/l	6	200	200	200
Boron	µg/l	6	100	100	100
Cadmium	µg/l	6	24	25	26
Calcium	µg/l	6	26,617	27,770	28,000
Chromium	µg/l	6	33	49	70
Copper	µg/l	6	343	370	386
Cyanide	µg/l	6	8,361	11,663	10,000
Fluoride	µg/l	5	126	175	160
Hydrazine	µg/l	6	85	115	100
Iron	µg/l	6	5,327	6,091	6,900
Lead	µg/l	6	301	420	494
Lithium	µg/l	6	8,147	8,520	8,930
Magnesium	µg/l	6	6,812	7,035	7,110
Manganese	µg/l	6	101	107	111
Mercury	µg/l	6	0.30	0	0.39
Nickel	µg/l	6	42	46	53
Nitrate (as Nitrogen)	µg/l	6	133	176	200
Phosphate	µg/l	6	49,488	71,535	84,800
Potassium	µg/l	6	7,768	8,075	8,070
Selenium	µg/l	6	50	50	50
Silicon	µg/l	6	67,800	72,803	76,900
Silver	µg/l	6	10	10	10
Sodium	µg/l	6	32,067	45,202	42,300
Strontium	µg/l	6	100	100	100
Sulfate	µg/l	6	7,067	9,191	12,300
Sulfide	µg/l	6	100	100	100
Titanium	µg/l	6	103	110	120
Vanadium	µg/l	6	50	50	50
Zinc	µg/l	6	1,418	1,473	1,500

TABLE 2.2 (continued)
WASTEWATER CHARACTERIZATION – TREATABILITY STUDY BATCH SAMPLES a/
BEST AVAILABLE TECHNOLOGY ANALYSIS
DECONTAMINATION LAUNDRY FACILITY
WESTINGHOUSE HANFORD COMPANY, RICHLAND, WASHINGTON

Analyte	Units	n	Mean b/	90 % Confidence Interval	Maximum
Organic Species					
Acetone	µg/l	6	116	167	200
Benzoic Acid	µg/l	6	2,667	3,140	3,300
Benzyl Alcohol	µg/l	6	154	233	220
Bis–(2–ethylhexyl)–phthalate	µg/l	6	562	694	830
Butylbenzyl phthalate	µg/l	6	135	192	220
Chloroform	µg/l	6	68	76	77
Di–n–octyl–phthalate	µg/l	6	213	293	340
Phenol	µg/l	6	151	233	220
Total Organic Carbon	µg/l	6	111,967	130,850	146,000
Radionuclides					
Gross Alpha	pCi/l	6	265	291	284
Gross Beta	pCi/l	6	9,865	10,713	11,560
Americium–241	pCi/l	6	43	44	45
Gamma Scan:					
Potassium–40	pCi/l	6	1,473	1,811	2,310
Manganese–54	pCi/l	6	647	1,319	10,000
Cobalt–60	pCi/l	6	9,609	10,287	10,500
Cesium–137	pCi/l	6	2,810	2,990	3,059
Europium–154	pCi/l	6	569	750	981
Europium–155	pCi/l	6	342	477	667
Radium–226	pCi/l	6	295	335	374
Thorium–228	pCi/l	6	183	201	214
Thorium–232	pCi/l	6	945	1,028	548
Strontium–90	pCi/l	6	560	585	595
Total Radium	pCi/l	6	1	1	5
Uranium–234	pCi/l	6	5	5	5
Uranium–235	pCi/l	6	1	1	5
Uranium–238	pCi/l	6	4	4	21
Plutonium–238	pCi/l	6	18	20	161
Plutonium–239,240	pCi/l	6	109	168	153

Notes

a/ This data was generated during treatability testing performed during June and July, 1991 by by Resouce Technologies Group at the Personal Equipment Decontamination Facility to simulate the expected effluent from the DLF. The wastewater collected for batch testing was designed to simulated expected worst–case wastewater quality.

b/ Data reported by the laboratory at the Project Quantitation Limit (PQL) was used as a detect at the PQL for calculating the Mean, Confidence Interval, and Maximum.

TABLE 2.3
WASTEWATER CHARACTERIZATION – TREATABILITY STUDY NONREGULATED SAMPLE
BEST AVAILABLE TECHNOLOGY ANALYSIS
DECONTAMINATION LAUNDRY FACILITY
WESTINGHOUSE HANFORD COMPANY, RICHLAND, WASHINGTON

Analyte	Units	Wastewater Sample a/
Miscellaneous Data		
Total Dissolved Solids	µg/l	300,000
Metals		
Aluminum	µg/l	200 U b/
Ammonia (as N)	µg/l	380
Arsenic	µg/l	10.0 U
Barium	µg/l	200 U
Boron	µg/l	100 U
Cadmium	µg/l	5.0 U
Calcium	µg/l	11,300
Chloride	µg/l	100,000
Chromium	µg/l	10.0 U
Copper	µg/l	35.4
Fluoride	µg/l	100 U
Hydrazine	µg/l	100 U
Iron	µg/l	6,530
Lead	µg/l	150 U
Lithium	µg/l	100 U
Magnesium	µg/l	5,000 U
Manganese	µg/l	37.6
Mercury	µg/l	0.51
Nickel	µg/l	40.0 U
Nitrate (as N)	µg/l	190
Phosphate (as P)	µg/l	215,000
Potassium	µg/l	5,000 U
Selenium	µg/l	5.0 U
Silicon	µg/l	15,200
Silver	µg/l	10.0 U
Sodium	µg/l	7,250
Strontium	µg/l	100 U
Sulfate	µg/l	5,000 U
Titanium	µg/l	100 U
Vanadium	µg/l	50.0 U
Zinc	µg/l	304
Organic Species		
Acetone	µg/l	41 B
Benzoic acid	µg/l	21 J
Benzyl alcohol	µg/l	10 U
bis(2-Ethylhexyl)phthalate	µg/l	120 B

TABLE 2.3 (continued)
WASTEWATER CHARACTERIZATION – TREATABILITY STUDY NONREGULATED SAMPLE
BEST AVAILABLE TECHNOLOGY ANALYSIS
DECONTAMINATION LAUNDRY FACILITY
WESTINGHOUSE HANFORD COMPANY, RICHLAND, WASHINGTON

Analyte	Units	Wastewater Sample a/
Butylbenzylphthalate	µg/l	10 U
Chloroform	µg/l	10
Di–n–Octyl phthalate	µg/l	9 J
Phenol	µg/l	10 U
Total Organic Carbon	µg/l	16,400
Radionuclides		
Gross Alpha	pCi/l	18.6
Gross Beta	pCi/l	3,310
Gamma Scan:		
Potassium–40	pCi/l	
Manganese–54	pCi/l	
Cobalt–58	pCi/l	<110.4
Cobalt–60	pCi/l	<121.0
Cesium–134	pCi/l	<68.62
Cesium–137	pCi/l	2,835
Europium–154	pCi/l	<227.9
Strontium–90	pCi/l	150.91
Total Radium	pCi/l	<0.135
Uranium–234	pCi/l	0.3813
Uranium–235	pCi/l	0.02544
Uranium–238	pCi/l	0.2942
Plutonium–238	pCi/l	2.988
Plutonium–239,240	pCi/l	25.16
Americium–241	pCi/l	3.159

Notes

a/ This sample was collected from wastewater generated during washing of a load of nonregulated (containing no radioactivity) laundry at the PEDF. The sample was collected 50% by volume from the wash cycle and 50% by volume from the rinse cycle during treatability testing conducted by RTG personnel in June and July, 1991.

b/ U, B, and J are data qualifiers as defined by the EPA Contract Laboratory Program Statement of Work. Refer to Table 2.5 for an explanation of the data qualifiers.

TABLE 2.4
WASTEWATER CHARACTERIZATION – TREATABILITY STUDY REGULATED SAMPLE
BEST AVAILABLE TECHNOLOGY ANALYSIS
DECONTAMINATION LAUNDRY FACILITY
WESTINGHOUSE HANFORD COMPANY, RICHLAND, WASHINGTON

Analyte	Units	Wastewater Sample a/
Miscellaneous Data		
Total Dissolved Solids	µg/l	510,000
Metals		
Aluminum	µg/l	200 U b/
Ammonia (as N)	µg/l	33,100
Arsenic	µg/l	100 U
Barium	µg/l	200 U
Boron	µg/l	100 U
Cadmium	µg/l	5.0 U
Calcium	µg/l	26,100
Chloride	µg/l	44,000
Chromium	µg/l	10.0 U
Copper	µg/l	25.0 U
Fluoride	µg/l	110
Hydrazine	µg/l	100 U
Iron	µg/l	2,240
Lead	µg/l	1760
Lithium	µg/l	100 U
Magnesium	µg/l	6,520
Manganese	µg/l	57.2
Mercury	µg/l	0.20 U
Nickel	µg/l	40.0 U
Nitrate (as N)	µg/l	220
Phosphate (as P)	µg/l	213,000
Potassium	µg/l	6,520
Selenium	µg/l	5.0 U
Silicon	µg/l	57,300
Silver	µg/l	10.0 U
Sodium	µg/l	30,700
Strontium	µg/l	100 U
Sulfate	µg/l	5000 U
Titanium	µg/l	100 U
Vanadium	µg/l	50.0 U
Zinc	µg/l	678
Organic Species		
Acetone	µg/l	320 B
Benzoic acid	µg/l	450
Benzyl alcohol	µg/l	43 J
bis(2–Ethylhexyl)phthalate	µg/l	540 B

TABLE 2.4 (continued)
WASTEWATER CHARACTERIZATION – TREATABILITY STUDY REGULATED SAMPLE
BEST AVAILABLE TECHNOLOGY ANALYSIS
DECONTAMINATION LAUNDRY FACILITY
WESTINGHOUSE HANFORD COMPANY, RICHLAND, WASHINGTON

Analyte	Units	Wastewater Sample a/
Butylbenzylphthalate	µg/l	50 U
Chloroform	µg/l	10
Di–n–Octyl phthalate	µg/l	49 J
Phenol	µg/l	510
Total Organic Carbon	µg/l	74,300
Radionuclides		
Gross Alpha	pCi/l	158.0
Gross Beta	pCi/l	74,840
Gamma Scan:		
Potassium–40	pCi/l	1,905
Manganese–54	pCi/l	
Cobalt–58	pCi/l	307.3
Cobalt–60	pCi/l	<197.2
Cesium–134	pCi/l	<114.8
Cesium–137	pCi/l	78,540
Europium–154	pCi/l	<401.4
Strontium–90	pCi/l	2,207.5
Total Radium	pCi/l	0.349
Uranium–234	pCi/l	3.778
Uranium–235	pCi/l	0.2947
Uranium–238	pCi/l	2.331
Plutonium–238	pCi/l	10.43
Plutonium–239,240	pCi/l	111.1
Americium–241	pCi/l	25.37

Notes

a/ This sample was collected from wastewater generated during washing of a load of regulated (containing radioactivity) laundry at the PEDF. The sample was collected 50% by volume from the wash cycle and 50% by volume from the first rinse cycle during treatability testing by RTG personnel in June and July, 1991.

b/ U, B, and J, are data qualifiers as defined by the EPA Contract Laboratory Program Statement of Work. Refer to Table 2.5 for an explanation of the data qualifiers.

TABLE 2.5
ANALYTICAL DATA QUALIFIERS
BEST AVAILABLE TECHNOLOGY ANALYSIS
DECONTAMINATION LAUNDRY FACILITY
WESTINGHOUSE HANFORD COMPANY, RICHLAND, WASHINGTON

Data Qualifier	Explanation
Organics	
U	Compound was analyzed for but not detected. The associated numerical value is the estimated sample quantitation limit.
J	Estimated value. Either indicates a tentatively identified compound or a compound that is less than the specified detection limit but greater than zero.
B	Indicates that the analyte is found in the associated blank.
E	Indicates that the compound was detected beyond the range and was subsequently analyzed at a dilution.
I	Interference.
Inorganics	
B	Indicates that the reported value is less than the CRDL but greater than the IDL.
U	Indicates that the analyte was analyzed for but not detected.
E	The reported value is estimated because of the presence of interference.
M	Duplicate injection precision was not met.
N	Spiked sample recovery was not within control limits

TABLE 2.6
INFLUENT ESTIMATED MEANS
BEST AVAILABLE TECHNOLOGY ANALYSIS
DECONTAMINATION LAUNDRY FACILITY
WESTINGHOUSE HANFORD COMPANY, RICHLAND, WASHINGTON

Analyte	Units	Design Basis Influent a/	Expected Influent b/
Miscellaneous Data			
pH	SU	8.73	NA c/
Temperature	C	46.93	NA
Conductivity	µmhos	829.25	NA
Alkalinity	µg/l	348,700	NA
Total Dissolved Solids	µg/l	885,500	440,000
Total Suspended Solids	µg/l	193,400	NA
Oil and Grease	µg/l	159,333	NA
Inorganic Species			
Aluminum	µg/l	1,595	200 U d/
Ammonia (as N)	µg/l	14,365	22,193
Arsenic	µg/l	32	70 U
Barium	µg/l	424	200 U
Boron	µg/l	116	100 U
Cadmium	µg/l	18	5.0 U
Calcium	µg/l	24,400	21,167
Chloride	µg/l	133,333	62,667
Chromium	µg/l	34	10.0 U
Copper	µg/l	289	28.5
Cyanide	µg/l	6,682	NA
Fluoride	µg/l	357	107
Hydrazine	µg/l	86	100 U
Iron	µg/l	6,093	3,670
Lead	µg/l	363	1,223
Lithium	µg/l	4,334	100 U
Magnesium	µg/l	6,492	6,013
Manganese	µg/l	91	50.7
Mercury	µg/l	0.34	0.30
Nickel	µg/l	53	40.0 U
Nitrate (as N)	µg/l	660	210
Phosphate (as P)	µg/l	102,483	213,667
Potassium	µg/l	8,696	6,013
Selenium	µg/l	39	5.0 U
Silicon	µg/l	50,050	43,267
Silver	µg/l	10	10.0 U
Sodium	µg/l	61,646	22,883
Strontium	µg/l	110	100 U
Sulfate	µg/l	10,708	5,000 U
Sulfide	µg/l	677	NA
Titanium	µg/l	159	100 U
Vanadium	µg/l	37	50.0 U
Zinc	µg/l	1,087	553

TABLE 2.6 (continued)
INFLUENT ESTIMATED MEANS
BEST AVAILABLE TECHNOLOGY ANALYSIS
DECONTAMINATION LAUNDRY FACILITY
WESTINGHOUSE HANFORD COMPANY, RICHLAND, WASHINGTON

Analyte	Units	Design Basis Influent		Expected Influent
Organic Species				
Acetone	µg/l	93		227 B
Benzoic acid	µg/l	1,434		307
Benzyl alcohol	µg/l	144		32
bis(2-Ethylhexyl)phthalate	µg/l	362		400 B
Butylbenzylphthalate	µg/l	89		37
Chloroform	µg/l	52		10
Di-n-Octyl phthalate	µg/l	154		36 J
Phenol	µg/l	124		343
Total Organic Carbon	µg/l	82,950		55,000
Total Carbon	µg/l	116,500		NA
Total Organic Halides (TOX)	µg/l	623		NA
Radionuclides				
Gross Alpha	pCi/l	252		111.5
Gross Beta	pCi/l	12,168		50,997
Americium-241	pCi/l	46		17.97
Curium-244	pCi/l	0.70		ND e/
Gamma Scan:				
Potassium-40	pCi/l	1,343		1,270
Manganese-54	pCi/l	339		ND
Cobalt-58	pCi/l	209	<	241.7
Cobalt-60	pCi/l	4,952	<	171.8
Cesium-134	pCi/l	92	<	99.4
Cesium-137	pCi/l	8,270		53,305
Europium-154	pCi/l	505	<	343.6
Europium-155	pCi/l	342		ND
Radium-226	pCi/l	295		ND
Radium-228	pCi/l	250		ND
Thorium-228	pCi/l	183		ND
Thorium-232	pCi/l	945		ND
Strontium-90	pCi/l	1,222		1,522
Total Radium	pCi/l	0.70	<	0.278
Uranium-234	pCi/l	35		2.646
Uranium-235	pCi/l	3.7		0.2049
Uranium-238	pCi/l	39.1		1.652
Plutonium-238	pCi/l	17.7		7.95
Plutonium-239,240	pCi/l	176		82.5
Lead-210	pCi/l	1.57		ND
Hydrogen-3	pCi/l	1,898		ND
Ruthenium-106	pCi/l	44		ND
Total Uranium	pCi/l	342		ND

Notes

a/ The design basis influent has been calculated as discussed in Section 2.2.
b/ The expected influent has been calculated as discussed in Section 2.2.
c/ NA = not analyzed.
d/ U, B, and J, are data qualifiers as defined by the EPA Contract Laboratory Program Statement of Work. Refer to Table 2.5 for an explanation of the data qualifiers.
e/ ND = not detected.

The constituent list analyzed during process wastewater characterization and treatability studies was based on the contaminants identified in 2724-W Laundry Wastewater Stream - Specific Report (WHC 1990a). Data collected at the PEDF during June and July of 1991 in support of this BAT/AKART report are given in Tables 2.2, 2.3, and 2.4. Table 2.2 presents the mean, the upper value of the 90 percent confidence interval, and maximum for six samples collected to simulate expected worst-case process wastewater effluent. Values reported at the project quantitation limit (PQL) were included in the statistical calculations at the PQL. The six samples were 50 gallon composites of equal parts of regulated and nonregulated wash and first rinsewaters. PEDF laundry personnel set aside particularly contaminated bags of both regulated and nonregulated laundry for several days prior to selection of the laundry washed during wastewater sample collection, and therefore the data presented in Table 2.2 is considered worst-case effluent. Details on sample collection procedures may be found in Treatability Study Work Plan for Hanford Decontamination Laundry Facility Best Available Technology Analysis (WHC 1991b).

Tables 2.3 and 2.4 present data from normal washing procedures for a nonregulated and a regulated batch of laundry. For the normal-case process wastewater effluent, PEDF personnel selected from particularly contaminated bags of laundry present onsite on that sampling day. Bags of laundry were not set aside for days prior to the sampling occasion. Therefore, the laundry used to produce the normal-case effluent was not as contaminated as the laundry used to produce the worst-case effluent, and produced wastewater more typical of the expected DLF effluent. The samples collected consisted of equal volumes of washwater and first rinsewater from each respective batch. The observed differences in the concentrations of ammonia, chloride, silicon, and total organic carbon are believed to be due to the differences in the detergents and miscellaneous laundry additives used for regulated versus nonregulated laundry. In addition, the extremely high cesium-137 concentration in the

regulated sample is believed to be an anomaly. No other cesium-137 concentrations have been observed near the indicated value of 78,540 pCi/l.

All of the raw data summarized in Tables 2.1 through 2.4 have been used to calculate a design basis influent mean value and an expected influent mean value for each contaminant as shown in Table 2.6. The design basis influent has been calculated by determining the mean value using the historical data from Table 2.1, worst-case data from Table 2.2, and normal-case data from Tables 2.3 and 2.4. Values reported at the PQL, which are flagged "U" on Tables 2.3. and 2.4, were included in the statistical calculations at the PQL. The design basis influent as shown in Table 2.6 is a conservative estimate because the worst-case data (Table 2.2) was included when calculating the mean value for each constituent. These conservative values, as presented in Table 2.6, will be used as the design basis influent for the eventual design of the DLF BAT/AKART treatment facility.

It is expected that one-third of the process wastewater generated at the DLF will be produced from the washing of non-regulated laundry and two-thirds of the process wastewater will be produced from the washing of regulated laundry. The mean values for the expected influent have been calculated by applying the one-third and two-thirds ratio to the normal-case data presented in Tables 2.3 and 2.4, respectively. The expected influent values will be used to in conjunction with Comparative Levels (Appendix A, Attachment 1) to compare potential exceedances of the treatment system alternatives (Section 5.0).

2.3 ASSOCIATED DISCHARGES

In addition to process wastewater, associated discharges from the DLF could include domestic wastewater, noncontact cooling water, and evaporation. Each of these discharges are discussed in the following sections.

2.3.1 Domestic Wastewater

The domestic wastewater generated at the DLF will include conventional sources expected at any process plant, and include sinks, showers, toilets, and drinking fountains. This wastewater will be separated from any contaminated process wastewaters and should therefore be characteristic of typical domestic wastewater. The domestic wastewater will be collected in a septic system onsite at the DLF.

2.3.2 Noncontact Cooling Water

The noncontact cooling water generated at the DLF will include air conditioning and steam condensates. The air conditioning condensate will be collected and go to the domestic wastewater system and eventually to the septic system. The steam condensate generated will be reused in the nonregulated washers.

2.3.3 Evaporation

There are no evaporative processes such as cooling towers at the DLF, therefore this section does not apply.

3.0 BEST AVAILABLE TECHNOLOGY PROCEDURE APPLICATION

The process wastewater produced by a given facility such as the DLF is considered to be the primary wastestream. The primary wastestream in the DLF is the process wastewater produced from both the regulated and nonregulated laundries. The following sections review the application of the BAT determination procedure for primary wastestream treatment.

In addition to primary wastestream treatment, most treatment processes will produce a secondary wastestream which must be handled. Generally, this secondary wastestream will have a significantly lower volume than the primary wastestream, but will be much more highly concentrated in terms of hazardous or radioactive species. The BAT/AKART procedure has been specifically developed to evaluate and select management alternatives for liquid effluents. As such, it cannot be directly applied to the management of secondary wastes. Therefore, a standard engineering evaluation using criteria such as technical feasibility, level of development, cost reliability, and other criteria as appropriate, will be used to evaluate and select secondary waste treatment alternatives. The results of this evaluation are provided in Section 4.4.

3.1 Wastewater Designation Relative to Comparative Levels

As discussed in Section 1.2, Comparative Levels have been identified for many of the species present in the process wastewater. These values are presented in Table 3.1 along with the target decontamination factors and the pounds per year of each contaminant that will be present in the process wastewater effluent for discharge to the TEDF in the absence of any treatment. Target decontamination factors that are

TABLE 3.1
WASTEWATER CHARACTERISTICS, COMPARATIVE LEVELS
AND TARGET DECONTAMINATION FACTORS
BEST AVAILABLE TECHNOLOGY ANALYSIS
DECONTAMINATION LAUNDRY FACILITY
WESTINGHOUSE HANFORD COMPANY, RICHLAND, WASHINGTON

Analyte	Units	Expected Influent a/	Comparative Levels	Target Decontamination Factor b/	Total Pounds in Influent per Year
Miscellaneous Data					
pH	SU	8.7 c/	6.5 – 8.5	– d/	–
Temperature	C	47 c/	–	–	–
Conductivity	µmhos	829 c/	–	–	–
Alkalinity	µg/l	348,700 c/	–	–	–
Total Dissolved Solids	µg/l	440,000	500,000	–	76,308
Total Suspended Solids	µg/l	193,400 c/	–	–	33,541
Oil and Grease	µg/l	159,333 c/	–	–	27,633
Inorganic Species					
Aluminum	µg/l	200 U e/	50	4.0	35
Ammonia (as N)	µg/l	22,193	1,300 f/	17.1	3,849
Arsenic	µg/l	70 U	0.05	1,400	12
Barium	µg/l	200 U	1,000	–	35
Boron	µg/l	100 U	–	–	17
Cadmium	µg/l	5.0 U	10	–	[illegible]
Calcium	µg/l	21,167	–	–	3,[illegible]
Chloride	µg/l	62,667	250,000	–	10,868
Chromium	µg/l	10.0 U	50	–	2
Copper	µg/l	28.5	1,000	–	5
Cyanide	µg/l	6,682 c/	5.2	1,285	1,159
Fluoride	µg/l	107	2,000	–	18
Hydrazine	µg/l	100 U	0.03	3,333.3	17
Iron	µg/l	3,670	300	12.2	636
Lead	µg/l	1,223	50	24.5	212
Lithium	µg/l	100 U	–	–	17
Magnesium	µg/l	6,013	–	–	1,043
Manganese	µg/l	50.7	50	1.0	9
Mercury	µg/l	0.30	2	–	0.05
Nickel	µg/l	40.0 U	100	–	7
Nitrate (as N)	µg/l	210	10,000	–	36
Phosphate (as P)	µg/l	213,667	–	–	37,056
Potassium	µg/l	6,013	–	–	1,043
Selenium	µg/l	5.0 U	10	–	1
Silicon	µg/l	43,267	–	–	7,504
Silver	µg/l	10.0 U	50	–	2
Sodium	µg/l	22,883	–	–	3,969
Strontium	µg/l	100 U	–	–	17
Sulfate	µg/l	5,000 U	250,000	–	867
Sulfide	µg/l	677 c/	14,000	–	[illegible]
Titanium	µg/l	100 U	–	–	[illegible]
Vanadium	µg/l	50.0 U	42	1.2	[illegible]
Zinc	µg/l	553	5,000	–	96

TABLE 3.1 (continued)
WASTEWATER CHARACTERISTICS, COMPARATIVE LEVELS
AND TARGET DECONTAMINATIONS FACTORS
BEST AVAILABLE TECHNOLOGY ANALYSIS
DECONTAMINATION LAUNDRY FACILITY
WESTINGHOUSE HANFORD COMPANY, RICHLAND, WASHINGTON

Analyte	Units		Expected Influent a/	Comparative Levels	Target Decontamination Factor b/	Total Pounds in Influent per Year
Organic Species						
Acetone	µg/l		227 B	50	4.5	39
Benzoic acid	µg/l		307	–	–	53
Benzyl alcohol	µg/l		32	20	1.6	6
bis(2-Ethylhexyl)phthalate	µg/l		400 B	6	66.7	69
Butylbenzylphthalate	µg/l		37	17	2.2	6
Chloroform	µg/l		10	6	1.7	2
Di-n-Octyl phthalate	µg/l		36 J	17	2.1	6
Phenol	µg/l		343	39	8.8	60
Total Organic Carbon	µg/l		55,000	–	–	9,539
Total Carbon	µg/l		116,500 c/	–	–	20,204
Total Organic Halides	µg/l		623 c/	–	–	108
Radionuclides						
Gross Alpha	pCi/l		111.5	15	7.4	3.16E-04
Gross Beta	pCi/l		50,997	50	1,019.9	6.27E-05
Americium-241	pCi/l		17.97	1.2 g/	15	9.61E-07
Curium-244	pCi/l		ND h/	2.4 g/	–	0.00E+00
Gamma Scan:						
Potassium-40	pCi/l		1,270	280 g/	4.5	3.10E+01
Manganese-54	pCi/l		ND	2,000 g/	–	0.00E+00
Cobalt-58	pCi/l	<	241.7	2,000 g/	–	1.33E-09
Cobalt-60	pCi/l	<	171.8	100	1.7	2.64E-08
Cesium-134	pCi/l	<	99.4	80 g/	1.2	1.33E-08
Cesium-137	pCi/l		53,305	200	266.5	1.06E-04
Europium-154	pCi/l	<	343.6	800 g/	–	4.10E-07
Europium-155	pCi/l		ND	4,000 g/	–	0.00E+00
Radium-226	pCi/l		ND	3	–	0.00E+00
Radium-228	pCi/l		ND	4 g/	–	0.00E+00
Thorium-228	pCi/l		ND	16 g/	–	0.00E+00
Thorium-232	pCi/l		ND	2 g/	–	0.00E+00
Strontium-90	pCi/l		1,522	8	190.2	1.87E-06
Total Radium	pCi/l	<	0.278	5	–	– i/
Uranium-234	pCi/l		2.646	20 g/	–	2.14E-01
Uranium-235	pCi/l		0.2049	24 g/	–	1.66E-02
Uranium-238	pCi/l		1.652	24 g/	–	8.60E-01
Plutonium-238	pCi/l		7.95	1.6	5.0	7.92E-08
Plutonium-239,240	pCi/l		82.5	1.2	68.7	2.33E-04
Lead-210	pCi/l		ND	2,000 g/	–	0.00E+00
Hydrogen-3	pCi/l		ND	20,000	–	0.00E+00
Ruthenium-106	pCi/l		ND	30	–	0.00E+00
Total Uranium	pCi/l		ND	40	–	– i/

Notes

a/ Compiled as discussed in Section 2.2 from data presented in Tables 2.3 and 2.4, unless otherwise noted.

b/ The target decontamination factor is the influent value divided by the effluent comparative level.

c/ This constituent was not analyzed in the data used to prepare the expected influent, and therefore this value is taken from the design basis influent.

TABLE 3.1 (continued)
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Notes (contiuned)

d/ Dash (–) indicates that the calculation could not be performed due to insufficient data or because the calculation did not apply to the parameter. A dash (–) may also indicate that a Compartive Level does not exist.

e/ U, B, and J are data qualifiers as defined by the EPA Contract Laboratory Program Statement of Work. Refer to Table 2.5 for an explanation of the data qualifiers.

f/ The Comparative Level listed is as un–ionized ammonia.

g/ A Comparative Level is not available for this constituent. The value listed is based on 4% of the Derived Concentration Guide in accordance with DOE Order 5400.5 (DOE 1990).

h/ ND = not detected.

i/ The particular species of this constituent have already been accounted for.

less than one indicate that the compound is present in the process wastewater at less than the Comparative Level and requires no removal for discharge to the TEDF. However, the complete characterization of the process wastewater is included as many contaminants that may not require removal to meet effluent Comparative Levels may affect operation of treatment processes.

As shown in Table 3.1, there are 26 species or parameters present at concentrations which exceed Comparative Levels. These include 9 inorganic species, 7 organic species, and 10 radionuclide species or parameters. Therefore, the BAT/AKART determination process must consider technologies capable of accomplishing the following:

- Removal of suspended solids (including particulate radionuclides);
- Removal of dissolved solids (including metals, cesium, and strontium);
- Reduction of total dissolved solids; and
- Removal of organic compounds.

3.2 Applicable Effluent Guidelines

Federal and state effluent guidelines developed under the National Pollutant Discharge Elimination System (NPDES) Program that are relevant or applicable may establish BAT/AKART. Other standards may also provide useful guidance on acceptable effluent quality, environmental exposure, or control intensity. Preliminary BAT/AKART determinations involving control measures that fall short of those standards should be carefully reviewed. If BAT/AKART is not established using the effluent guidelines method, the BAT/AKART determination proceeds to the technology transfer method.

3.2.1 Industrial Source Categories

Under the Clean Water Act (CWA), effluent limits have been established for 34 industrial source categories. These effluent limits represent the degree of contaminant reduction attainable by the application of best available treatment technologies as identified by the EPA. In establishing the limitations set forth in the CWA, the EPA took into account all information it was able to collect, develop, and solicit with respect to factors (age and size of plant, raw materials, manufacturing processes, products produced, treatment technology available, energy requirements, and cost) which can affect the industry subcategorization and effluent levels established. If an applicable effluent guideline is found, the documentation on treatment technologies which can achieve these limits would be investigated.

The 34 industrial source categories were examined for similarities to the proposed DLF. Two categories, effluent guidelines and standards for soaps and detergents, and effluent guidelines and standards for organic chemicals, seemed to have the greatest potential for establishing a BAT/AKART by the effluent guidelines method. However, these effluent guidelines and standards were found to be inappropriate to the DLF for several reasons.

The effluent guidelines and standards for soaps and detergents were established as discharge limits specific to manufacturers of soaps and detergents. The effluent limitations guidelines are five-day biological oxygen demand (BOD_5), chemical oxygen demand (COD), total suspended solids (TSS), oil and grease, and pH. Although these same parameters may be used as indicators for discharges from a laundry, the contamination in the effluents would be a result of different processes. For example, exceedances occurring at a soap or manufacturing plant could be caused by raw

materials or spilled product. The major source of contaminants in the laundry effluent is the dirt which is being removed from the articles being laundered. These contaminants are likely to be more varied and include radionuclides which would not be included in the effluent guidelines established for a soap and detergent manufacturer. Additionally, the effluent limitations guidelines for manufacturers of soaps and detergents are stated in units of kilograms (kg) per 1,000 kilograms of anhydrous product, and therefore, cannot be applied to laundry effluents.

The effluent guidelines and standard for organic chemicals regulate the manufacture of organic chemicals, plastics, and synthetic fibers. Under these effluent limitations guidelines, BOD_5, TSS, pH, and a list of individual constituents are regulated. As in manufacture of soaps and detergents, the contaminants in the effluent from an organic chemical manufacturer may be the same as in the effluent from a laundry. However, their sources will not be the same. Organic chemical manufacturers would have contaminant levels as a result of spills or raw materials. Effluent guidelines for manufacturers of organic chemicals also do not include radionuclide limitations.

The effluent limits established under the CWA are specific to the 34 industrial source categories and are based on economically achievable levels of contaminants in the discharges. Because laundries, specifically radiological laundries, are not one of the categories, a BAT/AKART cannot be established using the 34 industrial source categories of the effluent guidelines method.

3.2.2 Radiation Protection Standards

Radiation protection standards established by the DOE, EPA, and NRC for offsite or uncontrolled areas may be considered analogous to water quality standards within the NPDES program. These standards set upper bounds on the acceptable consequences

of a discharge, with these bounds expressed in terms of risk, rather than pollutant concentrations.

The DOE has established requirements for the disposal of liquid effluents on the Hanford Site. These requirements are contained in a set of orders that require protection of public health and safety, and are intended to control, to the extent possible, adverse impacts to the environment. Currently, liquid disposal practices on the Hanford Site are conducted in accordance with these requirements. The application of BAT/AKART to the liquid effluents may result in an additional level of control, as well as contribute to the overall ALARA program at the Hanford Site. These requirements offer guidance on discharges, however assumptions on treatment and disposal methods which are not appropriate at this stage of the BAT/AKART determination process would be required to estimate public exposure attributable to the DLF wastewater.

The EPA limits for total annual radiation doses to members of the public are 25 millirem per year (mrem/yr) to the whole body, 75 mrem per year to the thyroid, and 25 mrem per year to any other organ (40 CFR 190 and 191 Subpart A). The limits specified in 40 CFR 190 are for commercial electric-power generation and apply to the cumulative effects of all activities that are part of a nuclear fuel cycle. The limits specified in 40 CFR 191 are for activities related to the management and disposal of spent nuclear fuel, high-level waste (HLW), and transuranic (TRU) radioactive wastes at any facility regulated by the NRC, or at DOE disposal sites for TRU wastes, spent fuel, or HLW. The limits are not considered directly applicable to the DLF waste because DLF waste does not fall into any of the categories managed by the EPA limits specified to 40 CFR 190 and 40 CFR 191. Additionally, it was not possible to select a BAT/AKART based on the EPA limits for total annual radiation doses to members of the public. To estimate radiation doses to the public from the DLF wastewater would

require assumptions regarding the type of treatment and disposal methods which are not appropriate at this stage of the BAT/AKART determination process.

The NRC regulations set forth in 10 CFR 50 establish licensing standards for nuclear facilities, including some reactors operated to produce primarily uranium and plutonium, and some separation facilities. Although Hanford Site facilities are exempt from 10 CFR 50, these standards provide guidance on design objectives and limiting conditions for radiation releases. The provisions of 10 CFR 50 require that new commercial reactors be designed and operated to comply with ALARA principles and numerical standards listed in 10 CFR 50 Appendix I. Appendix I standards limit offsite doses from each reactor to not more than 3 mrem per year to the whole body and 10 mrem per year to any organ. In addition, Appendix I standards require that all controls be used that can reduce exposures within a 50 mile radius at cost of $1,000 per man-rem or less. Appendix I of 10 CFR 50 further advises that the maximum dose in unrestricted areas resulting from all liquid effluents from all reactors at a site should not exceed 5 mrem per year, and that radiation releases in liquid effluents from each reactor should not exceed 5 Curies per year (Ci/yr).

The 10 CFR 50 Appendix I standards are not applicable to the DLF wastewater for several reasons. First, these standards are applicable to new commercial reactors. Because the DLF is neither a commercial operation nor a reactor, these standards are not applicable. Also, the standards are written in terms of exposure for each reactor, and cannot be applied to the DLF.

The DOE, EPA, and NRC radiation exposure regulations were examined for effluent guidelines applicable to DLF wastewater. Effluent guidelines from these sources were not applicable in terms of establishing BAT/AKART for the DLF.

3.2.3 Hazardous Waste Standards

The Washington Department of Ecology (Ecology) and EPA have promulgated standards related to hazardous waste that may affect the limits to be established on discharges from the DLF. State standards for hazardous waste are promulgated pursuant to Chapter 70.105 of the Revised Code of Washington (RCW), Hazardous Waste Management Act. Federal standards for hazardous waste are promulgated under the 1976 Resource Conservation and Recovery Act (RCRA) and the 1984 Hazardous and Solid Waste Amendments (HSWA).

These standards are typically applied to waste streams that are or may be hazardous waste, or that may be the result of processing hazardous waste. Neither case is true for the DLF, and these standards are not applicable.

3.2.4 Drinking Water Standards

The Washington Department of Health (Health) and EPA have promulgated regulations to protect the quality of water supplied for human use and consumption. Generally referred to as drinking water standards, they are derived from state authority under Chapter 43.20 RCW State Board of Health Act, and from federal authority under the Safe Drinking Water Act (SDWA). The drinking water standards are directed primarily at persons who provide public water supplies. However, because the standards are based on human health protection, they are frequently used as guidance in determining allowable chemical concentrations in water that may be used for human consumption.

Health has promulgated water standards in WAC 248-54 (Public Water Supplies). EPA's drinking water standards appear in 40 CFR Parts 141 and 143. Drinking water standards are generally classified as:

- Maximum contaminant level goals (MCLGs) established for carcinogens. MCLGs are generally set as close to zero as possible, and are not supposed to account for economic or treatability factors;

- Maximum contaminant levels (MCLs) established for toxics and carcinogens. MCLs are to be set at non-toxic effect levels, and as close as possible to MCLGs, with some allowance for economic and technical factors; and

- Secondary maximum contaminant levels (SMCLs) established primarily on the basis of secondary water effects such as color, odor, and taste. SMCLs are generally set for compounds that are not considered to be toxic or carcinogenic to humans.

Until recently, drinking water standards existed for only about a dozen compounds. Changes to federal regulations (soon to be mirrored in state regulations) have added nearly fifty additional compounds, and more compounds are projected for addition over the next several years. Both Ecology and EPA utilize the drinking water standards to determine potential for adverse impact on ground water and surface water. Exceedance of the drinking water standards has been, and is likely to remain, a standard basis for identifying environmental concerns.

The drinking water standards are performance standards only, and do not provide guidance on acceptable or recommended treatment technologies which could be considered to be BAT/AKART. However, the performance standards are not directly applicable to Hanford.

3.2.5 Ambient Surface Water Quality Standards

Ecology and EPA have identified ambient surface water criteria designed to prevent adverse effects to aquatic organisms living in the water, and to humans who may be consuming aquatic organisms. Ecology had promulgated surface water regulations pursuant to Chapter 90.48 RCW, Water Pollution Control Act (WPCA). EPA has established water quality criteria (although not yet promulgated in regulations) pursuant to authority under the Clean Water Act (CWA). The focus of these standards and criteria is to define ambient levels of chemical concentrations that are not expected to pose adverse effects if present in the aquatic environment.

At this time, EPA has not adopted regulations. Federal surface water criteria are established in EPA program guidance documents, principally Quality Criteria for Water, EPA 440/5-86-001, better known as the Gold Book (EPA 1986). There is some indication that EPA intends to promulgate actual regulations next year. Ecology has essentially adopted directly or by reference the federal Gold Book criteria. Ecology's regulations are in Chapter WAC 173-201 (Water Quality Standards for Surface Waters of the State of Washington).

Protection of Aquatic Life. One goal of the ambient surface water standards is the protection of aquatic species from direct toxic effects. Per proposed revisions to the State of Washington's Water Quality Standards for Surface Waters, toxic substances, which may cause acute or chronic conditions to aquatic biota, may not be introduced to surface waters at concentrations above natural background levels. Acute conditions, which will be measured by acute toxicity tests, are defined as changes in the physical, chemical, or biological environment which may be lethal to organisms within a 96 hour period. Chronic conditions, which will be measured by chronic toxicity tests, are defined as changes in the physical, chemical, or biological

environment for a period of greater that 96 hours, which may be lethal to the organism or result in deleterious effects.

Generally, the allowable size and location of mixing zones and associated effluent limits will be established on a case-by-case basis in an effort to protect aquatic species from discharges into surface waters. Mixing zones and associated effluents will be based on the following:

- The requirement that all known, available, and reasonable methods of prevention, control, and treatment be fully applied;
- Consideration of the chemical and physical interaction of the effluent and the receiving water;
- The critical conditions for discharge;
- The protection of sensitive and important habitats, and existing and characteristic uses of the water body; and
- Minimization of the area of water quality degradation.

Protection of Human Consumption. A second goal of the surface water standards is the protection of people who may be consuming aquatic organisms living in the surface water. Criteria are established for organism consumption only, where the water does not also serve as a source of drinking water (e.g., marine or estuarine waters). Criteria also exist for consumption of organisms and water where the surface water is used as a drinking water source. The latter criterion is typically more restrictive because it assumes an additional route of exposure to chemical compounds.

Human consumption criteria may also reflect certain factors related to the tendency of some compounds (typically carcinogens) to accumulate and/or bioconcentrate in aquatic species prior to consumption. Thus, EPA's Gold Book lists a range of criteria reflecting 1 in 100,000, 1 in 1,000,000, and 1 in 10,000,000 incremental human

cancer risk form consuming affected aquatic organisms, or organisms and water. The standard agency practice is to strive for the lowest possible risk level, and except in rare instances, to accept no greater than 1 in 1,000,000.

Anticipated Amendments to State Standards. Draft copies of amendments to the state surface water standards are currently being circulated for public review. Ecology is expected to be adding many new compounds to the list of already regulated chemicals. In addition to the EPA Gold Book criteria, Ecology is expected to incorporate some of the risk-based approach used to set drinking water standards, thus developing criteria based on human consumption of the surface water as a drinking water source. In summary, Ecology and EPA are likely to consider the relevant surface water standards in setting discharge limits for treated effluent from Hanford facilities. However, all these standards should be performance standards, and no guidance on acceptance or recommended treatment technologies is likely to be provided.

3.2.6 Ground Water Quality Standards

Ecology recently adopted regulations pursuant to the state WPCA setting forth standards for protection of ground water. The purpose of these standards is to establish criteria that must not be exceeded in order to protect existing and potential future uses of ground water. The presumption by Ecology is that ground water, other than naturally contaminated or nonusable waters (e.g., perched and seasonal, brackish), should be reserved and protected for use as drinking water. Such usability will be ensured if the ground water standards are met. Ecology's ground water standards are promulgated in WAC 173-200 (Water Quality Standards for Ground Waters of the State of Washington). These standards establish both numeric and narrative criteria. Numeric criteria are derived from Federal and State MCLGs, MCLs,

and SMCLs. In addition, for carcinogens, Ecology has adopted a risk-based equation and standard exposure assumptions for calculating a 1 in 1,000,000 incremental human cancer risk from consumption of affected water. The numeric criteria are considered by Ecology to be maximum allowable levels after all other options have been exhausted. If lower levels can be achieved through more aggressive treatment or management options, then Ecology will require such options. Discharges that could affect ground water, and thus cannot ensure the standards will be met, will generally not be allowed by Ecology unless some overriding public interest will be served.

In addition to the numeric criteria, Ecology has general narrative criteria promoting an "antidegradation policy". In many cases, it will not be sufficient to show that discharges entering an aquifer will not exceed ground water standards. The antidegradation policy will require a determination that all available and reasonable efforts have been undertaken to avoid degrading the ground water quality. In order to show that ground water quality will not be degraded, or that any degradation will be minimized as much as possible, current and projected ground water conditions may have to be established. Thus, background (i.e., uninfluenced by anthropogenic activities) ground water quality may be used by Ecology as a criterion for limiting effluent discharges.

Ecology shall incorporate the relevant ground water standards in defining discharge limits for the treated effluent from Hanford. However, these are performance standards, and no guidance on acceptance or recommended treatment technologies is available.

3.2.7 Cleanup Standards

Ecology has adopted standards pursuant to Chapter 70.105D RCW (Model Toxics Control Act), relative to the cleanup of sites at which hazardous substances have been released to the environment. These standards set forth methods for determining if hazardous substances in soil and water pose a significant risk to human health and the environment (hazard ranking), and procedures for undertaking remedial actions. Since no hazardous wastes will be treated or managed in the DLF, these standards are not applicable.

3.2.8 Radionuclide Guidelines

DOE concentration guidelines for radionuclides in the environment are based on a primary standard of 100 mrem effective dose equivalent to the public in a year. Derived Concentration Guides (DCGs) are radionuclide concentrations which, under hypothetical conditions of continuous exposure for one year, would result in a 100 mrem dose. DCGs are reported in DOE Order 5400.5 (DOE 1990). In addition to DOE DCGs, the Safe Drinking Water Act has established MCLs for total alpha, beta, and radium. The MCL for beta/gamma exposure is set at 4 mrem per year, which is 4 percent of the DOE DCGs. Because the DCGs are performance standards no information is available concerning treatment technologies which could be BAT/AKART.

3.3 Applicable Transferable Technologies

BAT/AKART determination by the technology transfer method involves identification of BAT/AKART effluent treatment systems used on similar effluent streams to the effluent stream under consideration at the Hanford Site. It entails the assembly of

data on potentially comparable effluent streams, followed by a determination of comparability. If the selected effluent and Hanford Site streams are comparable, it is likely that similar treatment technologies may be used at the Hanford Site and effluent limitations established at other facilities may be adapted for use at the Hanford Site. If technology transfer is not feasible, then the BAT/AKART determination must proceed to the treatability studies method.

3.3.1 Potentially Comparable Laundry Facilities

Data requirements for the BAT/AKART technology transfer method include general and specific criteria for comparing waste streams. The general criteria could include flow, pH, total suspended solids (TSS), silt index, total dissolved solids (TDS), alkalinity, temperature, oil and grease, total organic carbon, gross alpha, and gross beta. The specific criteria include cations, trace metals, anions, organics, and radionuclides. The data should be sufficient to identify similar streams and to reject those treatment systems that are not comparable in influent characteristics and system performance.

The regulatory motivations and effluent limits at the other facilities must also be examined to ensure control measures installed were intended to be BAT/AKART. At many facilities, controls are designed to meet state regulatory requirements, local water quality concerns, or site-specific environmental objectives.

Table 3.2 summarizes the contacts made to attempt an identification of potentially comparable facilities. A total of 35 facilities were contacted. These included full-scale operating facilities at DOE, industrial, and commercial nuclear power plants which generate and/or treat radiologically contaminated laundry.

TABLE 3.2
TECHNOLOGY TRANSFER CONTACTS
BEST AVAILABLE TECHNOLOGY ANALYSIS
DECONTAMINATION LAUNDRY FACILITY
WESTINGHOUSE HANFORD COMPANY, RICHLAND, WASHINGTON

Contact Name	Company	Facility	Telephone Number
Keith Bracknell	Martin Marietta Energy Systems	Portsmouth Uranium Enrichment Facility	614/289-2331
Paul Deltete	Analytical Resources	N/A	215/678-4441
Len Elikan	Westinghouse Materials Company of Ohio	Feed Materials Production Facility	513/738-6296
Roy Haight	Northeast Utilities	Connecticut Yankeee Nuclear Station Millstone Nuclear Station	203/267-2556
Jerry Hettinger	Pennsylvania Power and Light	Susquehanna Nuclear Station	717/542-3828
Sam Hickson	Tennessee Valley Authority	Browns Ferry Nuclear Station Sequoyah Nuclear Station	615/751-4705
Hugo Hughes	Martin Marietta Energy Systems	Oak Ridge National Laboratory – K25	615/574-8361
Rod Kimmitt	Martin Marietta Energy Systems	Oak Ridge National Laboratory – Y12	615/576-7767
Jim Jenchura	EG&G	Rocky Flats Plant	303/966-5003
Judy Lish	EG&G	Idaho National Engineering Laboratory	208/526-2324
Don Maffei	Consolidated Electric	Indian Point 2 Nuclear Station	914/526-5039
Russel Propst	Duke Power	Catawba Nuclear Station Oconee Nuclear Station Maguire Nuclear Station	704/373-2377

TABLE 3.2 (continued)
TECHNOLOGY TRANSFER CONTACTS
BEST AVAILABLE TECHNOLOGY ANALYSIS
DECONTAMINATION LAUNDRY FACILITY
WESTINGHOUSE HANFORD COMPANY, RICHLAND, WASHINGTON

Contact Name	Company	Facility	Telephone Number
Patricia Robinson	Electric Power Research Institute	N/A	415/855–2412
Tim Schleiger	Public Service Company of Colorado	Fort St. Vrain Nuclear Station	303/620–1008
Bruce Sewter	Westinghouse Radiological Services	Multiple (2)	609/722–5700
Jeff Siler	Westinghouse Savannah River Site	Savannah River Site	803/725–6379
Bill Simon	Martin Marietta Energy Systems	Oak Ridge National Laboratory – X10	615/574–7081
Mark Vandale	Yankee Atomic	Yankee Rowe Nuclear Station	413/424–5261
Guy Wilson	Interstate Nuclear Services	Multiple (12)	413/543–6911

3.3.2 Candidate Treatment Systems

The basic test in applying technology transfer for BAT/AKART is to determine how closely the candidate stream compares to the Hanford Site effluent stream in question. Significant differences in pollutants, concentrations, flow, or flow variability may indicate that technology transfer is inappropriate from an engineering standpoint.

A summary of the types and numbers of facilities contacted, and the range of treatment technologies is presented in Table 3.3. Of the 35 facilities, 25 actually generated a liquid waste stream. Of these 25 facilities, six combine their laundry effluents with other plant effluents and treat the combined stream in a centralized sewage treatment plant or other facility that is not designed specifically to treat laundry effluent. One of the remaining 19 facilities discharges directly to a drainfield. The remaining 18 facilities all use chemical pretreatment and/or filtration to remove suspended solids. However, only four of these facilities treat for removal of dissolved solids. Of these four, only one plant must remove dissolved solids to meet discharge requirements. This is a recent development, and installation of an ion exchange system is planned. The other three remove dissolved solids using ion exchange or reverse osmosis, but they recycle treated effluent back to the laundry or use it for cooling water make-up.

A summary of the range of data provided by the different facilities is presented in Table 3.4. It was expected that the wastewater characteristics of the projected DLF effluents would be similar to the characteristics of effluents produced in the other facilities. The major reason for this assumption is that all of the facilities generate the wastewater as a result of washing radiologically contaminated laundry. Qualitatively, the data indicate that this assumption is valid. However, a quantitative comparison is not possible because the data collected at many of these facilities is incomplete and

TABLE 3.3
TECHNOLOGY TRANSFER SUMMARY
BEST AVAILABLE TECHNOLOGY ANALYSIS
DECONTAMINATION LAUNDRY FACILITY
WESTINGHOUSE HANFORD COMPANY, RICHLAND, WASHINGTON

Type of Facility	Number of Sites	Treatment Method	Number of Facilities per Treatment Method
Nuclear Power Plants	11	Ship to offsite laundry service	7
		Filtration	3
		Filtration/ion exchange	1 a/
DOE Facilities	10	Ship to offsite laundry service	3 b/
		Sewage treatment plant	4
		Discharge to drying bed	1
		Filtration/reverse osmosis/ evaporator (concentrate)/ cooling water makeup (permeate)	1
		Evaporator	1 a/
Commercial Laundry	14 c/	Chemical pretreatment/ solids separation/filtration/ ion exchange	12 d/
		Chemical pretreatment/ filtration/activated carbon/ion exchange/ UV disinfection	2

Notes

a/ The laundry effluent is combined with the general facility liquid effluent and treated through a centralized facility.

b/ Two of the facilities reportedly ship to a commercial laundry. This has not been verified. The third facility ships their laundry to another DOE site nearby.

c/ One company owns 12 facilites, and a second company owns the other 2; these facilities include the offsite services used by certain nuclear power plants and DOE facilities.

d/ Ion exchange is currently planned for only one of the facilities, and is due to unusually high soluble cesium and strontium concentrations caused by laundry from Three Mile Island.

TABLE 3.4
TECHNOLOGY TRANSFER DATA SUMMARY
BEST AVAILABLE TECHNOLOGY ANALYSIS
DECONTAMINATION LAUNDRY FACILITY
WESTINGHOUSE HANFORD COMPANRY, RICHLAND, WASHINGTON

Parameter	Facilities a/	Units	Range		DLF Design Value
Flow	18	gpd	2,000 – 40,000		80,000
Suspended Solids	16	mg/l	10 – 3,000		193
Dissolved Solids	1	mg/l	1,000		886
Oil & Grease	3	mg/l	20 – 60		159
Total alpha	1	pCi/l	1,200,000	b/	252
Total beta	1	pCi/l	1,200,000	b/	12,168
Strontium–90	12	pCi/l	1,000 – 10,000	c/	1,222
Cesium–137	12	pCi/l	1,000 – 10,000	c/	8,270
Cobalt–60	12	pCi/l	10,000 – 100,000	c/	4,952
Uranium	12	pCi/l	–	d/	342
Amercicium–241	12	pCi/l	–		46
Europium–155	12	pCi/l	–		342
Plutonium–239	12	pCi/l	–		176

Notes
a/ Number of facilities which provided data. A total of 18 facilities have treatment systems specifically for laundry wastewater.
b/ Combined total alpha and beta.
c/ Specific data was not provided. It was reported that the untreated effluent is generally around the limits established in 10 CFR 20.
d/ Data not available.

are not specific enough to allow an accurate comparison. Therefore, a determination of BAT/AKART cannot be made.

In addition to the technical comparisons, a review of the permit status of each of the facilities was performed. Fifteen of the 19 plants which do not combine effluents have discharge permits. The other four include three which recycle their effluents and one which discharges directly to a drainfield. All of the other facilities are permitted under 10 CFR 50 for discharge of radionuclides. In addition, 11 of the facilities discharge to publicly owned treatment works (POTW) under pretreatment permits, and four discharge under NPDES permits. Three of the four NPDES-permitted facilities combine their treated laundry effluent with other effluents prior to the NPDES monitoring point. Discussions with all of the permitted facilities indicate that compliance with the permits is achieved with the systems they have installed. However, none of the systems were selected using a BAT/AKART-type of process. Rather, they were installed to meet the regulatory requirements in place at that specific facility. This is an additional reason why a determination of BAT/AKART cannot be made.

3.4 Applicable Treatability Studies

Identification of BAT/AKART by the treatability studies method is similar to the technology transfer method. Information from treatability studies is used to broaden the range of technology transfer. This method is useful when one treatment technology or treatment system is well established for wastewaters similar to the DLF effluent, but technology transfer is not justified.

Two sources of information were used to complete the treatability studies evaluation. The first was the data compiled from discussions with the 35 facility operators

identified in Table 3.2. The second was a literature search of three computer-assisted abstract review databases. The largest of these was Dialog. Specific files which were searched included the following:

- DOE Energy;
- Waternet;
- Water Resources Abstracts;
- PTS Prompt;
- Chemical Abstracts Search 1982-86;
- Chemical Abstracts Search 1987-89;
- Pollution Abstracts;
- Compendex Plus;
- NTIS; and
- Textile Technology Digest.

In addition, searches of the Dialog-ONTAP and WPCF Journal Abstracts databases were performed. The use of the keywords "laundry" and "wastewater" resulted in 279 records being identified. These records were reviewed, and 25 abstracts were requested. Complete copies of each reference were obtained only if they were readily available from technical journals or conference proceedings. Complete copies of reports from sources such as NTIS were not required.

The treatability studies method attempts to identify a pattern or trend with respect to treatment technologies applied at facilities similar to that under consideration. A pattern has been identified from discussions with the facilities identified in Table 3.2. That pattern consists of chemical pretreatment and/or filtration for suspended solids removal. All but one of the facilities with discharge permits are able to meet their effluent requirements utilizing this technology. In most cases, the permits are based

upon 10 CFR 20 for radionuclide limits. Additional parameters requiring treatment under pretreatment or NPDES permits include TSS, BOD, pH and oil and grease. With the exception of pH, all of these parameters are routinely met or exceeded with the use of chemical pretreatment and/or filtration. This conclusion is reasonable given that the majority of the radionuclides present result from particulate contamination transferred to the protective clothing during its use. Only the most soluble of radionuclides (i.e., cesium or strontium) would be expected to be present as a dissolved species.

Suspended solids removal utilizing chemical pretreatment and/or filtration was also discussed in multiple references identified during the literature search. The U.S. Army has extensively studied pretreatment with polyelectrolytes followed by conventional solid-liquid separation and a pressure precoat filter for treatment of laundry and shower wastewater (Lent 1975). Powdered activated carbon is also added to reduce organic concentrations. Prototype units have also been constructed and operated. Another reference discussed the same basic system for commercial and residential laundry wastewater with the addition of ion exchange or reverse osmosis if necessary for dissolved solids control (Ackerman 1981). Treatment of radioactive effluents by flocculation and conventional solid-liquid separation has also been used for laundry wastewater in France (Lundy 1985).

In addition to the more conventional processes, a number of references were found which discuss membrane processes. These include the use of ultrafiltration for solid-liquid separation of commercial laundry wastewater (Bhattacharyya 1978), and for nuclear power plant laundry effluents in Russia (Kichik 1987). The use of reverse osmosis by itself was also discussed, although results were mixed due to fouling (Jeng 1985). Finally, the use of pretreatment, conventional solid-liquid separation, ultrafiltration and activated carbon for commercial laundry wastewater was discussed

in three references (Van Gils 1985a and 1985b, Memtek 1987). The activated carbon is used for reducing organic concentrations, and may be either a fixed bed or powered activated carbon added to a recycle stream on the ultrafiltration system.

The removal of suspended solids from laundry effluents has also been investigated through laboratory testing by Westinghouse Hanford. Specific technologies which were investigated included ultrafiltration and precoat filtration (Ebasco Services, Incorporated 1987). This work demonstrated that with the exception of cesium, all other radionuclides were removed with an efficiency of 95 to 99 percent. This corresponds to decontamination factors between 20 and 100. In addition, the lower removal efficiencies were observed for strontium, which like cesium, can be very soluble. The work also indicated that outlet concentrations were below assumed Federal drinking water standards except for cesium and gross beta activity. However, gross beta activity was reduced by 95 percent, and the remaining beta activity is likely to be associated with the remaining cesium and strontium.

Radioactive cesium and strontium, which are soluble species, may be present in the DLF wastewater, and therefore removal of these species must be considered. Only one of the facilities contacted is concerned with removal of cesium and strontium. Currently, that facility is considering the use of ion exchange for this operation. The usefulness of ion exchange for cesium and strontium removal is well documented (Ebasco Services, Incorporated 1987). References include pilot and full-scale applications of both standard and selective ion exchange at both DOE facilities and commercial nuclear power plants. In one survey (ORNL 1986), 41 out of 41 respondents indicated that ion exchange is currently used for liquid radioactive waste treatment at commercial nuclear power plants. Savannah River Plant has also investigated ion exchange for the removal of cesium and strontium from high level waste (Baumgarten 1979; Wallace 1982). Additional work on cesium removal has

also been reported by West Valley Nuclear Services (Swenson 1987) and by Duke Power Company (Propst 1986). Oak Ridge National Laboratory has also conducted extensive laboratory and pilot scale work in the area of cesium and strontium removal from wastewater (Robinson 1988), and similar work has been done through projects funded by EPRI (Jacob 1985).

In order to identify BAT/AKART using the treatability studies method, the influent to the DLF wastewater treatment system must be similar to the influents treated at other facilities. However, the effluent generated from commercial or nuclear power plant laundry facilities is not typically contaminated with transuranics, radionuclides which may be present in the DLF process wastewater, and therefore effluents generated from these laundry facilities are not comparable to the DLF effluent. Effluent from DOE laundry facilities may be contaminated with similar radionuclides, and therefore is more comparable to the DLF effluent. However, the effluents from the DOE laundry facilities are managed as follows:

- Discharged to a sewage treatment plant;
- Discharged to drying beds; or
- Combined with general facility liquid effluent streams before treatment.

The DLF effluent will be treated in a dedicated facility, and no conclusions regarding potential BAT/AKART can be reached based on the effluent treatment operations at other DOE facilities.

In summary, although patterns in treatment technologies have been identified, either the effluents from the surveyed facilities are not comparable or the treatment of these effluents are not comparable to the DLF effluent. Therefore, a determination of

BAT/AKART by the treatability studies method cannot be justified, and the generic treatment systems method must be used.

3.5 Applicable Generic Treatment Alternatives

As discussed in Section A.5 of Appendix A, the generic treatment systems method includes the development of a range of progressive treatment alternatives. These alternatives include a combination of source controls and treatment processes designed to remove suspended solids and dissolved solids of concern. The development of both source control alternatives and the treatment alternatives is discussed in Section 4.0.

4.0 TECHNOLOGY ALTERNATIVES

In completing the generic treatment systems method, an evaluation of both source controls and end-of-pipe treatment technologies is required. The following sections identify potential source control alternatives for the DLF. In addition, the required range of progressive alternatives is developed. An evaluation is also made regarding retention and stand-by treatment alternatives. Finally, secondary waste treatment alternatives are discussed.

4.1 SOURCE CONTROL ALTERNATIVES

The use of source controls is generally limited to streams such as steam condensates, cooling waters, and chemical and laboratory sewers. Source controls are used to minimize, or in some cases, eliminate, wastewater requiring treatment. There are three primary source control methods including the use of administrative and engineering controls, internal recycle, and zero discharge. Each of these are further discussed in the following sections.

4.1.1 Administrative and Engineering Controls

Administrative and engineering controls which can be used in the laundry to limit the production of wastewater requiring treatment include the following:

- Process design;
- Waste segregation;
- Waste minimization;
- Spill control;
- Spill containment; and

- Procedure modification.

Unlike many of the other wastewater producing facilities at Hanford, the DLF is not an operating facility. Rather, it is currently in the definitive design phase. Therefore, the opportunity exists to include all of the design features listed above into the facility design. However, none of these controls will eliminate the wastewater discharge from the DLF, although they will help reduce it.

4.1.2 Internal Recycle

Figure 2.1 presented an overall water-use flow diagram for the DLF. As shown, the discharge from the facility will be reduced by the use of internal recycle. Specifically, effluent will be recycled back to the regulated laundry. It is estimated that approximately 50% of the make-up water used by the regulated washing machines can be recycled water.

Recycle of 100% of the wastewater will not be practical in the DLF. As configured, both the regulated and nonregulated wastewater will be combined for treatment. However, to prevent any possible cross-contamination, between regulated and nonregulated systems, water will only be returned to the regulated laundry. Therefore, there will be an excess of treated water which will be discharged to the TEDF.

Steam condensate will also be recycled in the DLF for two reasons. First, it results in a lower overall discharge of water from the facility. In addition, it increases the overall energy efficiency of the facility. The steam condensate will be used primarily for make-up water to feed the non-regulated washing machines.

4.1.3 Zero Discharge

Zero discharge could be achieved by either recycling the wastewater to other Hanford operations, or by installing and operating double-lined solar evaporation ponds. Both alternatives are not practical for multiple reasons.

As shown in Section 2.2, the DLF wastewater will be relatively high in dissolved solids and radionuclides, and will contain trace concentrations of other organic and inorganic species. All of these compounds make the water very undesirable for any process make-up purposes at other Hanford facilities.

The concept of solar evaporation ponds carries several other major disadvantages. Construction of such ponds is inconsistent with current Hanford Site wastewater management practices. Over the past decade, several projects have been implemented to eliminate ponds which have been used to evaporate aqueous streams containing radioactive materials.

4.2 END-OF-PIPE TREATMENT ALTERNATIVES

There are a wide range of suspended solids and dissolved solids removal processes potentially applicable to treatment of DLF wastewater. These processes are summarized in Table 4.1, and were identified based on the results of the technology transfer research, experience from other projects, and recommendations provided in the BAT guidance document.

A bench scale treatability study was performed to support the evaluation of the listed treatment technologies. The purpose of the treatability study was as follows:

TABLE 4.1
POTENTIALLY APPLICABLE PROCESSES
BEST AVAILABLE TECHNOLOGY ANALYSIS
DECONTAMINATION LAUNDRY FACILITY
WESTINGHOUSE HANFORD COMPANY, RICHLAND, WASHINGTON

Technology Type	Process Options
Suspended Solids Removal	
Sedimentation	Gravity Separation
Filtration	Conventional Filtration Precoat Filtration Multi–media Filtration
Flotation	Dissolved Air Flotation
Membrane Processes	Ultrafiltration Microfiltration
Dissolved Solids Removal	
Primary Removal	Hydroxide Precipitation Sulfide Precipitation Coprecipitation Conventional Ion Exchange Reverse Osmosis
Secondary Treatment	Insoluble Sulfide Process Selective Ion Exchange
Organic Treatment	
Adsorption	Granular Activated Carbon
Destruction	UV Oxidation

- Provide baseline wastewater characterization data;
- Provide performance data on achievable effluent concentrations;
- Provide design information for each of the processes;
- Identify wastewater characteristics which could limit the efficiency or effectiveness of treatment processes; and
- Provide a database of information potentially useful for other wastewater treatment projects at the Hanford Site.

Details on the planning for the study may be found in Treatability Study Work Plan for Hanford Decontamination Laundry Facility Best Available Analysis (WHC 1991b). To provide a high degree of assurance that only high quality data were produced, a comprehensive Quality Assurance document was also prepared and implemented (WHC 1991c).

Appendix B summarizes the results of the treatability study, and identifies the optimum technologies to be considered for suspended solids and varying degrees of dissolved solids removal. Also discussed are technologies for pretreatment and organic removal. Complete details on the treatability study may be found in Treatability Study Report for Hanford Decontamination Laundry Facility Best Available Technology Analysis (WHC 1991d).

The optimum technologies identified from the treatability study are as follows:

- Pretreatment - lint separation, heat recovery, flow equalization;
- Suspended solids removal - membrane microfiltration;
- Dissolved solids (metals) removal - lime precipitation;
- Dissolved solids (cesium and strontium) removal - zeolite ion exchange;
- Total dissolved solids reduction - reverse osmosis; and

- Organic removal - granular activated carbon.

As discussed in Section A.5 of Appendix A, the generic treatment alternatives should represent a range of progressive treatment. Therefore, these optimum technologies have been sequentially combined, and the following four alternatives have been formulated. A simplified schematic of these alternatives is presented in Figure 4.1. More complete descriptions of these alternatives are provided in Section 5.0.

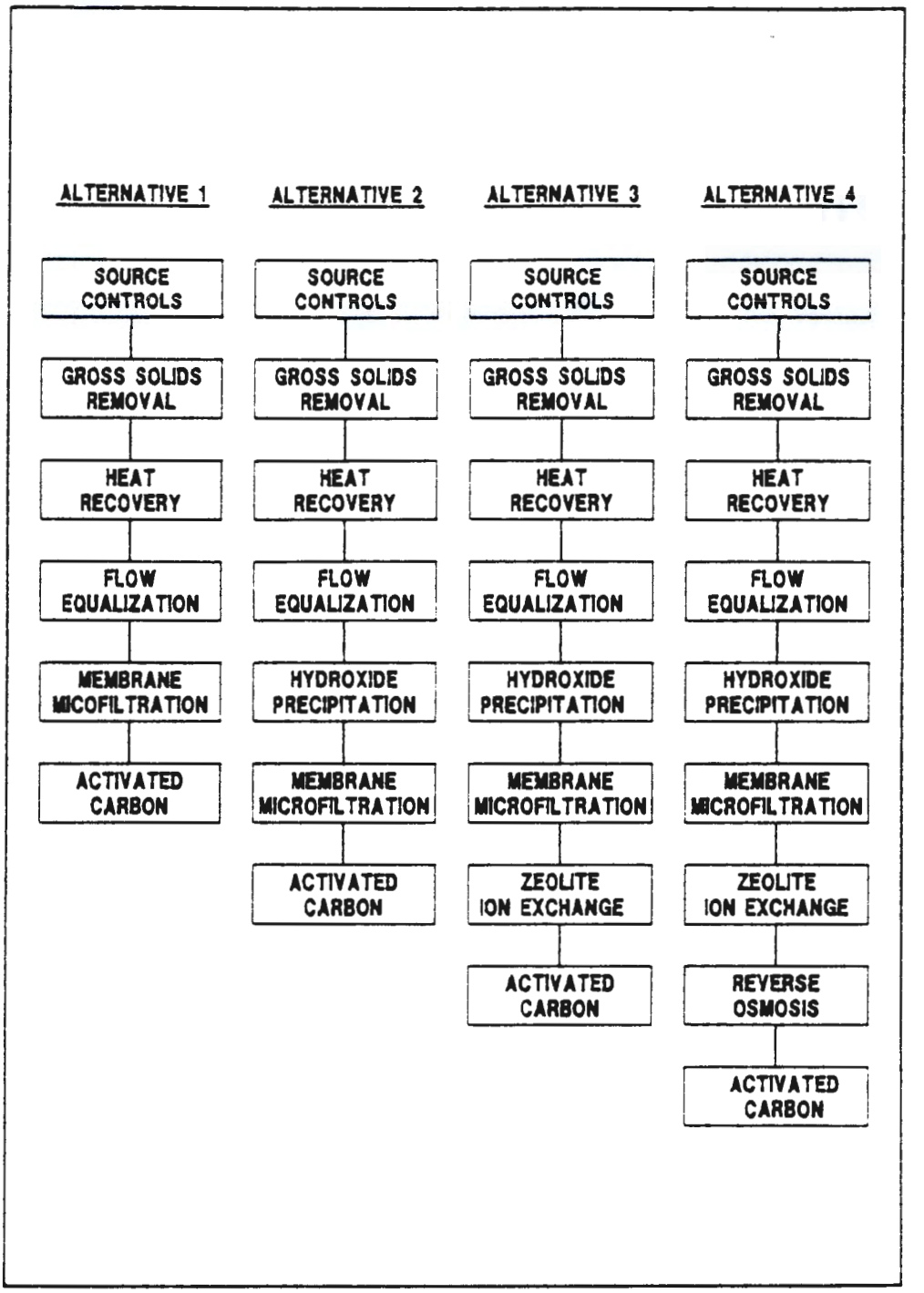
4.2.1 Alternative 1

Alternative 1 includes the following steps:

- Source controls;
- Pretreatment;
- Suspended solids removal; and
- Organic removal.

Source control will include engineering and administrative controls. This alternative will also use pretreatment processes consisting of gross solids removal and flow equalization. Gross solids removal will be accomplished by using vibrating screens to remove lint and other large particulate. The screened wastewater will be cooled in a wastewater heat recovery system and held in a equalization tank prior to treatment. Suspended solids removal will be accomplished by using a membrane microfiltration system. Solids will be allowed to concentrate in a concentration tank, and will be periodically removed from the system for dewatering and disposal. Organic removal will be accomplished by use of a granular activated carbon system. Spent carbon will be slurried from the columns for dewatering and disposal.

FIGURE 4.1


ALTERNATIVE 1
SOURCE CONTROLS
GROSS SOLIDS REMOVAL
HEAT RECOVERY
FLOW EQUALIZATION
MEMBRANE MICOFILTRATION
ACTIVATED CARBON
ALTERNATIVE 2
SOURCE CONTROLS
GROSS SOLIDS REMOVAL
HEAT RECOVERY
FLOW EQUALIZATION
HYDROXIDE PRECIPITATION
MEMBRANE MICROFILTRATION
ACTIVATED CARBON
ALTERNATIVE 3
SOURCE CONTROLS
GROSS SOLIDS REMOVAL
HEAT RECOVERY
FLOW EQUALIZATION
HYDROXIDE PRECIPITATION
MEMBRANE MICROFILTRATION
ZEOLITE ION EXCHANGE
ACTIVATED CARBON
ALTERNATIVE 4
SOURCE CONTROLS
GROSS SOLIDS REMOVAL
HEAT RECOVERY
FLOW EQUALIZATION
HYDROXIDE PRECIPITATION
MEMBRANE MICROFILTRATION
ZEOLITE ION EXCHANGE
REVERSE OSMOSIS
ACTIVATED CARBON

4.2.2 Alternative 2

Alternative 2 includes the following steps:

- Source controls;
- Pretreatment;
- Chemical precipitation;
- Suspended solids removal; and
- Organic removal.

This alternative will use the same pretreatment and suspended solids removal processes as Alternative 1. However, dissolved solids removal by use of chemical precipitation will be coupled with the membrane microfiltration system. Lime will be added to a pH of 11 to 12 to precipitate heavy metals and radionuclides from solution. The precipitated solids will be allowed to concentrate, and will be periodically removed for dewatering and disposal. Organic removal for this alternative will be the same as for Alternative 1.

4.2.3 Alternative 3

Alternative 3 includes the following steps:

- Source controls;
- Pretreatment;
- Chemical precipitation;
- Suspended solids removal;
- Dissolved solids removal (one step); and
- Organic removal.

This alternative will be the same as Alternative 2 except that zeolite ion exchange will be used as the second step of dissolved solids removal. The ion exchange system will be used to remove soluble cesium and strontium from solution.

4.2.4 Alternative 4

Alternative 4 includes the following steps:

- Source controls;
- Pretreatment;
- Chemical precipitation;
- Suspended solids removal;
- Dissolved solids removal (two steps);
- Total dissolved solids reduction; and
- Organic removal.

This alternative will be the same as Alternative 3, except that reverse osmosis will be used to reduce total dissolved solids levels. The zeolite ion exchange system is still required to ensure removal of radioactive cesium and strontium.

4.3 RETENTION AND STANDBY TREATMENT ALTERNATIVES

There are several facilities either in existence or in the planning stages at Hanford which can possibly retain and treat liquid effluents. The following sections review these alternatives. In addition, the general alternative of retention at the DLF itself is considered.

4.3.1 Generator Retention and Standby Treatment

Some streams at the Hanford Site may be managed by retention for analysis at the generator facility, and processing through a standby treatment facility if a particular contaminant of concern is identified. However, the wastewater characterization data from the PEDF demonstrates that this type of approach would not be practical for the DLF because significant quantities and concentrations of contaminants in excess of Comparative Levels are present. In addition, contaminated laundry will continue to be produced at the Hanford Site which will require washing in the DLF. Because the nature of the process (i.e., washing of contaminated clothing) which produces the wastewater cannot be changed it is very unlikely that the basic characteristics of the wastewater will ever change. Therefore, continuous treatment of DLF wastewater is mandated.

4.3.2 Generator Retention and C-018H Standby Treatment

Project C-018H will involve the design and construction of a treatment facility incorporating multiple unit operations including pH adjustment, membrane filtration, ultraviolet oxidation, reverse osmosis, ion exchange, and evaporation. Based solely on the processes available within the facility, this facility would likely be capable of providing treatment of the DLF wastewater on a standby basis.

Project C-018H is being constructed specifically to treat the 242-A Evaporator Process Condensate, and the PUREX Plant Process Distillate Discharge and Ammonia Scrubber Distillate. However, it is possible that this facility could be available on a standby basis for intermittent treatment of other Hanford Site effluents. Such an approach would require that the generator (i.e., the DLF) construct a retention facility to collect and hold wastewater for analysis. If contaminants of concern were identified, the

contents of the retention facility would be transferred to the C-018H facility for treatment.

The option of retention and C-018H standby treatment is not viable for the DLF because continuous treatment of the DLF wastewater is required as discussed in Section 4.3.1. Because of the quantities and concentrations of contaminants, it is highly improbable that a batch of wastewater would ever be capable of direct discharge to the TEDF from the retention facility. Therefore, daily treatment at the C-018H facility would be required rather than standby treatment. Further, the required capacity for the treatment of DLF wastewater (80,000 gallons per day) is not available in the C-018H facility.

4.3.3 LERF Retention and C-018H Standby Treatment

This option is similar to that above the exception that wastewater would be transferred to the Liquid Effluent Retention Facility (LERF) located near the planned location of the C-018H facility. Similar to generator retention and C-018H treatment, this option is not practical for the DLF.

4.4 SECONDARY WASTE

Although the secondary waste from a given process and the steps required to manage the secondary waste will not effect how the primary treatment process works, secondary waste management costs may be a significant part of facility operating cost and could have a tremendous impact on the economic achievability analysis.

The following sections review the sources and characteristics of the secondary wastes produced by each of the four generic treatment systems. In addition, specific

processes which can be used to treat each secondary waste are reviewed, and an optimum process selected.

4.4.1 Secondary Waste Characteristics

Table 4.2 summarizes the types, form, and estimated volume of secondary wastes produced by each of the generic treatment alternatives. As shown, the secondary wastes may be present in any of the following forms:

- Dewatered lint;
- Dewatered sludge;
- Spent media; and
- Liquid brine.

There are no hazardous wastes known or expected to be present in the wastewater, and hazardous constituents are not expected to be sufficiently concentrated such that they would be considered a low level radioactive mixed waste (RMW). In addition, the bulk of the hazardous constituents removed from the wastewater will be present in the sludge. However, these constituents will be present as metal hydroxide precipitates in a lime matrix, and these types of sludges are very effective in limiting the mobility of hazardous constituents. Therefore, all of the secondary wastes are expected to be designated as low level radioactive waste (LLW).

In general, all waste materials requiring storage and/or disposal at the Hanford Site must comply with the requirements of the Hanford Site Radioactive Solid Waste Acceptance Criteria (WHC 1990b). This document establishes criteria for low level radioactive waste, high level radioactive waste, and radioactive mixed waste. These criteria are applied equally to all wastes regardless of their source. Therefore, the

TABLE 4.2
SECONDARY WASTE SUMMARY
BEST AVAILABLE TECHNOLOGY ANALYSIS
DECONTAMINATION LAUNDRY FACILITY
WESTINGHOUSE HANFORD COMPANY, RICHLAND, WASHINGTON

Alternative	Process	Secondary Waste	Form	Volume/ year (ft^3)
1	Lint Separation	Lint	Dewatered Lint	60
	Heat Recovery	None	N/A	–
	Equalization	None	N/A	–
	Membrane Filtration	Sludge	Dewatered Sludge (35%–40% solids)	1,400
	Activated Carbon	Carbon	Dewatered Media	10,000
2	Lint Separation	Lint	Dewatered Lint	60
	Heat Recovery	None	N/A	–
	Equalization	None	N/A	–
	Chemical Precipitation	None	N/A	–
	Membrane Filtration	Sludge	Dewatered Sludge (35%–40% solids)	10,500
	Activated Carbon	Carbon	Dewatered Media	10,000
3	Lint Separation	Lint	Dewatered Lint	60
	Heat Recovery	None	N/A	–
	Equalization	None	N/A	–
	Chemical Precipitation	None	N/A	–
	Membrane Filtration	Sludge	Dewatered Sludge (35%–40% solids)	10,500
	Zeolite Ion Exchange	Zeolite	Dewatered Media	1,200
	Activated Carbon	Carbon	Dewatered Media	10,000
4	Lint Separation	Lint	Dewatered Lint	60
	Heat Recovery	None	N/A	–
	Equalization	None	N/A	–
	Chemical Precipitation	None	N/A	–
	Membrane Filtration	Sludge	Dewatered Sludge (35%–40% solids)	10,500
	Zeolite Ion Exchange	Zeolite	Dewatered Media	1,200
	Reverse Osmosis	Liquid Brine	Liquid	2,780
	Activated Carbon	Carbon	Dewatered Media	10,000

secondary wastes produced from wastewater treatment operations at the Hanford Site must meet the same criteria for acceptance as wastes forwarded by generators from other sites.

The primary objectives of secondary waste treatment include volume reduction and physical stabilization prior to storage or disposal. An assessment of the acceptance criteria indicates that the most acceptable final form for secondary waste is as a dry solid. This form will also have the least volume due to the removal of excess water.

4.4.2 Secondary Waste Treatment Alternatives

There are a number of processes currently available which are capable of volume reducing and drying secondary wastes such as those expected from the four generic treatment alternatives. In addition, the preferred alternative for each waste is identified based on overall technical feasibility and commercial availability, reliability, and an assessment of capital and operating cost. Each of the selected secondary waste treatment alternatives will be incorporated into each of the primary waste treatment alternatives, as appropriate.

4.4.2.1 Dewatered Lint. Dewatered lint will be produced as a result of the lint separation process used as a pretreatment. The lint will be removed using a vibrating screen, and will be dewatered in a hydraulic or screw press. The final material will be a stringy mass with no free standing water.

Lint separation currently takes place at the PEDF. After dewatering, lint is placed in low level waste boxes for burial. No other treatment is required or performed. Therefore, for the purposes of this BAT/AKART, it has been assumed that additional treatment of the dewatered lint will not be required.

4.4.2.2 Dewatered Sludge. Sludge will be produced by the membrane microfiltration system in Alternative 1, and the chemical treatment and membrane microfiltration system in Alternatives 2, 3, and 4. In all four cases, a dewatered sludge with an overall solids content of approximately 35% to 40% by weight will be produced through a primary dewatering device such as a filter press or a centrifuge.

The dewatered material for these alternatives should have no free standing water upon initial production. However, over prolonged storage, it is possible that some amount of water will be released from the solid matrix. Therefore, stabilization of the dewatered sludge is recommended.

The most practical methods of sludge stabilization include the following:

- Use of absorbent;
- Solidification; and
- Drying.

Absorbent materials are added to dewatered sludges to absorb moisture and prevent its release from the solid. Absorbent materials include diatomaceous earth, flyash, and others. In a sludge application such as the DLF, the absorbent would either be placed in layers in the disposal container, or mixed in a screw mixer assembly.

The solidification process requires that the sludge be transferred to a large disposable solidification container, or to a mixing container for transfer to 55-gallon drums. Either container would be fitted with a mixing blade to continuously agitate the contents. Solidification agents (cement and lime) would be added to the container, and the mixture allowed to harden. Some amount of water may actually have to be added

back to the sludge to obtain the proper water to cement ratio. The usual volume increase with this process would be 1.5 to 2 times the original waste volume.

A drying system is the only process capable of achieving a volume reduction. Dryers may be either direct or indirect heated, and use heat sources including steam, direct gas combustion, or infrared heating. Sludges are typically passed through the dryer on a belt, by a rotating inclined cylinder, or by a heated screw. The dry material is discharged directly into the final disposal container. The overall volume reduction achieved by drying can range from approximately 25% to 50% or more. For the purposes of this evaluation, a reduction of 25% will be assumed.

The three methods of sludge stabilization are technically feasible, proven in actual commercial applications and quite reliable. Table 4.3 presents a summary of capital equipment, and annual disposal costs for each of the three dewatered sludge treatment alternatives. The disposal costs are based on the volumes presented in Table 3.6, and assume a disposal cost of $68.62/ft^3 (DOE 1991). The absorption system costs are based on a screw mixing system, the solidification system on the use of a batch mixing system, and the drying system on the use of a belt dryer with infrared heating. In addition, volume increases of 15% and 50% were assumed for absorption and solidification, respectively. A volume reduction of 25% was assumed for drying.

As shown, the absorption system has the lowest overall equipment cost, but a high annual disposal cost. Solidification is moderate in terms of capital, but has the highest annual disposal cost. Drying is moderate in terms of capital cost, but significantly lower in annual disposal costs. Therefore, drying will be assumed as the secondary waste treatment process for dewatered sludges.

TABLE 4.3
SECONDARY WASTE TREATMENT COST SUMMARY
BEST AVAILABLE TECHNOLOGY ANALYSIS
DECONTAMINATION LAUNDRY FACILITY
WESTINGHOUSE HANFORD COMPANRY, RICHLAND, WASHINGTON

Alternative	Equipment Cost a/ $'s	Disposal Volume b/ ft^3	Disposal Cost c/ $'s
Dewatered Lint	0	60	4,117
Dewatered Sludge			
Absorption	60,000	10,500	720,510
Solidification	220,000	21,000	1,441,020
Drying	197,000	7,875	540,383
Dewatered Media			
Dewatering	25,000	11,200	768,544
Heated Air Drying	275,000	11,200	768,544
Solidification	220,000	22,400	1,537,088
Liquid Brine			
Evaporation and Drying	2,100,000	2,780	190,764

Notes

a/ Equipment cost only, does not inlclude installation and engineering.

b/ Based on Alternative 4 volume estimates from Table 4.2. This is the worst case alternative in terms of secondary waste production.

c/ Assumes current low level waste disposal rate for the Hanford Site of $68.62/ft^3$ (DOE, 1991).

4.4.2.3 Spent Media. The various adsorption processes which are incorporated into the primary treatment alternatives include granular activated carbon and zeolites. Both of these media are granular, porous materials typically in the 16 to 40 mesh size range. Spent media such as these may either be regenerated of disposed of directly.

Although the purpose of the granular activated carbon is the removal of organic constituents, it is not expected that the spent carbon will be classified as a hazardous waste due to the concentration of adsorbed organic constituents. Regeneration of granular activated carbon is accomplished by thermal processing at high temperatures. The regeneration process, which is similar to an incineration process, thermally destroys the organic compounds. Therefore, a regeneration facility would require permitting under RCRA similar to a hazardous waste incinerator. Such an expense is not justified given the usage of activated carbon.

Regeneration of zeolites is possible in some applications such as the removal of ammonia. However, there are no recorded instances in which zeolites have been regenerated when used for radioactive cesium and strontium removal. Therefore, regeneration of zeolites will not be considered.

Media such as activated carbon, zeolites, and ion exchange resin are a predominant part of the low level radioactive waste produced at commercial nuclear power plants. The three major processes used to prepare these wastes for disposal include the following:

- Vacuum-assisted dewatering;
- Heated air drying; and
- Solidification.

The dewatering process involves transferring the media to a dewatering container fitted with a screen device which will not allow media to pass. Various size containers ranging from approximately 75 ft^3 to 240 ft^3 are available. Vacuum is applied to the container, typically with an air-operated diaphragm pump. The combination of gravity drainage and the pumping action results in the removal of all free-standing water. The dewatering container is then disposed of directly. There is minimal volume reduction using this process.

The heated air drying system also requires the media to be transferred to a disposal container. These containers are the same as those used for dewatering. The majority of the water is allowed to drain by gravity. Dry heated air is then passed through the media to remove the remainder of the water. The air is typically cooled through a condensing unit, reheated, and routed back to the container of discharged to atmosphere. There is minimal volume reduction using this process for medias such as activated carbon and zeolites.

Finally, the solidification process requires that the media be transferred to a large disposable solidification container, or to a holding tank for transfer to 55-gallon drums. Either container would be fitted with a mixing blade to continually agitate the container contents. Solidification agents (cement and lime) would be added to the container, and the mixture allowed to harden. Typically, the final waste volume would be approximately 1.5 to 2 times the original waste volume.

All three processes are technically feasible and proven in actual commercial applications. The processes are also quite reliable, and capable of consistently producing a product which meets acceptance criteria for LLW disposal.

Table 4.3 presents a summary of capital equipment, and annual disposal costs for each of the three secondary waste treatment alternatives. The disposal costs are based on the volumes presented in Table 4.2, and assume the current low level waste disposal rate for the Hanford Site of $68.62/ft^3 (DOE 1991).

As shown, the dewatering system is least expensive in terms of both capital and annual disposal cost. Typically, the heated air system would be expected to result in the lowest annual disposal cost due to volume reduction. However, the usual application for this system is for ion exchange resins which will shrink upon drying. It is not anticipated that ion exchange resin secondary waste will be produced in the DLF. The shrinking effect is not noted in medias such as activated carbon and zeolites which will be produced as wastes in the DLF, and no annual disposal cost reductions will be realized.

For the purposes of the BAT/AKART study, the use of a dewatering system will be assumed. This system is lowest in both capital and annual disposal costs, and has been proven to be capable of producing a product which meets established waste acceptance criteria.

4.4.2.4 Liquid Brine. Of all the secondary wastestreams produced by the generic treatment alternatives, the liquid brine produced by the Alternative 4 reverse osmosis system will require the most significant treatment to meet waste acceptance criteria. Potential treatment alternatives for this stream include the following:

- Solidification;
- Evaporation and spray drying;
- Direct spray drying; and
- Wiped surface evaporation.

All of these alternatives have been previously evaluated for treatment of a liquid brine from a reverse osmosis system. This evaluation is presented in Project C-018H Waste Water Treatment Permit Engineering Report (WHC 1991e). This document concluded that evaporation was the preferred technology for treatment of liquid brine streams. The specific evaporator system was not selected, and final drying was assumed to be either centrifugation or spray drying. Because the DLF brine steam will be very similar to that evaluated for the C-018H facility, the use of evaporation and drying will be assumed for treatment of this stream.

5.0 DESCRIPTION OF ALTERNATIVES

Each of the final four candidate alternatives for process wastewater treatment are described in the following sections. The preferred secondary waste treatment processes discussed in Section 4.4.2 are assumed to be part of each of the primary treatment alternatives, as appropriate. Each of the combined primary/secondary treatment alternatives is also evaluated with respect to nine criteria. These criteria, and their characteristics, are as follows.

- Treated Water Quality - the ability of the candidate system to provide sufficient treatment in order to discharge treated effluent having contaminant concentrations at or below Comparative Levels;

- Reliability - the ability of the candidate system to have a high availability factor with regard to component replacement and complexity in terms of components replacement frequency, fouling, and potential of off-specification effluent;

- Safety - the ability of the candidate system to be maintained and operated with a minimum potential for chemical and radiation exposure to workers, the public, or the environment;

- Process Development Status - a measure of the maturity of the process technologies in terms of demonstrated experience in commercial-scale installations;

- Ease of Maintenance - the ability of each candidate system to be maintained in terms of accessibility, frequency, expected radiation dose during maintenance, spare parts, and maintenance waste production;

- Flexibility - the ability of each candidate system to respond to changes in operating conditions such as flow or concentrations which are other than those used as the facility design basis;

- Permitting - describes the challenges, cost, duration, and limits of required permitting activities;

- Interdependence - the ability of each candidate system to function with other influent and effluent processes;

- Secondary Wastes - the ability of each candidate system to minimize the number of types, volumes, and hazards of secondary wastes which require further treatment prior to their disposal; and

- Cost - a projection of capital and operating costs associated with the candidate.

5.1 PRIMARY WASTE TREATMENT ALTERNATIVES

The four candidate treatment alternatives are described in the following sections. In addition, an evaluation of the alternatives with respect to the criteria listed above is provided.

5.1.1 Process Description

The following sections review the basic unit operations and equipment which are included in each alternative. The design of each system is based on a flowrate of 100 gpm. This value is based on the production of 80,000 gallons per day of wastewater. It also assumes a two shift per day operation and an on-line factor of 85%. It has also been assumed that systems which require significant routine maintenance which results in down-time of more than several days will be provided in parallel trains capable of processing 50 gpm each. This will allow continued processing at approximately 60% of design capacity (50 gpm) if one of the trains is down for maintenance.

5.1.1.1 Alternative 1. A simplified process flow diagram for Alternative 1 is presented on Figure 5.1. The primary unit operations which are included in this alternative are as follows:

- Lint separation;
- Heat recovery;
- Flow equalization;
- Membrane microfiltration; and
- Activated carbon.

Gross solids removal will be accomplished using vibrating screens to remove lint and large particulates. The screens will be approximately 100 mesh, and will provide continuous operation due to the continuous removal of solids from the vibratory motion. The lint and other solids collected from the screen will be transferred to a hydraulic or screw press for dewatering prior to disposal.

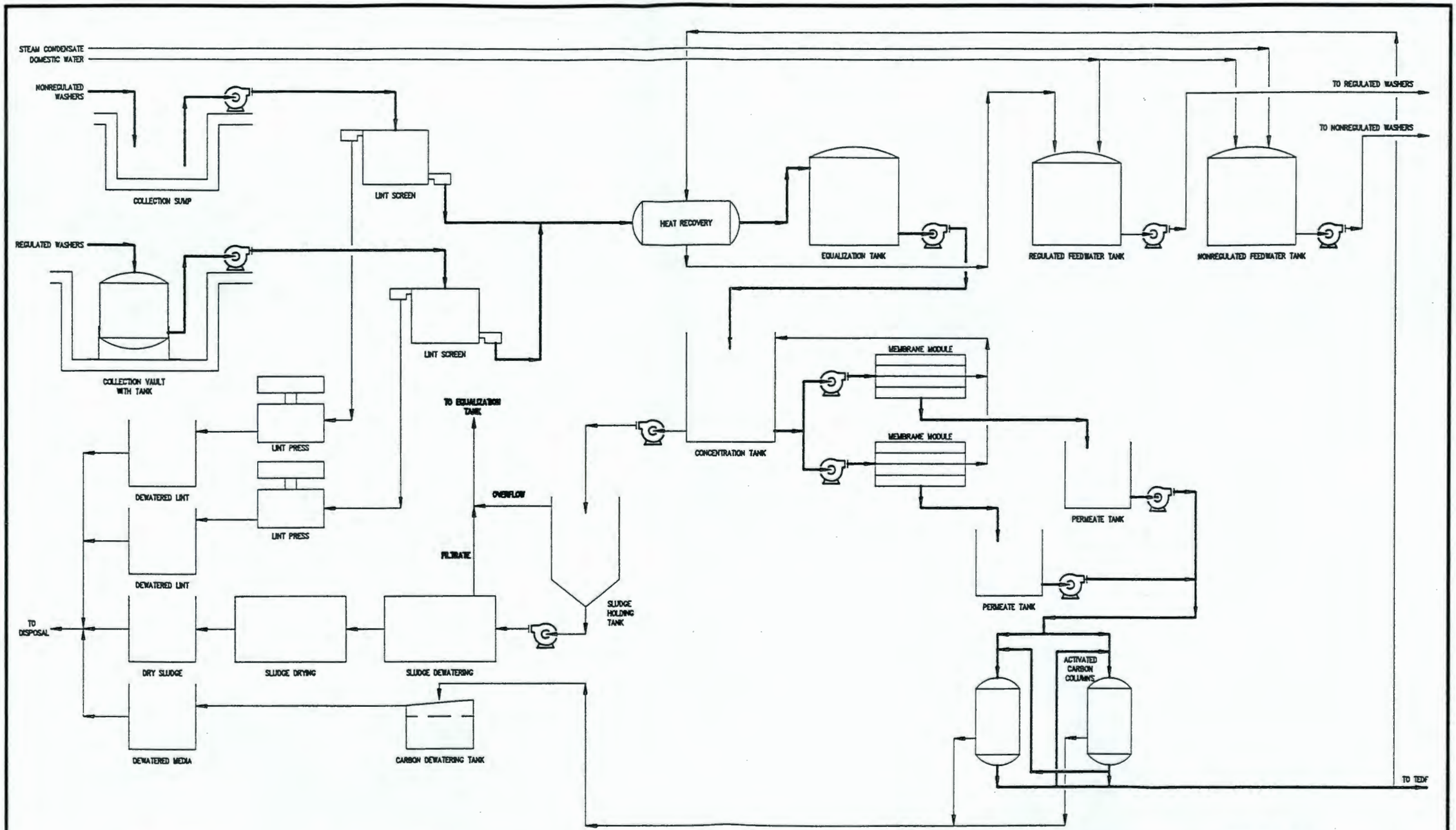


FIGURE 5.1

DWG. NO.	REFERENCE DRAWINGS

REVISIONS				
NO.	DESCRIPTION	BY	CHK.	APPR.

DRAWING STATUS	BY	DATE
DONE		
CHECKED		
PRELIMINARY		
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PROCESS FLOW DIAGRAM
GENERIC TREATMENT SYSTEM ALTERNATIVE 1

SCALE: NONE DRAWN BY: JP DATE: PROJECT LOCATION: RICHLAND, WA PROJECT #: 90104

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DRAWING NUMBER: 90104S01

Screened wastewater will be processed through a wastewater heat recovery system to an equalization tank. The heat recovery system will reduce the overall energy cost of the DLF as a whole. In addition, the wastewater will be cooled to a temperature which is optimal for wastewater treatment.

Suspended solids removal will be accomplished by membrane microfiltration. Membrane microfiltration is a pressure-driven separation process used to remove particles in the 0.1 micron size range. Microfiltration membranes function to selectively reject particles that are smaller than the pore size of the membranes.

Particles that are smaller than the pore size of the membrane pass through the membrane with the aqueous solution (permeate). As a pressure differential is applied to the membranes, permeate passes through the membrane as rejected particles concentrate in the retained liquid (concentrate).

Membranes are available in a variety of geometries and membrane materials. Membrane configurations include hollow fibers, flat sheets, spiral wound sheets or tubular forms. The majority of membranes in commercial use are made of organic polymers such as cellulose acetate, polysulfone, or polyethylene. The selection of membrane configuration is dependent upon the operational mode and influent characteristics. The membrane material selection is based primarily on compatibility of the membrane material with the stream being processed.

For this application a tubular type configuration is recommended. The tubular configuration was tested during the treatability testing conducted at the PEDF and is widely used in this type of operation. The tubular membranes are not easily plugged in the event that large particulate are present in the feed, and the system is easy to

clean and operate. Polysulfone or another material capable of tolerating oil and grease is recommended as the membrane material of construction.

Two parallel trains of membrane modules will be provided. This allows continuous processing during maintenance periods. In addition, a membrane cleaning system will be provided. The cleaning system is used to periodically remove any film or particulate which are deposited on the membrane surface. Different chemical cleaning agents can be used including detergents, hypochlorite, dilute acid, and dilute caustic. Used cleaning solutions are processed back through the system, and no additional handling of spent cleaning solutions with respect to treatment and disposal is required.

Concentrate from the membrane microfiltration system will be periodically transferred to a sludge holding tank. Thickened underflow from the tank will then be dewatered in a filter press or centrifuge, and processed through a small infrared belt dryer. Dry sludge will then be discharged directly into drums for final disposal.

Organic removal will be accomplished through the use of a granular activated carbon process. Activated carbon is most effective when used to treat single-phase aqueous organic wastes with high molecular weight and boiling point and low solubility and polarity. The carbon is not selective for one compound over another, but certain compounds will adsorb more effectively than others based on their chemical characterization. Therefore, activated carbon processes can be used to remove a variety of organics from a wastewater stream, however, the active sites of the carbon can be taken by molecules that do not require removal. This nonselectivity does not preclude the use of carbon for the removal of specific compounds to the Comparative Levels but may require the usage of large amounts of carbon if significant concentrations of organics are present that do not require removal.

The activated carbon system will use two carbon vessels operated in series. The columns will be operated at a hydraulic loading of 1 to 2 gpm/ft^2, and a minimum empty bed contact time (EBCT) of 15 minutes per column. This results in a column 8 feet in diameter with a bed depth of 4 feet and a bed volume of 200 ft^3. Overall column height will be approximately 8 feet. The columns will be operated in series, and regular sampling will be performed at a point between the two columns, to detect breakthrough. The first column will be replaced when organic compounds are detected in the effluent from the column. The second vessel then becomes the primary unit while the exhausted carbon is replaced. After the bed has been replaced, the new vessel will be operated second in the series. The columns will be operated in series to remove contaminants which breakthrough the first column, and to allow more complete saturation of the material in the first column prior to replacement.

When the activated carbon bed is exhausted, it will be transferred to a dewatering tank. After dewatering, the carbon will be loaded into drums or other suitable disposal containers for final disposition. Backwashing capabilities will be provided with each column for redistribution of the bed. Backwash water will be recycled back to the front end of the wastewater treatment plant.

5.1.1.2 Alternative 2. A simplified process flow diagram for Alternative 2 is presented in Figure 5.2. The primary unit operations included in this alternative are as follows:

- Lint separation;
- Heat recovery;
- Flow equalization;
- Chemical treatment;
- Chemical storage;

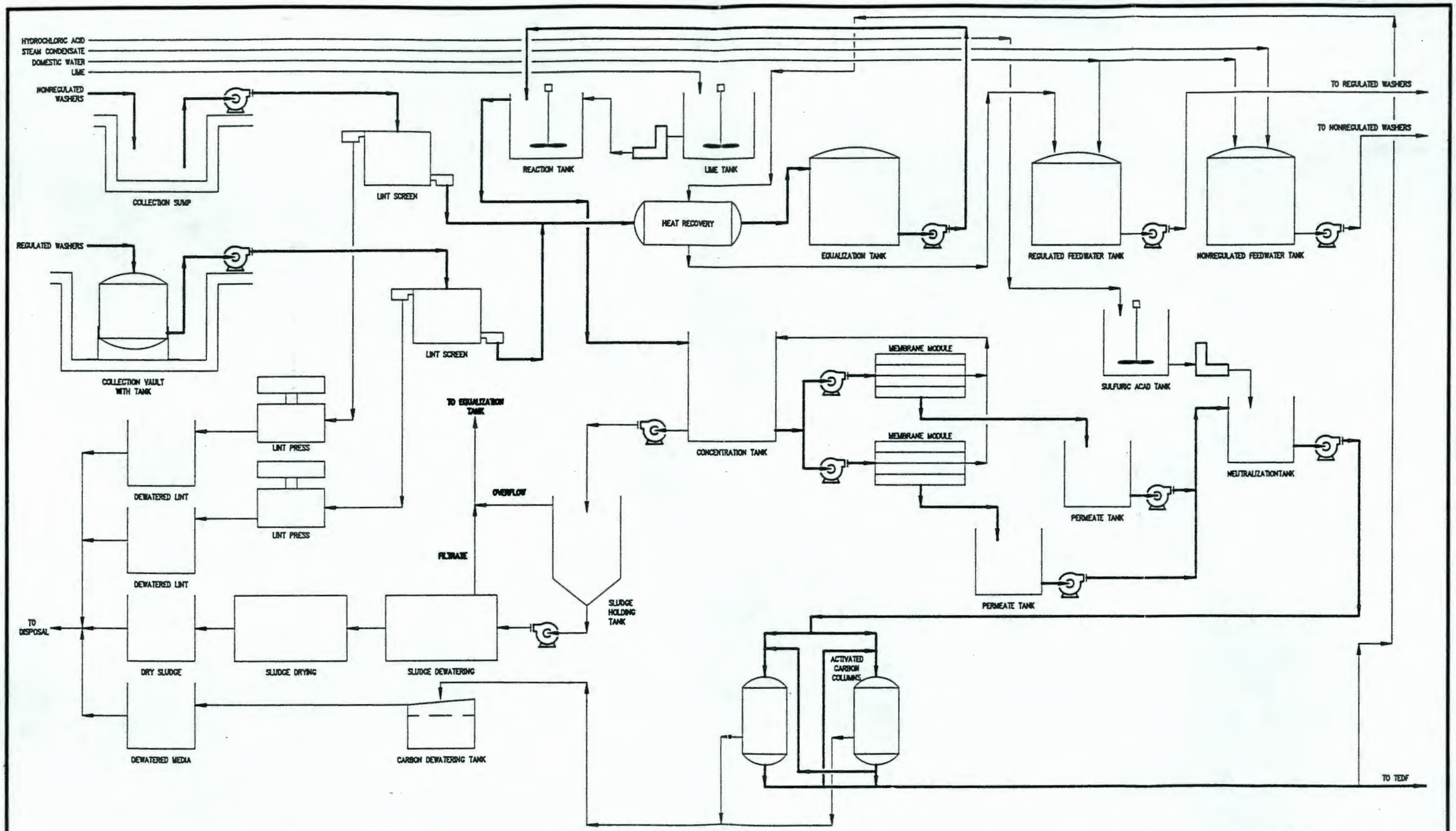

FIGURE 5.2

DWG. NO.	REFERENCE DRAWINGS

REVISIONS				
NO.	DESCRIPTION	BY	CHK.	APPD.

DRAWING STATUS	BY	DATE
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PROCESS FLOW DIAGRAM
GENERIC TREATMENT SYSTEM ALTERNATIVE 2

SCALE: NONE DRAWN BY: PROJECT LOCATION: RICHLAND, WA PROJECT #

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DRAWING NUMBER: 90104S02

- Membrane microfiltration;
- pH adjustment;
- Sludge handling; and
- Activated carbon.

Lint separation, heat recovery and flow equalization will be the same as that described for Alternative 1. Wastewater will be pumped from the equalization tank to a chemical reaction tank. This tank will have a retention time of 30 minutes, and will be baffled to promote complete mixing. A mixer will be used to keep the tank contents completely agitated.

A slurry of lime will be added to the reaction tank to precipitate metals from solution. Addition will be controlled by a pH control system interlocked with a lime metering pump. Based on the treatability study results, it is estimated that the pH in the reaction tank will be maintained at approximately 12.0.

The chemical storage system will consist of the lime mixing and feed tank, bulk lime loading, lime feed pump, and associated controls and piping. Overall lime usage is estimated at approximately 670 pounds per day, and a bulk storage silo will be used for lime storage and loading.

Wastewater will overflow from the reaction tank by gravity to a membrane concentration tank. The wastewater will then be processed through the same membrane system described for Alternative 1. The concentrate from the membrane system will be periodically transferred to the sludge handling system. This system will be the same as that described for Alternative 1 except that a larger sludge tank will be used to account for increased sludge production due to chemical precipitation.

The permeate from the membrane microfiltration system will be at an elevated pH of approximately 12.0. Therefore, neutralization to a final pH of 6.5 to 8.5 will be required to meet established Comparative Levels. This neutralization step will take place in a reaction tank with an approximate retention time of 15 minutes. A solution of sulfuric acid will be fed to the neutralization tank from an acid storage tank. Addition of acid will be controlled by a pH control system. After pH adjustment, wastewater will be processed through granular activated carbon as described for Alternative 1.

5.1.1.3 Alternative 3. A simplified process flow diagram for Alternative 3 is presented on Figure 5.3. The primary unit operations which are included in this alternative are as follows:

- Lint separation;
- Heat recovery;
- Flow equalization;
- Chemical treatment;
- Chemical storage;
- Membrane microfiltration;
- pH adjustment;
- Sludge handling;
- Zeolite ion exchange; and
- Activated carbon.

This alternative is the same as Alternative 2 with the addition of zeolite ion exchange for the removal of radioactive cesium and radioactive strontium. There are a variety of zeolites available including both natural and synthetic materials. Natural materials

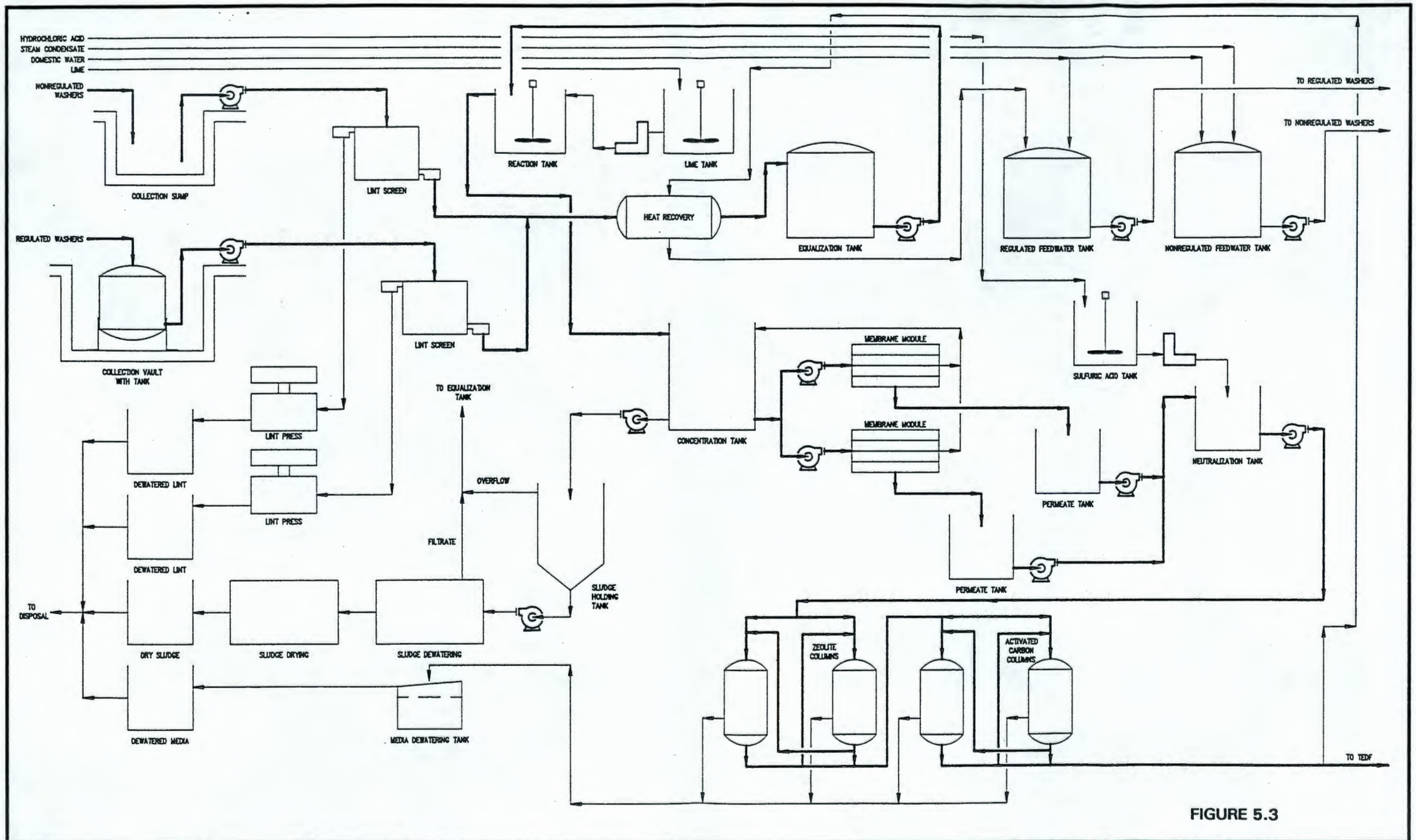

FIGURE 5.3

DWG. NO.	REFERENCE DRAWINGS

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PRELIMINARY		
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PROCESS FLOW DIAGRAM
GENERIC TREATMENT SYSTEM ALTERNATIVE 3

RTG RESOURCE TECHNOLOGIES GROUP, INC.

DEPARTMENT OF ENERGY
RICHLAND, WA

90104503

are more commonly used, and are essentially sodium aluminosilicate minerals. Based on the results of the treatability study, the natural zeolite clinoptilolite will be used.

The zeolites will be loaded into two columns operated in series, and regular sampling will be performed at a point between the two columns to detect breakthrough. The first column will be replaced when contaminants are detected in the effluent from the first column. The second vessel then becomes the primary unit while the exhausted zeolite is replaced. After the bed has been replaced, the new vessel will be operated second in this series. The columns will be operated in series to remove contaminants which breakthrough the first column, and to allow more complete saturation of the material in the first column prior to replacement.

The columns will be operated at a hydraulic loading of approximately 5gpm/ft^2. This results in a column 5 feet in diameter with a bed depth of 7 feet and a bed volume of 140 ft^3. Overall column height will be approximately 12 feet. Spent zeolites will be transferred to the same dewatering and packaging system used for the granular activated carbon.

5.1.1.4 Alternative 4. A simplified process flow schematic for Alternative 4 is presented on Figure 5.4. The primary unit operations which are included in this alternative are as follows:

- Lint separation;
- Heat recovery;
- Flow equalization;
- Chemical treatment;
- Chemical storage;
- Membrane microfiltration;

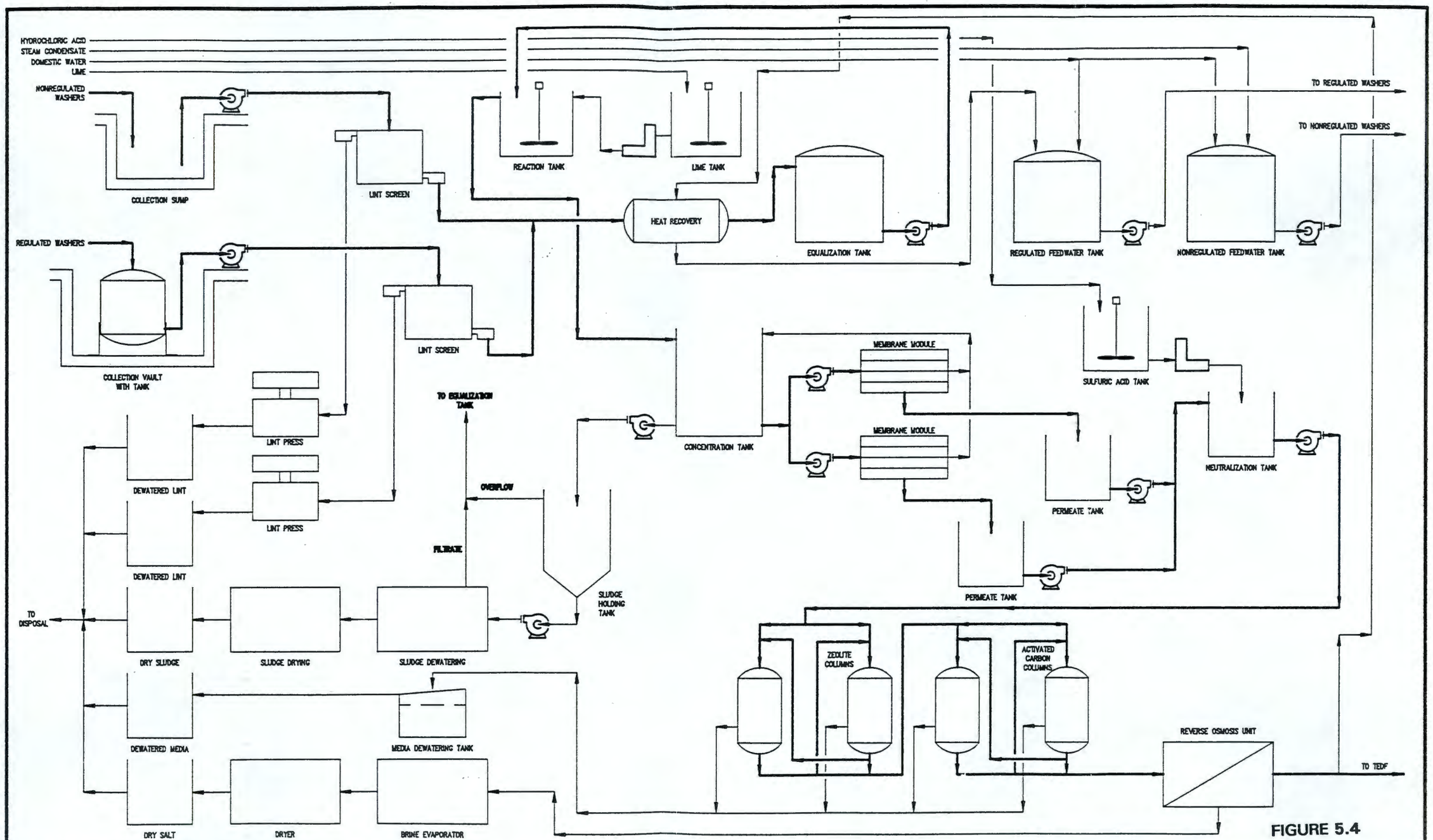

FIGURE 5.4

DWG. NO.	REFERENCE DRAWINGS

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PROCESS FLOW DIAGRAM
GENERIC TREATMENT SYSTEM ALTERNATIVE 4

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DRAWING NUMBER: 90104S04

- Sludge handling;
- Zeolite ion exchange;
- pH adjustment;
- Activated carbon;
- Reverse osmosis; and
- Liquid brine handling.

This alternative is the same as Alternative 3 with the addition of reverse osmosis to reduce total dissolved solids levels prior to discharge. Reverse osmosis is a membrane separation process that uses a semi-permeable membrane and pressure differential to separate wastewater into a clean fraction (permeate) and a concentrated fraction (brine). Reverse osmosis is capable of removing total dissolved solids including organics having a molecular weight greater than approximately 200, and will remove dissolved salts.

Reverse osmosis membrane configurations and materials of construction are similar to those discussed for the membrane microfiltration system in Alternative 1. The DLF wastewater treatment system would include a minimum of two stages, and would achieve an overall water recovery of approximately 90%. The remaining 10% of the incoming wastewater would be discharged as the concentrated brine. Two parallel trains would also be provided to ensure continued operation if one train were down for maintenance.

The liquid brine stream will be treated in an evaporator and spray dryer system. The specific type of evaporator will be determined during definitive design. Dry product from the spray dryer will be packaged in drums for final disposal.

5.1.2 Treated Water Quality

Projected treated water quality from the DLF has been estimated for each alternative by applying the calculated decontamination factors to the expected influent concentrations. The decontamination factors were determined based on treatability study data.

The projected treated water quality for each of the alternatives is summarized in Tables 5.1 through 5.4. These tables show the expected influent concentration, the projected decontamination factors, the resultant projected effluent concentrations, and Comparative Levels. The expected influent concentration was determined, as discussed in Section 2.2, from non-regulated and regulated wastewater samples. The projected decontamination factors have been determined from the treatability study data (EMC 1991c). When a constituent was removed during the treatability studies to a non-detectable concentration, the detection limit was used to calculate the projected decontamination factor and a greater-than (">") sign was assigned to the decontamination factor. The greater-than sign indicates that the contaminant was not detected, and therefore contaminant removal was greater than the calculated decontamination factor.

The projected effluent quality has been calculated by dividing the expected influent by the projected decontamination factor. Effluent qualities which have been calculated using greater-than decontamination factors have been assigned less-than signs ("<"). The less-than sign indicates that due to the greater-than decontamination factor, more of the contaminant would be removed from the wastewater resulting in less of the contaminant remaining in the treated effluent.

TABLE 5.1
PROJECTED WATER QUALITY – ALTERNATIVE 1
BEST AVAILABLE TECHNOLOGY ANALYSIS
DECONTAMINATION LAUNDRY FACILITY
WESTINGHOUSE HANFORD COMPANY, RICHLAND, WASHINGTON

Analyte	Units	Expected Influent a/	Projected Decontamination Factor	Projected Effluent Quality	Comparative Levels
Miscellaneous Data					
pH	SU	8.7 b/	– c/	–	6.5 – 8.5
Temperature	C	47 b/	–	–	–
Conductivity	µmhos	829 b/	–	–	–
Alkalinity	µg/l	348,700 b/	–	–	–
Total Dissolved Solids	µg/l	440,000	1.00	440,000	500,000
Total Suspended Solids	µg/l	193,400 b/	12.00	16,117	–
Oil and Grease	µg/l	159,333 b/	48.08	3,314	–
Inorganic Species					
Aluminum	µg/l	200 U d/	e/	200	50
Ammonia (as N)	µg/l	22,193	e/	22,193	1,300 f/
Arsenic	µg/l	70 U	e/	70	0.05
Barium	µg/l	200 U	e/	200	1,000
Boron	µg/l	100 U	e/	100	–
Cadmium	µg/l	5.0 U	e/	5.0	10
Calcium	µg/l	21,167	e/	21,167	–
Chloride	µg/l	62,667	e/	62,667	250,000
Chromium	µg/l	10.0 U	e/	10.0	50
Copper	µg/l	28.5	e/	28.5	1,000
Cyanide	µg/l	6,682 b/	e/	6,682	5.2
Fluoride	µg/l	107	e/	107	2,000
Hydrazine	µg/l	100 U	e/	100	0.03
Iron	µg/l	3,670	e/	3,670	300
Lead	µg/l	1,223	e/	1,223	50
Lithium	µg/l	100 U	e/	100	–
Magnesium	µg/l	6,013	e/	6,013	–
Manganese	µg/l	50.7	e/	50.7	50
Mercury	µg/l	0.30	e/	0.30	2
Nickel	µg/l	40.0 U	e/	40.0	100
Nitrate (as N)	µg/l	210	e/	210	10,000
Phosphate (as P)	µg/l	213,667	e/	213,667	–
Potassium	µg/l	6,013	e/	6,013	–
Selenium	µg/l	5.0 U	e/	5.0	10
Silicon	µg/l	43,267	e/	43,267	–
Silver	µg/l	10.0 U	e/	10.0	50
Sodium	µg/l	22,883	e/	22,883	–
Strontium	µg/l	100 U	e/	100	–
Sulfate	µg/l	5,000 U	e/	5,000	250,000
Sulfide	µg/l	677 b/	e/	677	14,000
Titanium	µg/l	100 U	e/	100	–
Vanadium	µg/l	50.0 U	e/	50.0	42
Zinc	µg/l	553	e/	553	5,000

TABLE 5.1 (continued)
PROJECTED WATER QUALITY – ALTERNATIVE 1
BEST AVAILABLE TECHNOLOGY ANALYSIS
DECONTAMINATION LAUNDRY FACILITY
WESTINGHOUSE HANFORD COMPANY, RICHLAND, WASHINGTON

Analyte	Units		Expected Influent		Projected Decontamination Factor		Projected Effluent Quality	Comparative Levels
Organic Species								
Acetone	µg/l		227 B		9.42		24	50
Benzoic acid	µg/l		307	>	1.80 g/	<	171	–
Benzyl alcohol	µg/l		32		1.00		32	20
bis(2-Ethylhexyl)phthalate	µg/l		400 B		2.48		161	6
Butylbenzylphthalate	µg/l		37		1.00		37	17
Chloroform	µg/l		10	>	2.20	<	5	6
Di-n-Octyl phthalate	µg/l		36 J		1.33		27	17
Phenol	µg/l		343	>	10.19	<	34	39
Total Organic Carbon	µg/l		55,000		2.93		18,778	–
Total Carbon	µg/l		116,500 b/		–		–	–
Total Organic Halides	µg/l		623 b/		–		–	–
Radionuclides								
Gross Alpha	pCi/l		111.5		ERR h/		0	15
Gross Beta	pCi/l		50,997		6.36		8,025	50
Americium-241	pCi/l		17.97		1.00		17.97	1.2 i/
Curium-244	pCi/l		ND j/		e/		–	2.4
Gamma Scan:								
Potassium-40	pCi/l		1,270		e/		1,270	280 i/
Manganese-54	pCi/l		ND		e/		–	2,000 i/
Cobalt-58	pCi/l	<	241.7		e/	<	241.7	2,000 i/
Cobalt-60	pCi/l	<	171.8		59.38	<	2.89	100
Cesium-134	pCi/l	<	99.4		1.00	<	99.41	80 i/
Cesium-137	pCi/l		53,305		1.73		30,839	200
Europium-154	pCi/l	<	343.6	>	7.59	<	45.28	800 i/
Europium-155	pCi/l		ND		1.00		–	4,000 i/
Radium-226	pCi/l		ND		1.00		–	3
Radium-228	pCi/l		ND		1.00		–	4 i/
Thorium-228	pCi/l		ND		1.00		–	16 i/
Thorium-232	pCi/l		ND		1.00		–	2 i/
Strontium-90	pCi/l		1,522		1.00		1,522	8
Total Radium	pCi/l	<	0.278		1.00	<	0.278	5
Uranium-234	pCi/l		2.646		1.00		2.646	20 i/
Uranium-235	pCi/l		0.2049		1.00		0.2049	24 i/
Uranium-238	pCi/l		1.652		1.00		1.652	24 i/
Plutonium-238	pCi/l		7.95		1.00		7.95	1.6
Plutonium-239,240	pCi/l		82.5		1.00		82.5	1.2
Lead-210	pCi/l		ND		e/		–	2,000 i/
Hydrogen-3	pCi/l		ND		e/		–	20,000
Ruthenium-106	pCi/l		ND		e/		–	30
Total Uranium	pCi/l		ND		1.00		–	40

Notes

a/ Compiled, as discussed in Section 2.2, from data presented in Tables 2.3 and 2.4.

b/ This constituent was not analyzed in the data used to prepare the expected influent, and therefore this value is taken from the design basis influent.

TABLE 5.1 (continued)
PROJECTED WATER QUALITY – ALTERNATIVE 1
BEST AVAILABLE TECHNOLOGY ANALYSIS
DECONTAMINATION LAUNDRY FACILITY
WESTINGHOUSE HANFORD COMPANY, RICHLAND, WASHINGTON

Notes (continued)

c/ Dash (–) indicates that a decontamination factor cannot be calculated, the effluent quality cannot be calculated, or a Comparative Level has not been established.

d/ U, B, and J are data qualifiers as defined by the EPA Contract Laboratory Statement of Work. Refer to Table 2.5 for an explanation of the data qualifiers.

e/ This alternative is not designed to remove dissolved species. Removal of some of these species may be accomplished if they are present as a particulate. This removal has not been considered, and the decontamination factor is assumed to be 1.00.

f/ The Comparative Level listed is as un-ionized ammonia.

g/ Greater than for the decontamination factor indicates that the compound was below detection limit in the treatability study so the detection limit was used in calculation.

h/ ERR indicates that all of the parameter is removed and therefore the decontamination is infinite.

i/ A Comparative Level is not available for this constituent. The value listed is based on 4% of Derived Concentration Guides in accordance with DOE Order 5400.5 (DOE 1990).

j/ ND = not detected.

TABLE 5.2
PROJECTED WATER QUALITY – ALTERNATIVE 2
BEST AVAILABLE TECHNOLOGY ANALYSIS
DECONTAMINATION LAUNDRY FACILITY
WESTINGHOUSE HANFORD COMPANY, RICHLAND, WASHINGTON

Analyte	Units	Expected Influent a/		Projected Decontamination Factor		Projected Effluent Quality	Comparative Levels
Miscellaneous Data							
pH	SU	8.7 b/		– c/		–	6.5 – 8.5
Temperature	C	47 b/		–		–	–
Conductivity	µmhos	829 b/		–		–	–
Alkalinity	µg/l	348,700 b/		–		–	–
Total Dissolved Solids	µg/l	440,000		1.00		440,000	500,000
Total Suspended Solids	µg/l	193,400 b/		12.00		16,117	–
Oil and Grease	µg/l	159,333 b/		48.08		3,314	–
Inorganic Species							
Aluminum	µg/l	200 U d/	>	7.55 e/	<	27	50
Ammonia (as N)	µg/l	22,193		1.09		20,428	1,300 f/
Arsenic	µg/l	70 U		10.00 g/		7	0.05
Barium	µg/l	200 U		1.00		200	1,000
Boron	µg/l	100 U		1.00		100	–
Cadmium	µg/l	5.0 U	>	4.50	<	1	10
Calcium	µg/l	21,167		h/		21,167	–
Chloride	µg/l	62,667		h/		62,667	250,000
Chromium	µg/l	10.0 U	>	3.53	<	3	50
Copper	µg/l	28.5		6.04		5	1,000
Cyanide	µg/l	6,682 b/		h/		6,682	5.2
Fluoride	µg/l	107	>	1.20	<	89	2,000
Hydrazine	µg/l	100 U		1.00		100	0.03
Iron	µg/l	3,670	>	55.87	<	66	300
Lead	µg/l	1,223		37.71		32	50
Lithium	µg/l	100 U		1.00		100	–
Magnesium	µg/l	6,013		1.00		6,013	–
Manganese	µg/l	50.7	>	6.93	<	7	50
Mercury	µg/l	0.30	>	1.65		0	2
Nickel	µg/l	40.0 U		1.00		40	100
Nitrate (as N)	µg/l	210		h/		210	10,000
Phosphate (as P)	µg/l	213,667		h/		213,667	–
Potassium	µg/l	6,013		h/		6,013	–
Selenium	µg/l	5.0 U		1.00		5	10
Silicon	µg/l	43,267		h/		43,267	–
Silver	µg/l	10.0 U		1.00		10	50
Sodium	µg/l	22,883		h/		22,883	–
Strontium	µg/l	100 U		1.00		100	–
Sulfate	µg/l	5,000 U		h/		5,000	250,000
Sulfide	µg/l	677 b/		h/		677	14,000
Titanium	µg/l	100 U		1.00		100	–
Vanadium	µg/l	50.0 U		1.00		50	42
Zinc	µg/l	553		44.51		12	5,000

TABLE 5.2 (continued)
PROJECTED WATER QUALITY – ALTERNATIVE 2
BEST AVAILABLE TECHNOLOGY ANALYSIS
DECONTAMINATION LAUNDRY FACILITY
WESTINGHOUSE HANFORD COMPANY, RICHLAND, WASHINGTON

Analyte	Units		Expected Influent a/		Projected Decontamination Factor		Projected Effluent Quality	Comparative Levels
Organic Species								
Acetone	µg/l		227 B		9.42		24	50
Benzoic acid	µg/l		307	>	1.80	<	171	–
Benzyl alcohol	µg/l		32		1.00		32	20
bis(2-Ethylhexyl)phthalate	µg/l		400 B		2.48		161	6
Butylbenzylphthalate	µg/l		37		1.00		37	17
Chloroform	µg/l		10	>	2.20	<	5	6
Di-n-Octyl phthalate	µg/l		36 J		1.33		27	17
Phenol	µg/l		343	>	10.19	<	34	39
Total Organic Carbon	µg/l		55,000		2.93		18,778	–
Total Carbon	µg/l		116,500 b/		–		–	–
Total Organic Halides (TOX)	µg/l		623 b/		–		–	–
Radionuclides								
Gross Alpha	pCi/l		111.5		ERR i/		0	15
Gross Beta	pCi/l		50,997		52.53		971	50
Americium-241	pCi/l		17.97	>	222		0	1.2 j/
Curium-244	pCi/l		ND k/		h/		–	2.4 j/
Gamma Scan:								
Potassium-40	pCi/l		1,270		h/		1,270	280 j/
Manganese-54	pCi/l		ND		h/		–	2,000 j/
Cobalt-58	pCi/l	<	241.7		h/	<	242	2,000 j/
Cobalt-60	pCi/l	<	171.8		9,717		0	100
Cesium-134	pCi/l	<	99.4		1.00	<	99	80 j/
Cesium-137	pCi/l		53,305		1.73		30,839	200
Europium-154	pCi/l	<	343.6	>	55.30	<	6	800 j/
Europium-155	pCi/l		ND		1.00		–	4,000 j/
Radium-226	pCi/l		ND		1.00		–	3
Radium-228	pCi/l		ND		1.00		–	4 j/
Thorium-228	pCi/l		ND		1.00		–	16 j/
Thorium-232	pCi/l		ND		1.00		–	2 j/
Strontium-90	pCi/l		1,522		19.24		79	8
Total Radium	pCi/l	<	0.278	>	8.16		0	5
Uranium-234	pCi/l		2.646	>	50.51		0.1	20 j/
Uranium-235	pCi/l		0.2049	>	6.84		0	24 j/
Uranium-238	pCi/l		1.652	>	44.44		0	24 j/
Plutonium-238	pCi/l		7.95	>	182		0	1.6
Plutonium-239,240	pCi/l		82.5	>	385		0.2	1.2
Lead-210	pCi/l		ND		h/		–	2,000 j/
Hydrogen-3	pCi/l		ND		h/		–	20,000
Ruthenium-106	pCi/l		ND		h/		–	30
Total Uranium	pCi/l		ND		1.00		–	40

Notes

a/ Compiled, as discussed in Section 2.2, from data presented in Tables 2.3 and 2.4.

b/ This constituent was not analyzed in the data used to prepare the expected influent, and therefore this value is taken from the design basis influent.

c/ Dash (–) indicates that a decontamination factor cannot be calculated, the effluent quality cannot be calculated, or a Comparative Level has not been established

TABLE 5.2 (continued)
PROJECTED WATER QUALITY – ALTERNATIVE 2
BEST AVAILABLE TECHNOLOGY ANALYSIS
DECONTAMINATION LAUNDRY FACILITY
WESTINGHOUSE HANFORD COMPANY, RICHLAND, WASHINGTON

Notes (continued)

d/ U, B, and J are data qualifiers as defined by the EPA Contract Laboratory Statement of Work. Refer to Table 2.5 for an explanation of the data qualifiers.

e/ Greater than for the decontamination factor indicates that the compound was below detection limit in the treatability study so the detection limit was used in calculation.

f/ The Comparative Level listed is as un-ionized ammonia.

g/ There was no arsenic in the treatability test feed therefore the removal was assumed based on literature and previous experience.

h/ Removal of these species may occur if they are precipitated from solution or are otherwise adsorbed. However, removal has not been considered, and the decontamination factor is assumed to be 1.00.

i/ ERR indicates that all of the parameter is removed and therefore the decontamination is infinite.

j/ A Comparative Level is not available for this constituent. The value listed is based on 4% of the Derived Concentration Guide in accordance with DOE Order 5400.5 (DOE 1990).

k/ ND = not detected.

TABLE 5.3
PROJECTED WATER QUALITY – ALTERNATIVE 3
BEST AVAILABLE TECHNOLOGY ANALYSIS
DECONTAMINATION LAUNDRY FACILITY
WESTINGHOUSE HANFORD COMPANY, RICHLAND, WASHINGTON

Analyte	Units	Expected Influent a/		Projected Decontamination Factor		Projected Effluent Quality	Comparative Levels
Miscellaneous Data							
pH	SU	8.7 b/		– c/		–	6.5 – 8.5
Temperature	C	47 b/		–		–	–
Conductivity	µmhos	829 b/		–		–	–
Alkalinity	µg/l	348,700 b/		–		–	–
Total Dissolved Solids	µg/l	440,000		1.00		440,000	500,000
Total Suspended Solids	µg/l	193,400 b/		12.00		16,117	–
Oil and Grease	µg/l	159,333 b/		48.08		3,314	–
Inorganic Species							
Aluminum	µg/l	200 U d/	>	7.55 e/	<	27	50
Ammonia (as N)	µg/l	22,193		1.09		20,428	1,300 f/
Arsenic	µg/l	70 U		10.00 g/		7	0.05
Barium	µg/l	200 U		1.00		200	1,000
Boron	µg/l	100 U		1.00		100	–
Cadmium	µg/l	5.0 U	>	4.50	<	1	10
Calcium	µg/l	21,167		h/		21,167	–
Chloride	µg/l	62,667		h/		62,667	250,000
Chromium	µg/l	10.0 U	>	3.53	<	3	50
Copper	µg/l	28.5		6.04		5	1,000
Cyanide	µg/l	6,682 b/		1.00		6,682	5.2
Fluoride	µg/l	107	>	1.20	<	89	2,000
Hydrazine	µg/l	100 U		1.00		100	0.03
Iron	µg/l	3,670	>	55.87	<	66	300
Lead	µg/l	1,223		37.71		32	50
Lithium	µg/l	100 U		1.00		100	–
Magnesium	µg/l	6,013		1.00		6,013	–
Manganese	µg/l	50.7	>	6.93	<	7	50
Mercury	µg/l	0.30	>	1.65		0	2
Nickel	µg/l	40.0 U		1.00		40	100
Nitrate (as N)	µg/l	210		h/		210	10,000
Phosphate (as P)	µg/l	213,667		h/		213,667	–
Potassium	µg/l	6,013		h/		6,013	–
Selenium	µg/l	5.0 U		1.00		5	10
Silicon	µg/l	43,267		h/		43,267	–
Silver	µg/l	10.0 U		1.00		10	50
Sodium	µg/l	22,883		h/		22,883	–
Strontium	µg/l	100 U		1.00		100	–
Sulfate	µg/l	5,000 U		h/		5,000	250,000
Sulfide	µg/l	677 b/		h/		677	14,000
Titanium	µg/l	100 U		1.00		100	–
Vanadium	µg/l	50.0 U		1.00		50	42
Zinc	µg/l	553		44.51		12	5,000

5.3 (continued)
PROJECTED WATER QUALITY – ALTERNATIVE 3
BEST AVAILABLE TECHNOLOGY ANALYSIS
DECONTAMINATION LAUNDRY FACILITY
WESTINGHOUSE HANFORD COMPANY, RICHLAND, WASHINGTON

Analyte	Units		Expected Influent		Projected Decontamination Factor		Projected Effluent Quality	Comparative Levels
Organic Species								
Acetone	µg/l		227 B		9.42		24	50
Benzoic acid	µg/l		307	>	1.80	<	171	–
Benzyl alcohol	µg/l		32		1.00		32	20
bis(2-Ethylhexyl)phthalate	µg/l		400 B		2.48		161	6
Butylbenzylphthalate	µg/l		37		1.00		37	17
Chloroform	µg/l		10	>	2.20	<	5	6
Di-n-Octyl phthalate	µg/l		36 J		1.33		27	17
Phenol	µg/l		343	>	10.19	<	34	39
Total Organic Carbon	µg/l		55,000		2.93		18,778	–
Total Carbon	µg/l		116,500 b/		–		–	–
Total Organic Halides (TOX)	µg/l		623 b/		–		–	–
Radionuclides								
Gross Alpha	pCi/l		111.5		ERR i/		0	15
Gross Beta	pCi/l		50,997		52.53		971	50
Americium-241	pCi/l		17.97	>	222.22		0	1.2 j/
Curium-244	pCi/l		ND k/		h/		–	2.4 j/
Gamma Scan:								
Potassium-40	pCi/l		1,270		h/		1,270	280 j/
Manganese-54	pCi/l		ND		1.42		–	2,000 j/
Cobalt-58	pCi/l	<	241.7		2.90	<	83	2,000 j/
Cobalt-60	pCi/l	<	171.8		9,717.44		0	100
Cesium-134	pCi/l	<	99.4		1.00	<	99	80 j/
Cesium-137	pCi/l		53,305		174.58		305	200
Europium-154	pCi/l	<	343.6	>	55.30	<	6	800 j/
Europium-155	pCi/l		ND		1.00		–	4,000 j/
Radium-226	pCi/l		ND		1.00		–	3
Radium-228	pCi/l		ND		1.00		–	4 j/
Thorium-228	pCi/l		ND		1.00		–	16 j/
Thorium-232	pCi/l		ND		1.00		–	2 j/
Strontium-90	pCi/l		1,522		58.03		26	8
Total Radium	pCi/l	<	0.278	>	8.16		0	5
Uranium-234	pCi/l		2.646	>	50.51		0.1	20 j/
Uranium-235	pCi/l		0.2049	>	6.84		0	24 j/
Uranium-238	pCi/l		1.652	>	44.44		0	24 j/
Plutonium-238	pCi/l		7.95	>	181.82		0	1.6
Plutonium-239,240	pCi/l		82.5	>	384.62		0.2	1.2
Lead-210	pCi/l		ND		h/		–	2,000 j/
Hydrogen-3	pCi/l		ND		h/		–	20,000
Ruthenium-106	pCi/l		ND		h/		–	30
Total Uranium	pCi/l		ND		1.00		–	40

Notes

a/ Compiled, as discussed in Section 2.2, from data presented in Table 2.3 and 2.4.

b/ This constituent was not analyzed in the data used to prepare the expected influent, and therefore this value is taken from the design basis influent.

c/ Dash (–) indicates that a decontamination factor cannot be calculated, the effluent quality cannot be calculated, or a Comparative Level has not been established.

5.3 (continued)
PROJECTED WATER QUALITY – ALTERNATIVE 3
BEST AVAILABLE TECHNOLOGY ANALYSIS
DECONTAMINATION LAUNDRY FACILITY
WESTINGHOUSE HANFORD COMPANY, RICHLAND, WASHINGTON

Notes (continued)

d/ U, B, and J are data qualifiers as defined by the EPA Contract Laboratory Statement of Work. Refer to Table 2.5 for an explanation of the data qualifiers.

e/ Greater than for the decontamination factor indicates that the compound was below detection the limit in the treatability study so the detection limit was used in calculation.

f/ The Comparative Level listed is for un-ionized ammonia.

g/ There was no arsenic in the treatability test feed, therefore the removal was assumed based on literature and previous experience.

h/ Some removal of these species may occur if they are precipitated from solution or are otherwise adsorbed. However, removal has not been considered, and the decontamination factor is assumed to be 1.00.

i/ ERR indicates that all of the parameter is removed and therefore the decontamination is infinite.

j/ A Comparative Level is not available for this constituent. The value listed is based on 4% of the Derived Concentration Guide in accordance with DOE Order 5400.5 (DOE 1990).

k/ ND = not detected.

TABLE 5.4
PROJECTED WATER QUALITY – ALTERNATIVE 4
BEST AVAILABLE TECHNOLOGY ANALYSIS
DECONTAMINATION LAUNDRY FACILITY
WESTINGHOUSE HANFORD COMPANY, RICHLAND, WASHINGTON

Analyte	Units	Expected Influent a/		Projected Decontamination Factor		Projected Effluent Quality	Comparative Levels
Miscellaneous Data							
pH	SU	8.7 b/		– c/		–	6.5 – 8.5
Temperature	C	47 b/		–		–	–
Conductivity	µmhos	829 b/		–		–	–
Alkalinity	µg/l	348,700 b/		–		–	–
Total Dissolved Solids	µg/l	440,000		21.22		20,733	500,000
Total Suspended Solids	µg/l	193,400 b/		12.00		16,117	–
Oil and Grease	µg/l	159,333 b/		48.08		3,314	–
Inorganic Species							
Aluminum	µg/l	200 U d/	>	7.55 e/	<	27	50
Ammonia (as N)	µg/l	22,193		5.54		4,003	1,300 f/
Arsenic	µg/l	70 U		10.00 g/		7	0.05
Barium	µg/l	200 U		1.00		200	1,000
Boron	µg/l	100 U		1.00		100	–
Cadmium	µg/l	5.0 U	>	5.67	<	1	10
Calcium	µg/l	21,167	>	4.43	<	4,777	–
Chloride	µg/l	62,667	>	23.98	<	2,613	250,00[illegible]
Chromium	µg/l	10.0 U	>	3.53	<	3	[illegible]
Copper	µg/l	28.5		6.04		5	1,00[illegible]
Cyanide	µg/l	6,682 b/		1.00		6,682	5.2
Fluoride	µg/l	107	>	1.20	<	89	2,000
Hydrazine	µg/l	100 U		1.00		100	0.03
Iron	µg/l	3,670		147.61		25	300
Lead	µg/l	1,223	>	5,095.94		0	50
Lithium	µg/l	100 U		1.00		100	–
Magnesium	µg/l	6,013	>	1.05	<	5,716	–
Manganese	µg/l	50.7	>	16.32	<	3	50
Mercury	µg/l	0.30	>	4.13		0	2
Nickel	µg/l	40.0 U		1.00		40	100
Nitrate (as N)	µg/l	210	>	1.90	<	111	10,000
Phosphate (as P)	µg/l	213,667		18.58		11,497	–
Potassium	µg/l	6,013		1.00		6,013	–
Selenium	µg/l	5.0 U		1.00		5	10
Silicon	µg/l	43,267		19.55		2,214	–
Silver	µg/l	10.0 U		1.00		10	50
Sodium	µg/l	22,883	>	3.78	<	6,055	–
Strontium	µg/l	100 U		1.00		100	–
Sulfate	µg/l	5,000 U		4.43 h/		1,129	250,000
Sulfide	µg/l	677 b/		1.00		677	14,000
Titanium	µg/l	100 U		1.00		100	–
Vanadium	µg/l	50.0 U	>	21.01	<	2	42
Zinc	µg/l	553		44.51		12	5,[illegible]

TABLE 5.4 (continued)
PROJECTED WATER QUALITY – ALTERNATIVE 4
BEST AVAILABLE TECHNOLOGY ANALYSIS
DECONTAMINATION LAUNDRY FACILITY
WESTINGHOUSE HANFORD COMPANY, RICHLAND, WASHINGTON

Analyte	Units		Expected Influent a/		Projected Decontamination Factor		Projected Effluent Quality	Comparative Levels
Organic Species								
Acetone	µg/l		227 B		9.42		24	50
Benzoic acid	µg/l		307	>	1.80	<	171	–
Benzyl alcohol	µg/l		32		1.00		32	20
bis(2-Ethylhexyl)phthalate	µg/l		400 B		2.48		161	6
Butylbenzylphthalate	µg/l		37		1.00		37	17
Chloroform	µg/l		10	>	2.20	<	5	6
Di-n-Octyl phthalate	µg/l		36 J		1.33		27	17
Phenol	µg/l		343	>	10.19	<	34	39
Total Organic Carbon	µg/l		55,000		2.93		18,778	–
Total Carbon	µg/l		116,500		–		–	–
Total Organic Halides (TOX)	µg/l		623		–		–	–
Radionuclides								
Gross Alpha	pCi/l		111.5		ERR i/		0	15
Gross Beta	pCi/l		50,997		781.72		65	50
Americium-241	pCi/l		17.97	>	27,100.27		0	1.2 j/
Curium-244	pCi/l		ND k/		l/		–	2.4 j/
Gamma Scan:								
Potassium-40	pCi/l		1,270		l/		1,270	280 j/
Manganese-54	pCi/l		ND		ERR		–	2,000 j/
Cobalt-58	pCi/l	<	241.7		2.90	<	83	2,000 j/
Cobalt-60	pCi/l	<	171.8		9,717.44		0	100
Cesium-134	pCi/l	<	99.4		1.00	<	99	80 j/
Cesium-137	pCi/l		53,305		1,744.73		31	200
Europium-154	pCi/l	<	343.6	>	55.30	<	6	800 j/
Europium-155	pCi/l		ND		1.00		–	4,000 j/
Radium-226	pCi/l		ND		1.00		–	3
Radium-228	pCi/l		ND		1.00		–	4 j/
Thorium-228	pCi/l		ND		1.00		–	16 j/
Thorium-232	pCi/l		ND		1.00		–	2 j/
Strontium-90	pCi/l		1,522		36,134.73		0	8
Total Radium	pCi/l	<	0.278		ERR		0	5
Uranium-234	pCi/l		2.646	>	952.93		0	20 j/
Uranium-235	pCi/l		0.2049	>	12.89		0	24 j/
Uranium-238	pCi/l		1.652	>	542.01		0	24 j/
Plutonium-238	pCi/l		7.95	>	2,222.72		0	1.6
Plutonium-239,240	pCi/l		82.5	>	226,244.3		0	1.2
Lead-210	pCi/l		ND		l/		–	2,000 j/
Hydrogen-3	pCi/l		ND		l/		–	20,000
Ruthenium-106	pCi/l		ND		l/		–	30
Total Uranium	pCi/l		ND		l/		–	40

Notes

a/ Compiled, as discussed in Section 2.2, from data presented in Tables 2.3 and 2.4.

b/ This constituent was not analyzed in the data used to prepare the expected influent, and therefore this value is taken from the design basis influent.

c/ Dash (–) indicates that a decontamination factor cannot be calculated, the effluent quality cannot be calculated, or a Comparative Level has not been established.

TABLE 5.4 (continued)
PROJECTED WATER QUALITY – ALTERNATIVE 4
BEST AVAILABLE TECHNOLOGY ANALYSIS
DECONTAMINATION LAUNDRY FACILITY
WESTINGHOUSE HANFORD COMPANY, RICHLAND, WASHINGTON

Notes (continued)

d/ U, B, and J are data qualifiers as defined by the EPA Contract Laboratory Statement of Work. Refer to Table 2.5 for an explanation fo the data qualifiers.

e/ Greater than for the decontamination factor indicates that the compound was below detection the limit in the treatability study so the detection limit was used in calculation.

f/ The Comparative Level listed is as un-ionized ammonia.

g/ There was no arsenic in the treatability test feed therefore the removal was assumed based on literature and previous experience.

h/ The removal efficiency was based on the removal efficiency for calcium.

i/ ERR indicates that all of the parameter is removed and therefore the decontamination is infinite.

j/ A Comparative Level is not available for this constituent. The value listed is based on 4% of the Derived Concentration Guide in accordance with DOE Order 5400.5 (DOE 1990).

ND = not detected.

Some removal of these species may occur if they are precipitated from solution or are otherwise adsorbed. However, removal has not been considered, and the decontamination factor is assumed to be 1.00.

Table 5.5 summarizes the species for each alternative which are projected to exceed Comparative Levels. As shown in this table, none of the alternatives meet all of the Comparative Levels. Comparative Levels are exceeded by Alternative 1 for 21 species, and include 9 inorganics, 4 organics, and 8 radionuclides. Alternative 2 removes aluminum, iron, lead, manganese, americium-241, plutonium-238, and plutonium 239, 240, in addition to the constituents removed by Alternative 1. Alternative 2 therefore reduces the number of exceedances to 14 species, including 5 inorganics, 4 organics, and 5 radionuclides. Although cesium-137 and strontium-90 concentrations are greatly reduced, Alternative 3 also has 14 exceedances. Alternative 4 further reduces cesium-137 and strontium-90 concentrations, and also removes vanadium. Alternative 4 therefore reduces the number of exceedances to 11, including 4 inorganics, 4 organics, and 3 radionuclide. The potential significance of these exeedances are summarized in the following paragraphs.

5.1.2.1 Aluminum. The aluminum Comparative Level is exceeded by Alternative 1 only. However, the expected influent value is a less than detection limit value. Alternative 2, 3, and 4, all achieve the Comparative Level.

5.1.2.2 Ammonia. None of the four alternatives meet the Comparative Level for ammonia. However, it is expected that some additional removal beyond that shown will be realized by Alternative 2 due to the use of chemical precipitation. The high pH conditions used in this alternative should volatilize a portion of the ammonia. Alternative 3 and 4 should remove the additional ammonia in the zeolite system. Zeolite ion exchange is a well understood process for the removal of ammonia from wastewater (EPA 1975). Ammonia was not analyzed for in samples from the zeolite columns during the treatability study.

TABLE 5.5
COMPARATIVE LEVELS EXCEEDANCES
BEST AVAILABLE TECHNOLOGY ANALYSIS
DECONTAMINATION LAUNDRY FACILITY
WESTINGHOUSE HANFORD COMPANY, RICHLAND, WASHINGTON

Analyte	Units	Expected Influent a/	Comparative Levels	Alternative 1 Projected Effluent Quality	Alternative 2 Projected Effluent Quality	Alternative 3 Projected Effluent Quality	Alternative 4 Projected Effluent Quality
Miscellaneous							
pH	SU	8.7 b/	6.5 – 8.5	– c/	–	–	–
Temperature	C	47 b/	–	–	–	–	–
Conductivity	µmhos	829 b/	–	–	–	–	–
Alkalinity	µg/l	348,700 b/	–	–	–	–	–
Total Dissolved Solids	µg/l	440,000	500,000	440,000	440,000	440,000	20,733
Total Suspended Solids	µg/l	193,400 b/	–	16,117	16,117	16,117	16,117
Oil and Grease	µg/l	159,333 b/	–	3,314	3,314	3,314	3,314
Inorganic Species							
Aluminum	µg/l	200 U d/	50	200 e/	< 27	< 27	< 27
Ammonia (as N)	µg/l	22,193	1,300 f/	22,193	20,428	20,428	4,003
Arsenic	µg/l	70 U	0.05	70	7	7	7
Barium	µg/l	200 U	1,000	200	200	200	200
Boron	µg/l	100 U	–	100	100	100	100
Cadmium	µg/l	5.0 U	10	5	< 1	< 1	< 1
Calcium	µg/l	21,167	–	21,167	21,167	21,167	< 4,777
Chloride	µg/l	62,667	250,000	62,667	62,667	62,667	< 2,613
Chromium	µg/l	10.0 U	50	10	< 3	< 3	< 3
Copper	µg/l	28.5	1,000	28	5	5	5
Cyanide	µg/l	6,682 b/	5.2	6,682	6,682	6,682	6,682
Fluoride	µg/l	107	2,000	107	< 89	< 89	< 89
Hydrazine	µg/l	100 U	0.03	100	100	100	100
Iron	µg/l	3,670	300	3,670	< 66	< 66	25
Lead	µg/l	1,223	50	1,223	32	32	0
Lithium	µg/l	100 U	–	100	100	100	100

TABLE 5.5 (continued)
COMPARATIVE LEVELS EXCEEDANCES
BEST AVAILABLE TECHNOLOGY ANALYSIS
DECONTAMINATION LAUNDRY FACILITY
WESTINGHOUSE HANFORD COMPANY, RICHLAND, WASHINGTON

Analyte	Units	Expected Influent a/	Comparative Levels	Alternative 1 Projected Effluent Quality	Alternative 2 Projected Effluent Quality	Alternative 3 Projected Effluent Quality	Alternative 4 Projected Effluent Quality
Inorganic Species (continued)							
Magnesium	µg/l	6,013	–	6,013	6,013	6,013	< 5,716
Manganese	µg/l	50.7	50	50.7	< 7	< 7	< 3
Mercury	µg/l	0.30	2	0.30	0.18	< 0.18	< 0.07
Nickel	µg/l	40.0 U	100	40	40	40	40
Nitrate (as N)	µg/l	210	10,000	210	210	210	< 111
Phosphate (as P)	µg/l	213,667	–	213,667	213,667	213,667	11,497
Potassium	µg/l	6,013	–	6,013	6,013	6,013	6,013
Selenium	µg/l	5.0 U	10	5	5	5	5
Silicon	µg/l	43,267	–	43,267	43,267	43,267	2,214
Silver	µg/l	10.0 U	50	10	10	10	10
Sodium	µg/l	22,883	–	22,883	22,883	22,883	< 6,055
Strontium	µg/l	100 U	–	100	100	100	100
Sulfate	µg/l	5,000 U	250,000	5,000	5,000	5,000	1,129
Sulfide	µg/l	677 b/	14,000	677	677	677	677
Titanium	µg/l	100 U	–	100	100	100	100
Vanadium	µg/l	50.0 U	42	50	50	50	< 2
Zinc	µg/l	553	5,000	553	12	12	12
Organic Species							
Acetone	µg/l	227 B	50	24	24	24	24
Benzoic acid	µg/l	307	–	< 171	< 171	< 171	< 171
Benzyl alcohol	µg/l	32	20	32	32	32	32
bis(2–Ethylhexyl)phthalate	µg/l	400 B	6	161	161	161	161
Butylbenzylphthalate	µg/l	37	17	37	37	37	37

TABLE 5.5 (continued)
COMPARATIVE LEVELS EXCEEDANCES
BEST AVAILABLE TECHNOLOGY ANALYSIS
DECONTAMINATION LAUNDRY FACILITY
WESTINGHOUSE HANFORD COMPANY, RICHLAND, WASHINGTON

Analyte	Units	Expected Influent a/	Comparative Levels	Alternative 1 Projected Effluent Quality	Alternative 2 Projected Effluent Quality	Alternative 3 Projected Effluent Quality	Alternative 4 Projected Effluent Quality
Organic Species (continued)							
Chloroform	µg/l	10	6	< 5	< 5	< 5	< 5
Di-n-Octyl phthalate	µg/l	36 J	17	27	27	27	27
Phenol	µg/l	343	39	< 34	< 34	< 34	< 34
Total Organic Carbon	µg/l	55,000	–	18,778	18,778	18,778	18,778
Total Carbon	µg/l	116,500 b/	–	–	–	–	–
Total Organic Halides	µg/l	623 b/	–	–	–	–	–
Radionuclides							
Gross Alpha	pCi/l	111.5	15	0	0	0	0
Gross Beta	pCi/l	50,997	50	8,025	971	971	65
Americium-241	pCi/l	17.97	1.2 g/	18	0	0	0
Curium-244	pCi/l	ND h/	2.4 g/	–	–	–	–
Gamma Scan:							
Potassium-40	pCi/l	1,270	280 g/	1,270	1,270	1,270	1,270
Manganese-54	pCi/l	ND	2,000 g/	–	–	–	–
Cobalt-58	pCi/l	< 241.7	2,000 g/	< 242	< 242	< 83	< 83
Cobalt-60	pCi/l	< 171.8	100	< 3	0	0	0
Cesium-134	pCi/l	< 99.4	80 g/	< 99	< 99	< 99	< 99
Cesium-137	pCi/l	53,305	200	30,839	30,839	305	31
Europium-154	pCi/l	< 343.6	800 g/	< 45	< 6	< 6	< 6
Europium-155	pCi/l	ND	4,000 g/	–	–	–	–
Radium-226	pCi/l	ND	3	–	–	–	–
Radium-228	pCi/l	ND	4 g/	–	–	–	–
Thorium-228	pCi/l	ND	16 g/	–	–	–	–

TABLE 5.5 (continued)
COMPARATIVE LEVELS EXCEEDANCES
BEST AVAILABLE TECHNOLOGY ANALYSIS
DECONTAMINATION LAUNDRY FACILITY
WESTINGHOUSE HANFORD COMPANY, RICHLAND, WASHINGTON

Analyte	Units	Expected Influent a/	Comparative Levels	Alternative 1 Projected Effluent Quality	Alternative 2 Projected Effluent Quality	Alternative 3 Projected Effluent Quality	Alternative 4 Projected Effluent Quality
Thorium-232	pCi/l	ND	2 g/	–	–	–	–
Strontium-90	pCi/l	1,522	8	1,522	79	26	0
Total Radium	pCi/l	< 0.278	5	< 0.278	0.0	0.0	0
Uranium-234	pCi/l	2.646	20 g/	2.646	0.1	0.1	0
Uranium-235	pCi/l	0.2049	24 g/	0.2049	0.0	0.0	0
Uranium-238	pCi/l	1.652	24 g/	1.652	0.0	0.0	0
Plutonium-238	pCi/l	7.95	1.6	7.95	0.0	0.0	0
Plutonium-239,240	pCi/l	82.5	1.2	82.5	0.2	0.2	0
Lead-210	pCi/l	ND	2,000 g/	–	–	–	–
Hydrogen-3	pCi/l	ND	20,000	–	–	–	–
Ruthenium-106	pCi/l	ND	30	–	–	–	–
Total Uranium	pCi/l	ND	40	–	–	–	–

Notes

a/ Compiled, as discussed in Section 2.2, from data presented in Tables 2.3 and 2.4.
b/ This constituent was not analyzed in the data used to prepare the expected influent, and therefore this value is taken from the design basis influent.
c/ Dash (–) indicates that the effluent quality for this constituent cannot be calculated, or that a Comparative Level has not been established.
d/ U, B, and J are data qualifiers as defined by the EPA Contract Laboratory Statement of Work. Refer to Table 2.5 for an explanation fo the data qualifiers.
e/ Shading of the constituent effluent qualities indicates that the constituent concentration exceeds Comparative Levels.
f/ The Comparative Level is for un-ionized ammonia.
g/ A Comparative Level is not available for this constituent. The value listed is based on 4% of the Derived Concentration Guide in accordance with DOE Order 5400.5 (DOE 1990).
h/ ND = not detected.

In addition to the technical factors discussed above, the source of the Comparative Level should be considered. The Comparative Level is actually a surface water standard. Typically, ammonia is only of major concern in a surface water environment due to toxicity to aquatic life. The treated effluent from the DLF will actually be discharged to a ground water system.

5.1.2.3 Arsenic. None of the four alternatives could achieve the Comparative Level for arsenic of 0.05 µg/l. However, the 0.05 µg/l value is not detectable by current state-of-the-art analytical equipment. The arsenic limit most often used for permitting of industrial wastewater systems is the Federal MCL of 10 µg/l. The technology proposed for Alternative 2, 3, and 4 are all capable of achieving effluent concentrations less than this value. It is assumed that the 0.05 µg/l Comparative Level would actually be applied at the point of compliance, not at the actual end of pipe. The end of pipe concentration would be a calculated value based on expected dispersion between the end of pipe and the compliance point.

5.1.2.4 Cyanide. None of the four alternatives meet the cyanide Comparative Level. However, cyanide was not analyzed for in the treatability study samples as it was not expected to be present. Therefore, actual removal efficiencies for cyanide cannot be determined. A review of the data shows that cyanide is consistently present in the wastewater. The consistent levels imply a consistent source, and it is not likely that this source is the protective clothing. A review of chemistry information indicates that some bleaches and whiteners used in laundry washing can contain isocyanate compounds. Therefore, it is believed that this may be the source of the cyanide. Specifications for the procurement of DLF laundry chemicals should preclude the use of cyanide containing compounds.

5.1.2.5 Hydrazine. The hydrazine Comparative Level is not met by any of the alternatives. However, similar to arsenic, the hydrazine Comparative Level is well below the capability of current analytical methods. In addition, hydrazine was not actually detected in the wastewater at the detection limit of 100 µg/l. Based on the activities that take place at the Hanford Site, hydrazine would not normally be expected to be present as contamination on protective clothing.

5.1.2.6 Iron. The iron Comparative Level is exceeded by Alternative 1, but is met by all other alternatives. This would be expected as these other alternatives are specifically designed to remove metals such as iron.

5.1.2.7 Lead. The lead Comparative Level is exceeded by Alternative 1, but is met by all other alternatives. Similar to iron, these results would normally be expected.

5.1.2.8 Manganese. The manganese Comparative Level is exceeded by Alternative 1 by only about 1.4%, and is met by all other alternatives. The additional removal by Alternatives 2, 3, and 4 would be expected as manganese is removed by a mechanism similar to iron and lead.

5.1.2.9 Vanadium. The vanadium Comparative Level is exceeded by Alternatives 1, 2, and 3 by approximately 20%, and is met by Alternative 4. However, the expected influent concentration for vanadium is based on a less than detection limit value.

5.1.2.10 Organic Species. There are four organic species whose Comparative Levels are exceeded by all four alternatives. One of these species (bis (2-ethylhexyl) phthalate) is a common contaminant from the leaching of plastic. Decontamination

factors for the other three contaminants were low due to the high TOC concentrations. It is expected that some removal of all four compounds will occur in the full scale system because of the long contact time afforded by the use of two granular activated carbon columns operated in series.

5.1.2.11 Gross Beta. The gross beta Comparative Level is not met by any of the four alternatives. However, Alternatives 2 and 3 remove a significant portion of the gross beta activity not removed by Alternative 1. Alternative 4 removes additional gross beta activity. The usual gross beta limit observed in industry is based on dose and not on concentration. Furthermore, it typically assumes only man-made radionuclides, and excludes those radionuclides which occur naturally (i.e., potassium-40). The other data in Table 5.5 show that the primary beta-emitting radionuclides (strontium-90, cesium-137) are removed quite well by Alternatives 2, 3, and 4.

5.1.2.12 Cesium-134. The cesium-134 Comparative Level is exceeded by all four alternatives. However, the projected effluent quality is the same as the estimated influent because cesium-134 was below the detection limit of 99 pCi/l for all samples. Some removal of cesium-134 will actually occur through the use of the zeolite system. The treatability study showed excellent removal of cesium-137 by the use of this process.

5.1.2.13 Cesium-137. The cesium-137 Comparative Level is exceeded by all alternatives except Alternative 4. A significant decrease in cesium-137 is observed for Alternative 3. This alternative utilizes zeolites for the specific removal of cesium. It should be noted that the expected influent value of 53,305 pCi/l may be high due to an anomalous concentration as discussed in Section 2.2.

5.1.2.14 Potassium-40. None of the four alternatives meet the potassium-40 Comparative Level. This is expected as no removal processes were considered for the removal of non-radioactive potassium which does not have a Comparative Level. Potassium removal is not typically considered in industrial wastewater treatment. Furthermore, potassium-40 is a naturally occurring radionuclide and is typically not considered in drinking water regulations.

5.1.2.15 Strontium-90. The strontium-90 Comparative Level is exceeded by all alternatives except Alternative 4. A significant portion of the strontium-90 is removed by Alternative 2, although the Comparative Levels is not met. Additional strontium-90 is removed by both Alternatives 3 and 4. Some additional strontium removal may actually occur in the DLF due to the use of two zeolite columns in series for Alternative 3 and 4.

5.1.2.16 Plutonium. The plutonium Comparative Levels are exceeded by Alternative 1, but are met by all other alternatives. This behavior is expected as precipitation and/or adsorption of plutonium should occur for the alternatives utilizing chemical precipitation.

5.1.3 Reliability

Each of the alternatives under consideration utilize well developed processes, and the equipment proposed to be used is commercially available. As such, the overall reliability of each alternative should be good.

Alternative 1 should be most reliable as it primarily includes passive treatment processes which can function without frequent operator attention, or which do not rely on chemical processes which require sophisticated control systems. These

passive processes include lint separation, heat recovery, and membrane microfiltration. The most complex unit operation in this alternative is the membrane microfiltration system. This system includes membrane cleaning, sludge transfer, and permeate handling. However, all of these systems are well developed, and typical failure modes have been identified and accounted for in equipment design.

This alternative will be reliable in producing water which meets specification with respect to contaminants for which it is designed. For example, this unit will consistently remove suspended solids by filtration. However, this unit will not be capable of removing dissolved contaminants. Therefore, if a particular dissolved species which meets specification suddenly increased in concentration, that species would not be removed from solution, and an off-specification effluent could be produced.

Alternative 2 would be slightly less reliable than Alternative 1 because of the addition of a chemical treatment system and associated chemical storage and feed systems. All equipment incorporated into these additional systems is commercially available, and relatively simple. However, there are additional pieces of rotating equipment included in this alternative which will require maintenance, or which could fail. In addition, the pH control system will require routine cleaning and calibration.

This alternative may be less reliable than Alternative 1 in terms of operation and maintenance, but will be more reliable than Alternative 1 in removing contaminants. The use of chemical precipitation will remove dissolved contaminants (primarily metals and radionuclides), as well as improve filtration performance for removal of contaminants present as particulates. Provided a significant change in influent characteristics does not occur, consistent removal of both dissolved and particulate contaminants should occur. Therefore, on an overall basis (operations and

maintenance, and contaminant removal) Alternative 2 is judged to be equal to Alternative 1.

Alternative 3 adds a second adsorption process (zeolites) to remove radioactive cesium and strontium. A zeolite system is quite passive, and requires no control other than monitoring for high differential pressure to initiate a backwash cycle. Backwashing is included as a means to redistribute the bed rather than as regeneration step because spent media will be replaced. Backwash water volumes should be relatively small containing only fines and will be returned to the head of the wastewater treatment plant. This process is virtually identical to the activated carbon process, and has no rotating equipment associated with it. Because the zeolite system adds a relatively small amount of complexity in comparison to Alternative 2, the overall reliability of Alternatives 2 and 3 are similar.

Alternative 4 is the most complex process due to the addition of the reverse osmosis system and liquid brine treatment system. Reverse osmosis membranes are more sensitive to process upsets than microfiltration membranes, and require more care and maintenance. In addition, the liquid brine system includes multiple pieces of equipment and complex control systems. Reliability in terms of meeting specifications for this alternative, will be similar to both Alternative 2 and Alternative 3. However, the overall reliability of Alternative 4 will be lower than any other alternative.

5.1.4 Safety

Potential safety hazards associated with all four alternatives include the hazards associated with handling strong chemicals, potential exposures to fugitive waste releases, moderately high pressures, and possible exposure to penetrating radiation and airborne radionuclides during maintenance. However, all these hazards can be

accounted for in the design phase through design of chemical containment systems, adequate leak protection systems through proper selection of materials of construction, and provisions for remote equipment flushing and clean-out.

Alternative 1 does not have any particular safety concerns other than those described above. The only chemicals which are used will be the membrane cleaning solutions.

Alternative 2 has additional safety concerns due to the use of multiple chemicals including a lime slurry, neutralization acid, and cleaning chemicals. All of these chemicals are commonly used in industrial wastewater applications, and safety requirements to be incorporated into facility design are well understood.

Alternative 3 is the same as Alternative 2 in terms of safety as no additional chemicals and a limited amount of extra equipment is included.

Alternative 4 has several significant safety concerns due to the use of the evaporator and dryer systems. These systems require operation at high temperatures and pressures and include multiple vapor (steam) streams. A substantial amount of high temperature equipment would also be required for this alternative.

5.1.5 Process Development Status

All four alternatives are well developed and understood, and no additional development would be required. The results of the treatability study will allow definitive design to commence.

5.1.6 Ease of Maintenance

Alternatives 1, 2 and 3 all utilize similar equipment in terms of maintenance. The equipment includes pumps, mixers, membrane systems, sludge and spent media handling systems, and controls. All of this equipment is easily maintained, and a predetermined maintenance schedule can be developed. The primary difference between the three alternatives is the additional chemical treatment equipment and large sludge handling equipment associated with Alternative 2 and Alternative 3. Alternatives 2 and 3 also have additional chemical treatment and control systems which will require refilling, cleaning, and calibration.

Alternative 3 includes an additional column system (zeolite) that will increase usage, and therefore maintenance, of the fresh media and spent media systems. A more extensive control system will also be required for Alternative 3 so that a common fresh and spent media system can be used for both the carbon and zeolite columns.

Alternative 4 will be much more difficult to maintain than any of the other three alternatives due to the complex evaporation and drying systems. This alternative contains a number of pieces of rotating equipment, as well as several sophisticated control systems. This equipment will require additional maintenance on both mechanical and electrical systems. In addition, control systems will require maintenance in terms of instrument calibration and replacement.

None of the four alternatives will require extensive spare parts inventories. However, all four alternatives will require a periodic replacement of microfiltration membranes. Alternative 4 will also require periodic replacement of the reverse osmosis membranes.

5.1.7 Flexibility

Alternative 1 would be the least affected alternative by changes in flow, as membrane microfiltration is a passive physical process. Membrane microfiltration will also tolerate changes in contaminants for which it is designed (i.e.,suspended solids) as it accomplishes removal through the use of a physical barrier. Significant increases or decreases in flow may decrease the efficiency of the granular activated carbon process due to channeling or reduced EBCT. Extremely low flow rates may cause incomplete distribution of flow throughout the bed and allow short circuiting, while extremely high flow rates will not allow enough contact time for the design equilibrium to be reached and contaminants may not be removed to the required levels. Columns are generally sized to efficiently handle a range of flow rates, and further, the two columns will be operated in series to remove contaminants which are not removed by the first column. The use of two columns allows for changes in contaminant concentrations as the second column will remove leakage of contaminants from the first column. The high TOC present in the wastewater may cause biofouling problems with the column processes. The media, however, requires replacement frequently enough to eliminate this concern.

Alternative 2 is not as flexible as Alternative 1 in terms of flow. The Alternative 2 reaction systems will be designed for a specific flowrate. Increases in this flow would reduce reaction tank residence time, and could result in decreased precipitation of toxic metals and radionuclides. Decreases in flow would not impact the performance of this alternative except for the possibility of channeling in the activated carbon column.

Alternative 2 is moderately flexible with respect to handling increased contaminant concentrations. The chemical feed system can be adjusted to feed additional

treatment chemicals (i.e., lime) if the concentration of metals and/or radionuclides which are removed by precipitation increase. Unfortunately, such an adjustment (except as dictated by pH) would not be made until after a problem with treated effluent quality had already been produced. Alternative 2 can adjust quite well to changes in organic concentrations due to the use of two columns in series. While carbon usage would go up, the treated effluent from the carbon should remain consistent.

Alternative 3 is similar to Alternative 2 with the addition of the use of zeolite ion exchange. The zeolite process is another adsorption process (like granular activated carbon) which can be affected by decreased flow or increased contaminant concentrations. However, the use of two columns in series allows for flexibility in terms of both flow and contaminant concentrations as the second column will remove any leakage of contaminants from the first column.

Alternative 4 is similar to Alternative 2 and 3 with respect to chemical treatment, membrane microfiltration, and the two adsorption processes. Reverse osmosis is also fairly flexible and could handle changes in either feed volume and/or wastewater characteristics. Overall, it is judged to be equal to Alternatives 2 and 3 in terms of flexibility.

5.1.8 Permitting

No actual formal permit applications will be required for the DLF wastewater treatment system. However, the DLF will discharge treated effluent to the TEDF. As a result, activities at the DLF must support the overall TEDF permitting effort.

The Comparative Levels discussed in Section 4.1.1 are those being imposed on the TEDF as a result of permitting activities. Therefore, individual generators who contribute to the overall feed to the TEDF should comply with these Comparative Levels through the application of BAT/AKART, or justify why the Comparative Levels cannot be met.

The projected water quality for treated effluent from the DLF for each of the four generic treatment alternatives was presented in Tables 5.1 through 5.4. Also shown are the Comparative Levels. Based on these projections none of the alternatives comply with all of the Comparative Levels. Therefore, any of the alternatives would require close coordination with Westinghouse Hanford to ensure that permitting problems are promptly resolved with the proper regulatory agencies. Of the four alternatives, Alternative 3 and 4 would be similar in terms of permitting, and would be easier to resolve than Alternatives 1 and 2 due to the fewer number of exceedances. Alternative 2 permitting problems would also be easier to resolve than Alternative 1 for the same reason.

5.1.9 Interdependence

The DLF is a self sufficient facility which only requires access to the TEDF for wastewater discharge purposes. The efficiency of each process will be monitored with in-line process control equipment. These systems will not provide specific analysis for each contaminant of concern, however, the systems will demonstrate that the process is operating properly as designed. Therefore, no problems in terms of interdependencies would be expected for any of the four alternatives.

5.1.10 Secondary Wastes Treatment Alternatives

All four alternatives produce secondary waste streams which will require packaging and disposal. Based on the available wastestream characteristics, it is expected that all secondary wastes will be capable of being disposed of as low level waste.

Alternative 1 produces the least amount of secondary waste with approximately 1,460 ft^3 per year. This includes approximately 60 ft^3 of dewatered lint, 1,400 ft^3 of dewatered sludge, and 10,000 ft^3 of granular activated carbon.

Alternative 2 produces the next lowest amount of secondary waste with approximately 20,560 ft^3 per year. The dewatered lint and granular activated carbon volumes are the same as Alternative 1 at 60 ft^3 and 10,000 ft^3, respectively. The dewatered sludge volume increases to approximately 10,500 ft^3 per year because of the added solids from lime precipitation.

Alternative 3 produces the same volume of secondary waste as Alternative 2 with respect to dewatered lint, dewatered sludge, and granular activated carbon. However, this alternative also produces spent zeolites, estimated at approximately 1,200 ft^3 per year.

Finally, Alternative 4 produces the most secondary waste. The volumes for dewatered lint, dewatered sludge, granular activated carbon, and zeolites will be the same as Alternative 3. However, an additional 278,000 ft^3 per year of secondary waste in the form of the reverse osmosis liquid brine will also be produced. After treatment in the evaporator and dryer system, the final estimated disposal volume is 2,780 $ft.^3$ per year.

5.1.11 Cost

The cost effectiveness method has been used to evaluate the costs of the four candidate alternatives. This cost evaluation method relies on an estimate of facility capital costs. Summaries of capital costs for each of the four candidates alternatives are provided on Tables 5.6, 5.7, 5.8 and 5.9. Assumptions used in developing these estimates are as follows.

- Major direct equipment costs were estimated on the basis of vendor quotes and experience on previous projects.

- A factor of 5% of direct equipment cost has been included to account for miscellaneous equipment.

- A factor of 10% of direct equipment cost has been included for instrumentation and controls.

- A factor of 15% of total equipment has been included to account for equipment installation.

- The facilities cost is based on a cost of $79.00 per square foot of floor space. This unit cost is the current construction cost estimate for basic structure including floors walls, and roofs. Mechanical and electrical services are not included in this estimate because the wastewater treatment area is a relatively small (<10%) part of the overall DLF facility.

TABLE 5.6
CAPITAL COST ESTIMATE – ALTERNATIVE 1
BEST AVAILABLE TECHNOLOGY ANALYSIS
DECONTAMINATION LAUNDRY FACILITY
WESTINGHOUSE HANFORD COMPANY, RICHLAND, WASHINGTON

Item	Cost
Equalization tank transfer pumps	10,000
Membrane system – includes concentration tank, feed pumps, membrane modules (2 trains), cleaning system, permeate tanks, and controls	410,000
Activated carbon system – includes 2 columns (8 ft. diameter), face piping, and initial carbon charge	160,000
Sludge holding tank	40,200
Sludge dewatering system	74,300
Sludge drying system	82,500
Media dewatering tank	25,000
Subtotal, direct equipment	802,000
Miscellaneous equipment (5% of direct equipment)	40,100
Instrumentation and controls (10% of direct equipment)	80,200
Subtotal, total equipment cost	922,300
Floor space (5,000ft² at $79.00/ft²)	395,000
Installation (15% of total equipment)	138,345
Subtotal, indirect costs	533,345
Subtotal, construction cost	1,455,645
Engineering (15% of construction cost)	218,347
Contract Administration / Project Management (10% of construction cost)	145,565
Contingency (15% of construction cost)	218,347
Total Estimated Cost	2,037,903

TABLE 5.7
CAPITAL COST ESTIMATE – ALTERNATIVE 2
BEST AVAILABLE TECHNOLOGY ANALYSIS
DECONTAMINATION LAUNDRY FACILITY
WESTINGHOUSE HANFORD COMPANY, RICHLAND, WASHINGTON

Item	Cost
Equalization tank transfer pumps	10,000
Reaction system – includes tank, mixer, and pH controls	22,500
Lime system – includes tank, mixer, loading system, and metering pumps	28,300
Membrane system – includes concentration tank, feed pumps, membrane modules (2 trains) cleaning system, permeate tanks, and controls	410,000
Transfer pumps	10,000
Neutralization system – includes tank, mixer, and pH controls	10,300
Acid system – inludes tank, mixer, and metering pumps	5,100
Activated carbon system – includes 2 columns (8 ft. diameter), face piping, and initial carbon charge	160,000
Sludge holding tank	40,200
Sludge dewatering system	74,300
Sludge drying system	82,500
Media dewatering tank	25,000
Subtotal, direct equipment	878,200
Miscellaneous equipment (5% of direct equipment)	43,910
Instrumentation and controls (10% of direct equipment)	87,820
Subtotal, total equipment cost	1,009,930

TABLE 5.7 (continued)
CAPITAL COST ESTIMATE – ALTERNATIVE 2
BEST AVAILABLE TECHNOLOGY ANALYSIS
DECONTAMINATION LAUNDRY FACILITY
WESTINGHOUSE HANFORD COMPANY, RICHLAND, WASHINGTON

Item	Cost
Floor space (5,600ft² at $79.00/ft²)	442,400
Installation (15% of total equipment cost)	151,490
Subtotal, indirect costs	593,890
Subtotal, constuction cost	1,603,820
Engineering (15% of construction cost)	240,573
Contract Administration / Project Management (10% of construction cost)	160,382
Contingency (15% of construction cost)	240,573
Total Estimated Cost	2,245,347

TABLE 5.8
CAPITAL COST ESTIMATE – ALTERNATIVE 3
BEST AVAILABLE TECHNOLOGY ANALYSIS
DECONTAMINATION LAUNDRY FACILITY
WESTINGHOUSE HANFORD COMPANY, RICHLAND, WASHINGTON

Item	Cost
Equalization tank transfer pumps	10,000
Reaction system – includes tank, mixer, and pH controls	22,500
Lime system – includes tank, mixer, loading system, and metering pumps	28,300
Membrane system – includes concentration tank, feed pumps, membrane modules (2 trains) cleaning system, permeate tanks, and controls	410,000
Transfer pumps	10,000
Neutralization system – includes tank, mixer, and pH controls	10,300
Acid system – includes tank, mixer, and metering pumps	5,100
Activated carbon system – includes 2 columns (8 ft. diameter), face piping, and initial carbon charge	160,000
Zeolite system – includes columns (5ft diameter), face piping, and initial zeolite charge	120,000
Sludge holding tank	40,200
Sludge dewatering system	74,300
Sludge drying system	82,500
Media dewatering tank	25,000
Subtotal, direct equipment	998,200
Miscellaneous equipment (5% of direct equipment)	49,910
Instrumentation and controls (10% of direct equipment)	99,820
Subtotal, total equipment cost	1,147,930

TABLE 5.8 (continued)
CAPITAL COST ESTIMATE – ALTERNATIVE 3
BEST AVAILABLE TECHNOLOGY ANALYSIS
DECONTAMINATION LAUNDRY FACILITY
WESTINGHOUSE HANFORD COMPANY, RICHLAND, WASHINGTON

Item	Cost
Floor space (6,000ft² at $79.00/ft²)	474,000
Installation (15% of total equipment cost)	172,190
Subtotal, indirect costs	646,190
Subtotal, construction cost	1,794,120
Engineering (15% of construction cost)	269,118
Contract Administration / Project Management (10% of construction cost)	179,412
Contingency (15% of construction cost)	269,118
Total Estimated Cost	2,511,767

TABLE 5.9
CAPITAL COST ESTIMATE – ALTERNATIVE 4
BEST AVAILABLE TECHNOLOGY ANALYSIS
DECONTAMINATION LAUNDRY FACILITY
WESTINGHOUSE HANFORD COMPANY, RICHLAND, WASHINGTON

Item	Cost
Equalization tank transfer pumps	10,000
Reaction system – includes tank, mixer, and pH controls	22,500
Lime system – includes tank, mixer, loading system, and metering pumps	28,300
Membrane system – includes concentration tank, feed pumps, membrane modules (2 trains) cleaning system, permeate tanks, and controls	410,000
Transfer pumps	10,000
Neutralization system – includes tank, mixer, and pH controls	10,300
Acid system – includes tank, mixer, and metering pumps	5,100
Activated carbon system – includes 2 columns (8 ft. diameter), face piping, and initial carbon charge	160,000
Zeolite system – includes 2 columns (5ft diameter), face piping, and initial zeolite charge	120,000
Reverse osmosis system – includes membrane modules, cleaning system, permeate tanks, and controls	230,000
Sludge holding tank	40,200
Sludge dewatering system	74,300
Sludge drying system	82,500
Media dewatering tank	25,000
Brine evaporation/ drying system	2,100,000
Subtotal, direct equipment	3,328,200
Miscellaneous equipment (5% of direct equipment)	166,410
Instrumentation and controls (10% of direct equipment)	332,820
Subtotal, total equipment cost	3,827,430

TABLE 5.9 (continued)
CAPITAL COST ESTIMATE – ALTERNATIVE 4
BEST AVAILABLE TECHNOLOGY ANALYSIS
DECONTAMINATION LAUNDRY FACILITY
WESTINGHOUSE HANFORD COMPANY, RICHLAND, WASHINGTON

Item	Cost
Floor space (7,500ft² at $79.00/ft²)	592,500
Installation (15% of total equipment cost)	574,115
Subtotal, indirect costs	1,166,615
Subtotal, construction cost	4,994,045
Engineering (15% of construction cost)	749,107
Contract Administration / Project Management (10% of construction cost)	499,404
Contingency (15% of construction cost)	749,107
Total Estimated Cost	6,991,662

- A factor of 15% of construction cost has been allowed for engineering.

- A factor of 10% of construction cost has been allowed for construction management, contract administrating, and WHC project management.

- An overall contingency of 15% of construction cost has been included.

The cost effectiveness method is based on an Equivalent Uniform Annual Cost (EUAC), which is based on the full value of capital expenditures. A 7% time value of money has also been applied over an assumed operations life at 20 years. The EUAC also requires an estimation of annual costs. Annual costs include both operations and secondary waste disposal costs.

An overall summary of capital, operations, and disposal costs for each of the alternatives is provided in Table 5.10. Assumptions in the calculation of annual costs include the following:

- Annual operating costs (operations and maintenance) are based on a factor of 15% of facility total equipment costs.

- Chemical and media costs have been estimated separately.

- Disposal costs are based on estimated volumes as discussed in Section 4.4.1.

Table 5.10 also presents the EUAC for each of the four candidate alternatives.

TABLE 5.10
CANDIDATE ALTERNATIVES COST SUMMARY
BEST AVAILABLE TECHNOLOGY ANALYSIS
DECONTAMINATION LAUNDRY FACILITY
WESTINGHOUSE HANFORD COMPANY, RICHLAND, WASHINGTON

Item	Alternative 1	Alternative 2	Alternative 3	Alternative 4
Capital Cost a/	2,037,903	2,245,347	2,511,767	6,991,662
Operations Cost				
Chemicals	0	45,000	55,000	55,000
Activated Carbon	350,000	350,000	350,000	350,000
Zeolites	0	0	25,000	25,000
Operations and Maintenance b/	218,300	240,600	269,100	749,000
Total Operations Cost	568,300	635,600	699,100	1,179,000
Disposal Cost c/	762,400	1,231,000	1,313,000	1,504,000
Total Annual Cost	1,330,700	1,866,600	2,012,100	2,683,000
Equivalent Uniform Annual Cost d/	1,523,058	2,078,538	2,249,186	3,342,943

Notes

a/ Capital costs from Tables 5.6 through 5.9.

b/ Operations and maintenance estimated at 15% of total construction cost from Tables 5.6 through 5.9.

c/ Disposal based on volumes from Table 4.2 and assumes current low level disposal rate for the Hanford Site of $68.62/ft3 (DOE 1991). Sludge volumes have been reduced by 20% to account for volume reduction due to drying.

d/ Assumes 20 year project life and 7% discount rate.

SECTION 6.0

6.0 EVALUATION OF ALTERNATIVES

The overall evaluation and selection of the preferred alternative for the DLF is based on both a technical evaluation and a cost evaluation. The following sections review the methods to perform each evaluation, the results of each evaluation, and the final recommended alternative.

6.1 EVALUATION CRITERIA

6.1.1 Technical Criteria

The technical evaluation of generic treatment alternatives is based on the ten criteria described in Section 5.0, and utilizes a matrix-based approach. In this approach, each criteria is assigned a weighting factor of 1 (low) to 10 (high). Each alternative is then assigned a raw score which is multiplied by the weighting factor. The highest overall score represents the preferred alternative.

Treated water quality, reliability, safety, permitting, and process development status have been assigned weighting factors of 10. These criteria are considered to be of major importance. Secondary waste production is also of considerable importance, and has been assigned a weight of 9. Flexible operation is assigned a weight of 8 because it is a desirable feature, but is not critical to the success of the system. Ease of maintenance and cost have been assigned a weight of 7, and interdependence has been assigned a weight of 5.

The results of the technical evaluation are presented in Table 6.1. As shown, Alternative 3 received the highest overall score of 232. Alternative 4 received the

TABLE 6.1
EVALUATION OF ALTERNATIVES
BEST AVAILABLE TECHNOLOGY ANALYSIS
DECONTAMINATION LAUNDRY FACILITY
WESTINGHOUSE HANFORD COMPANY, RICHLAND, WASHINGTON

Criterion	Weight	Alternative 1 (P/MF/AC)		Alternative 2 (P/CP/MF/AC)		Alternative 3 (P/CP/MF/Z/AC)		Alternative 4 (P/CP/MF/ Z/AC/RO)	
		Score	Extended	Score	Extended	Score	Extended	Score	Extended
Treated Water Quality	10	1	10	2	20	3	30	3	30
Reliability	10	3	30	3	30	3	30	3	30
Safety	10	3	30	2	20	2	20	1	10
Process Development Status	10	3	30	3	30	3	30	3	30
Ease of Maintenance	7	3	21	3	21	3	21	2	14
Flexibility	8	3	24	3	24	3	24	3	24
Permitting	10	1	10	2	20	3	30	3	30
Interdependence	5	3	15	3	15	3	15	3	15
Secondary Wastes	9	3	27	2	18	2	18	1	9
Cost	7	3	21	2	14	2	14	1	7
Total Score			**218**		**212**		**232**		**199**

Notes
a/ P = pretreatment, CP = chemical precipitation, MF = microfiltration, AC = activated carbon, Z = zeolite ion exchange, RO = reverse osmosis
b/ Scoring is as follows: high = 3, medium = 2, low = 1.

lowest overall score of 199, and would be least preferred on the basis of technical criteria.

6.1.2 Cost Effectiveness Criteria

The cost effectiveness evaluation relies on the results of the effectiveness analysis described in Appendix A, Section A.6.4. This method compares the incremental removal of toxic pollutants to the incremental cost of controls. The results of the effectiveness analysis are presented in Tables 6.2, 6.3, 6.4 and 6.5. The cost effectiveness summary is presented in Table 6.6, and compares the EUAC to the toxic pounds removed for each of the four alternatives. As shown, Alternative 4 removes the highest mass of toxic materials with approximately 45,585 pounds. Alternative 3 removes slightly less with 45,235 pounds. Finally, Alternative 2 and 1 remove 45,031 pounds and 14,036 pounds, respectively.

6.2 EVALUATION RESULTS

Alternative 3 received the highest overall technical score, and would be recommended on the basis of the technical evaluation. Alternative 2 would be recommended on the basis of the cost effectiveness evaluation as it removes the highest incremental amount of toxic pounds for the lowest expenditure of money. However, Alternative 3 accomplishes the removal of two important species (cesium-137 and strontium-90).

Based on the overall superior technical evaluation, and the relative benefits with respect to cost effectiveness, Alternative 3 is determined to be BAT/AKART, and is recommended for implementation in the DLF.

TABLE 6.2
EFFECTIVENESS ANALYSIS – ALTERNATIVE 1
BEST AVAILABLE TECHNOLOGY ANALYSIS
DECONTAMINATION LAUNDRY FACILITY
WESTINGHOUSE HANFORD COMPANY, RICHLAND, WASHINGTON

Analyte	Units	Expected Influent	Total Pounds in Treatment Plant Influent Per Year	Toxic Weighting Factor a/	Total Toxic Pounds in Treatment Plant Influent Per Year	Decon-tamination Factor	Toxic Pounds Remaining in Treatment Plant Effluent Per Year
Miscellaneous Data							
pH	SU	8.7 b/	– c/	0	–	–	0.00
Temperature	C	47 b/	–	0	–	–	0.00
Conductivity	µmhos	829 b/	–	0	–	–	0.00
Alkalinity	µg/l	348,700 b/	60,474	2.80E-04	16.93	1.00	16.93
Total Dissolved Solids	µg/l	440,000	76,308	2.24E-05	1.71	1.00	1.71
Total Suspended Solids	µg/l	193,400 b/	33,541	0	0.00	12	0.00
Oil and Grease	µg/l	159,333 b/	27,633	0	0.00	48.08	0.00
Inorganic Species							
Aluminum	µg/l	200 U	35	0	0.00	1.00 d/	0.00
Ammonia (as N)	µg/l	22,193	3,849	2.67E-03 e/	10.28	1.00	10.28
Arsenic	µg/l	70 U	12	2.55E+03 f/	30,956.90	1.00	30,956.90
Barium	µg/l	200 U	35	5.60E-03	0.19	1.00	0.19
Boron	µg/l	100 U	17	0	0.00	1.00	0.00
Cadmium	µg/l	5.0 U	1	5.65E+00 g/	4.90	1.00	4.90
Calcium	µg/l	21,167	3,671	0	0.00	1.00	0.00
Chloride	µg/l	62,667	10,868	0	0.00	1.00	0.00
Chromium	µg/l	10.0 U	2	6.21E-01 h/	1.08	1.00	1.08
Copper	µg/l	28.5	5	4.67E-01 g/	2.31	1.00	2.31
Cyanide	µg/l	6,682 b/	1,159	1.10E+00	1,275	1.00	1,275
Fluoride	µg/l	107	18	0	0.00	1.00	0.00
Hydrazine	µg/l	100 U	17	0	0.00	1.00	0.00
Iron	µg/l	3,670	636	2.43E-02	15.47	1.00	15.47
Lead	µg/l	1,223	212	1.86E+00 g/	394.62	1.00	394.62
Lithium	µg/l	100 U	17	0	0.00	1.00	0.00
Magnesium	µg/l	6,013	1,043	0	0.00	1.00	0.00
Manganese	µg/l	50.7	9	1.12E-01	0.98	1.00	0.98
Mercury	µg/l	0.30	0.05	5.06E+02	26.62	1.00	26.62
Nickel	µg/l	40.0 U	7	4.53E-01 g/	3.14	1.00	3.14
Nitrate (as N)	µg/l	210	36	5.60E-04	0.02	1.00	0.02
Phosphate (as P)	µg/l	213,667	37,056	0	0.00	1.00	0.00
Potassium	µg/l	6,013	1,043	0	0.00	1.00	0.00
Selenium	µg/l	5.0 U	1	7.20E-01	0.62	1.00	0.62
Silicon	µg/l	43,267	7,504	0	0.00	1.00	0.00
Silver	µg/l	10.0 U	2	4.68E+01	81.16	1.00	81.16
Sodium	µg/l	22,883	3,969	0	0.00	1.00	0.00
Strontium	µg/l	100 U	17	0	0.00	1.00	0.00
Sulfate	µg/l	5,000 U	867	0	0.00	1.00	0.00
Sulfide	µg/l	677 b/	117	2.80E+00 i/	328.75	1.00	328.75
Titanium	µg/l	100 U	17	0	0.00	1.00	0.00
Vanadium	µg/l	50.0 U	9	0	0.00	1.00	0.00
Zinc	µg/l	553	96	5.09E-02 g/	4.88	1.00	4.88

TABLE 6.2 (continued)
EFFECTIVENESS ANALYSIS – ALTERNATIVE 1
BEST AVAILABLE TECHNOLOGY ANALYSIS
DECONTAMINATION LAUNDRY FACILITY
WESTINGHOUSE HANFORD COMPANY, RICHLAND, WASHINGTON

Analyte	Units	Expected Influent	Total Pounds in Treatment Plant Influent Per Year	Toxic Weighting Factor a/	Total Toxic Pounds in Treatment Plant Influent Per Year	Decon-tamination Factor	Toxic Pounds Remaining in Treatment Plant Effluent Per Year
Organic Species							
Acetone	µg/l	227 B	39	0	0.00	9.42	0.00
Benzoic acid	µg/l	307	53	0	0.00	> 1.80 j/	0.00
Benzyl alcohol	µg/l	32	6	0	0.00	> 1.00	0.00
bis(2-Ethylhexyl)phthalate	µg/l	400 B	69	0	0.00	2.48	0.00
Butylbenzylphthalate	µg/l	37	6	0	0.00	1.00	0.00
Chloroform	µg/l	10	2	2.95E+01	51.16	> 2.20	< 23.30
Di-n-Octyl phthalate	µg/l	36 J	6	0	0.00	1.33	0.00
Phenol	µg/l	343	60	3.79E-03	0.23	> 10.19	< 0.02
Total Organic Carbon	µg/l	55,000	9,539	0	0.00	2.93	0.00
Total Carbon	µg/l	116,500 b/	20,204	0	0.00	–	–
Total Organic Halides	µg/l	623 b/	108	0	0.00	–	–
Radionuclides							
Gross Alpha	pCi/l	111.5	3.16E-04	6.87E+03 k/	2.17	ERR l/	0.00
Gross Beta	pCi/l	50.997	6.27E-05	2.63E+08 m/	16,490.10	6.36	2,594.81
Americium-241	pCi/l	17.97	9.61E-07	4.54E+05	0.44	1.00	0.44
Curium-244	pCi/l	ND	0.00E+00	6.67E+06	0.00	1.00	0.00
Gamma Scan:							
Potassium-40	pCi/l	1,270	3.10E+01	0 n/	0.00	1.00	0.00
Manganese-54	pCi/l	ND	0.00E+00	4.47E+07	0.00	1.00	0.00
Cobalt-58	pCi/l	< 241.7	1.33E-09	1.77E+08	0.24	1.00	0.24
Cobalt-60	pCi/l	< 171.8	2.64E-08	1.27E+07	0.34	59.38	0.01
Cesium-134	pCi/l	< 99.4	1.33E-08	8.09E+07	1.08	1.00	1.08
Cesium-137	pCi/l	53,305	1.06E-04	2.44E+06	258.64	1.73	149.63
Europium-154	pCi/l	< 343.6	4.10E-07	4.07E+06	1.67	> 7.59	< 0.22
Europium-155	pCi/l	ND	0.00E+00	3.57E+06	0.00	1.00	0.00
Radium-226	pCi/l	ND	0.00E+00	1.84E+07	0.00	1.00	0.00
Radium-228	pCi/l	ND	0.00E+00	4.37E+09	0.00	1.00	0.00
Thorium-228	pCi/l	ND	0.00E+00	6.57E+07	0.00	1.00	0.00
Thorium-232	pCi/l	ND	0.00E+00	3.05E-02	0.00	1.00	0.00
Strontium-90	pCi/l	1,522	1.87E-06	2.63E+08	491.81	1.00	491.81
Total Radium	pCi/l	< 0.278	0.00E+00 o/	0 o/	0.00 o/	1.00	0.00
Uranium-234	pCi/l	2.646	2.14E-01	3.99E-02	0.01	1.00	0.01
Uranium-235	pCi/l	0.2049	1.66E-02	4.00E-02	0.00	1.00	0.00
Uranium-238	pCi/l	1.652	8.60E-01	4.66E-03	0.00	1.00	0.00
Plutonium-238	pCi/l	7.95	7.92E-08	1.95E+06	0.15	1.00	0.15
Plutonium-239,240	pCi/l	82.5	2.30E-04	6.87E+03 k/	1.58	1.00	1.58
Lead-210	pCi/l	ND	0.00E+00	4.68E+08	0.00	1.00	0.00
Hydrogen-3	pCi/l	ND	0.00E+00	1.80E+06	0.00	1.00	0.00
Ruthenium-106	pCi/l	ND	0.00E+00	1.88E+08	0.00	1.00	0.00
Total Uranium	pCi/l	ND	0.00E+00 o/	0 o/	0.00 o/	1.00	0.00
					50,424.91		36,388.61

Notes

a/ The toxic weighting factor is a measure of the relative toxicity of a given constituent using the water quality criteria for copper as a baseline value.

b/ Where the expected influent values are not available the worst-case design basis values are used.

TABLE 6.2 (continued)
EFFECTIVENESS ANALYSIS – ALTERNATIVE 1
BEST AVAILABLE TECHNOLOGY ANALYSIS
DECONTAMINATION LAUNDRY FACILITY
WESTINGHOUSE HANFORD COMPANY, RICHLAND, WASHINGTON

Notes (continued)

c/ Dash (–) indicates that the parameter cannot be cannot be calculated.

d/ This alternative is not designed to remove dissolved species. Removal of some of these species may be accomplished if they are present as a particulate. This removal has not been considered and the decontamination factor is assumed to be 1.00.

e/ Calculated as total ammonia.

f/ Calculated as total arsenic.

g/ These values are hardness dependent (100 mg/l used).

h/ Calculated as hexavalent chromium.

i/ Calculated as hydrogen sulfide.

j/ Greater than for the decontamination factor indicates that the compound was present below the detection limit for the treatability study test effluent, and therefore the detection limit was used in the calculation.

k/ Calculated as Plutonium-239.

l/ ERR indicates that all of the parameter has been removed and therefore the decontamination is infinite.

m/ Calculated as Strontium-90.

n/ No radionuclide limit established in 10 CFR 20.

o/ The individual constituents of these general categories have been evaluated based on total pounds per year and the toxic weighting factor, and therefore these general categories have not been evaluated.

TABLE 6.3
EFFECTIVENESS ANALYSIS – ALTERNATIVE 2
BEST AVAILABLE TECHNOLOGY ANALYSIS
DECONTAMINATION LAUNDRY FACILITY
WESTINGHOUSE HANFORD COMPANY, RICHLAND, WASHINGTON

Analyte	Units	Expected Influent	Total Pounds in Treatment Plant Influent Per Year	Toxic Weighting Factor a/	Total Toxic Pounds in Treatment Plant Influent Per Year	Decon-tamination Factor	Toxic Pounds Remaining in Treatment Plant Effluent Per Year
Miscellaneous Data							
pH	SU	8.7 b/	– c/	0	–	–	0.00
Temperature	C	47 b/	–	0	–	–	0.00
Conductivity	µmhos	829 b/	–	0	–	–	0.00
Alkalinity	µg/l	348,700 b/	60,474	2.80E-04	16.93	1.00	16.93
Total Dissolved Solids	µg/l	440,000	76,308	2.24E-05	1.71	1.00	1.71
Total Suspended Solids	µg/l	193,400 b/	33,541	0	0.00	> 12.00 d/	0.00
Oil and Grease	µg/l	159,333 b/	27,633	0	0.00	48.08	0.00
Inorganic Species							
Aluminum	µg/l	200 U	35	0	0.00	> 7.55	0.00
Ammonia (as N)	µg/l	22,193	3,849	2.67E-03 e/	10.28	1.09	9.46
Arsenic	µg/l	70 U	12	2.55E+03 f/	30,956.90	10.00 g/	3,095.69
Barium	µg/l	200 U	35	5.60E-03	0.19	1.00	0.19
Boron	µg/l	100 U	17	0	0.00	1.00	0.00
Cadmium	µg/l	5.0 U	1	5.65E+00 h/	4.90	> 4.50	< 1.09
Calcium	µg/l	21,167	3,671	0	0.00	1.00 i/	0.00
Chloride	µg/l	62,667	10,868	0	0.00	1.00 i/	0.00
Chromium	µg/l	10.0 U	2	6.21E-01 j/	1.08	> 3.53	< 0.31
Copper	µg/l	28.5	5	4.67E-01 h/	2.31	6.04	0.38
Cyanide	µg/l	6,682 b/	1,159	1.10E+00	1,275	1.00 i/	1,275
Fluoride	µg/l	107	18	0	0.00	> 1.20	0.00
Hydrazine	µg/l	100 U	17	0	0.00	1.00	0.00
Iron	µg/l	3,670	636	2.43E-02	15.47	> 55.87	< 0.28
Lead	µg/l	1,223	212	1.86E+00 h/	394.62	37.71	10.46
Lithium	µg/l	100 U	17	0	0.00	1.00	0.00
Magnesium	µg/l	6,013	1,043	0	0.00	1.00	0.00
Manganese	µg/l	50.7	9	1.12E-01	0.98	> 6.93	< 0.14
Mercury	µg/l	0.30	0.05	5.06E+02	26.62	> 1.65	< 16.13
Nickel	µg/l	40.0 U	7	4.53E-01 h/	3.14	1.00	3.14
Nitrate (as N)	µg/l	210	36	5.60E-04	0.02	1.00 i/	0.02
Phosphate (as P)	µg/l	213,667	37,056	0	0.00	1.00 i/	0.00
Potassium	µg/l	6,013	1,043	0	0.00	1.00 i/	0.00
Selenium	µg/l	5.0 U	1	7.20E-01	0.62	1.00	0.62
Silicon	µg/l	43,267	7,504	0	0.00	1.00 i/	0.00
Silver	µg/l	10.0 U	2	4.68E+01	81.16	1.00	81.16
Sodium	µg/l	22,883	3,969	0	0.00	1.00 i/	0.00
Strontium	µg/l	100 U	17	0	0.00	1.00	0.00
Sulfate	µg/l	5,000 U	867	0	0.00	1.00 i/	0.00
Sulfide	µg/l	677 b/	117	2.80E+00 k/	328.75	1.00 i/	328.75
Titanium	µg/l	100 U	17	0	0.00	1.00	0.00
Vanadium	µg/l	50.0 U	9	0	0.00	1.00	0.00
Zinc	µg/l	553	96	5.09E-02 h/	4.88	44.51	0.11

TABLE 6.3 (continued)
EFFECTIVENESS ANALYSIS – ALTERNATIVE 2
BEST AVAILABLE TECHNOLOGY ANALYSIS
DECONTAMINATION LAUNDRY FACILITY
WESTINGHOUSE HANFORD COMPANY, RICHLAND, WASHINGTON

Analyte	Units	Expected Influent	Total Pounds in Treatment Plant Influent Per Year	Toxic Weighting Factor a/	Total Toxic Pounds in Treatment Plant Influent Per Year	Decon-tamination Factor	Toxic Pounds Remaining in Treatment Plant Effluent Per Year
Organic Species							
Acetone	µg/l	227 B	39	0	0.00	9.42	0.00
Benzoic acid	µg/l	307	53	0	0.00	> 1.80	0.00
Benzyl alcohol	µg/l	32	6	0	0.00	> 1.00	0.00
bis(2-Ethylhexyl)phthalate	µg/l	400 B	69	0	0.00	2.48	0.00
Butylbenzylphthalate	µg/l	37	6	0	0.00	1.00	0.00
Chloroform	µg/l	10	2	2.95E+01	51.16	> 2.20	< 23.30
Di-n-Octyl phthalate	µg/l	36 J	6	0	0.00	1.33	0.00
Phenol	µg/l	343	60	3.79E-03	0.23	> 10.19	< 0.02
Total Organic Carbon	µg/l	55,000	9,539	0	0.00	2.93	0.00
Total Carbon	µg/l	116,500 b/	20,204	0	0.00	–	–
Total Organic Halides	µg/l	623 b/	108	0	0.00	–	–
Radionuclides							
Gross Alpha	pCi/l	111.5	3.16E-04	6.87E+03 l/	2.17	ERR m/	0.00
Gross Beta	pCi/l	50,997	6.27E-05	2.63E+08 n/	16,490.10	52.53	313.91
Americium-241	pCi/l	17.97	9.61E-07	4.54E+05	0.44	> 222.22	0.00
Curium-244	pCi/l	ND	0.00E+00	6.67E+06	0.00	1.00 i/	0.00
Gamma Scan:							
Potassium-40	pCi/l	1,270	3.10E+01	0 o/	0.00	1.00 i/	0.00
Manganese-54	pCi/l	ND	0.00E+00	4.47E+07	0.00	1.00 i/	0.00
Cobalt-58	pCi/l	< 241.7	1.33E-09	1.77E+08	0.24	1.00 i/	0.24
Cobalt-60	pCi/l	< 171.8	2.64E-08	1.27E+07	0.34	9717.44	0.00
Cesium-134	pCi/l	< 99.4	1.30E-08	8.09E+07	1.05	1.00	1.05
Cesium-137	pCi/l	53,305	1.06E-04	2.44E+06	258.64	1.37	188.79
Europium-154	pCi/l	< 343.6	4.10E-07	4.07E+06	1.67	> 55.30	< 0.03
Europium-155	pCi/l	ND	0.00E+00	3.57E+06	0.00	1.00	0.00
Radium-226	pCi/l	ND	0.00E+00	1.84E+07	0.00	1.00	0.00
Radium-228	pCi/l	ND	0.00E+00	4.37E+09	0.00	1.00	0.00
Thorium-228	pCi/l	ND	0.00E+00	6.57E+07	0.00	1.00	0.00
Thorium-232	pCi/l	ND	0.00E+00	3.05E-02	0.00	1.00	0.00
Strontium-90	pCi/l	1,522	1.87E-06	2.63E+08	491.81	19.24	25.56
Total Radium	pCi/l	< 0.278	0.00E+00 p/	0 p/	0.00 p/	> 8.16	0.00
Uranium-234	pCi/l	2.646	2.14E-01	3.99E-02	0.01	> 50.51	0.00
Uranium-235	pCi/l	0.2049	1.66E-02	4.00E-02	0.00	> 6.84	0.00
Uranium-238	pCi/l	1.652	8.60E-01	4.66E-03	0.00	> 44.44	0.00
Plutonium-238	pCi/l	7.95	7.92E-08	1.95E+06	0.15	> 181.82	0.00
Plutonium-239,240	pCi/l	82.5	2.33E-04	6.87E+03 l/	1.60	> 384.62	< 0.004
Lead-210	pCi/l	ND	0.00E+00	4.68E+08	0.00	1.00 i/	0.00
Hydrogen-3	pCi/l	ND	0.00E+00	1.80E+06	0.00	1.00 i/	0.00
Ruthenium-106	pCi/l	ND	0.00E+00	1.88E+08	0.00	1.00 i/	0.00
Total Uranium	pCi/l	ND	0.00E+00 p/	0 p/	0.00 p/	1.00	0.00
					50,424.90		5,394.23

Notes

a/ The toxic weighting factor is a measure of the relative toxicity of a given constituent using the water quality criteria for copper as a baseline value.

b/ Where the expected influent values are not available the worst-case design basis values are used.

TABLE 6.3 (continued)
EFFECTIVENESS ANALYSIS – ALTERNATIVE 2
BEST AVAILABLE TECHNOLOGY ANALYSIS
DECONTAMINATION LAUNDRY FACILITY
WESTINGHOUSE HANFORD COMPANY, RICHLAND, WASHINGTON

Notes (continued)

c/ Dash (–) indicates that the parameter cannot be calculated.

d/ Greater than for the decontamination factor indicates that the compound was present below the detection limit for the treatability study test effluent, and therefore the detection limit was used in the calculation.

e/ Calculated as total ammonia.

f/ Calculated as total arsenic.

g/ The decontamination factor for arsenic is based on engineering experience.

h/ These values are hardness dependent (100 mg/l used).

i/ Removal of these species may occur if they are precipitated from solution or are otherwise adsorbed. However, removal has not been considered, and the decontamination factor is assumed to be 1.00.

j/ Calculated as hexavalent chromium.

k/ Calculated as hydrogen sulfide.

l/ Calculated as Plutonium–239.

m/ ERR indicates that all of the parameter has been removed and therefore the decontamination is infinite.

n/ Calculated as Strontium–90.

o/ No radionuclide limit established in 10 CFR 20.

p/ The individual constituents of these general categories have been evaluated based on total pounds per year and the toxic weighting factor, and therefore these general categories have not been evaluated.

TABLE 6.4
EFFECTIVENESS ANALYSIS – ALTERNATIVE 3
BEST AVAILABLE TECHNOLOGY ANALYSIS
DECONTAMINATION LAUNDRY FACILITY
WESTINGHOUSE HANFORD COMPANY, RICHLAND, WASHINGTON

Analyte	Units	Expected Influent	Total Pounds in Treatment Plant Influent Per Year	Toxic Weighting Factor a/	Total Toxic Pounds in Treatment Plant Influent Per Year	Decon-tamination Factor	Toxic Pounds Remaining in Treatment Plant Effluent Per Year
Miscellaneous Data							
pH	SU	8.7 b/	– c/	0	–	–	0.00
Temperature	C	47 b/	–	0	–	–	0.00
Conductivity	µmhos	829 b/	–	0	–	–	0.00
Alkalinity	µg/l	348,700 b/	60,474	2.80E-04	16.93	1.00	16.93
Total Dissolved Solids	µg/l	440,000	76,308	2.24E-05	1.71	1.00	1.71
Total Suspended Solids	µg/l	193,400 b/	33,541	0	0.00	> 12.00 d/	0.00
Oil and Grease	µg/l	159,333 b/	27,633	0	0.00	48.08	0.00
Inorganic Species							
Aluminum	µg/l	200 U	35	0	0.00	> 7.55	0.00
Ammonia (as N)	µg/l	22,193	3,849	2.67E-03 e/	10.28	1.09	9.46
Arsenic	µg/l	70 U	12	2.55E+03 f/	30,956.90	10.00 g/	3,095.69
Barium	µg/l	200 U	35	5.60E-03	0.19	1.00	0.19
Boron	µg/l	100 U	17	0	0.00	1.00	0.00
Cadmium	µg/l	5.0 U	1	5.65E+00 h/	4.90	> 4.50	< 1.09
Calcium	µg/l	21,167	3,671	0	0.00	1.00 i/	0.00
Chloride	µg/l	62,667	10,868	0	0.00	1.00 i/	0.00
Chromium	µg/l	10.0 U	2	6.21E-01 j/	1.08	> 3.53	< 0.31
Copper	µg/l	28.5	5	4.67E-01 h/	2.31	6.04	0.38
Cyanide	µg/l	6,682 b/	1,159	1.10E+00	1,275	1.00	1,275
Fluoride	µg/l	107	18	0	0.00	> 1.20	0.00
Hydrazine	µg/l	100 U	17	0	0.00	1.00	0.00
Iron	µg/l	3,670	636	2.43E-02	15.47	> 55.87	< 0.28
Lead	µg/l	1,223	212	1.86E+00 h/	394.62	37.71	10.46
Lithium	µg/l	100 U	17	0	0.00	1.00	0.00
Magnesium	µg/l	6,013	1,043	0	0.00	1.00	0.00
Manganese	µg/l	50.7	9	1.12E-01	0.98	> 6.93	< 0.14
Mercury	µg/l	0.30	0.05	5.06E+02	26.62	> 1.65	< 16.13
Nickel	µg/l	40.0 U	7	4.53E-01 h/	3.14	1.00	3.14
Nitrate (as N)	µg/l	210	36	5.60E-04	0.02	1.00 i/	0.02
Phosphate (as P)	µg/l	213,667	37,056	0	0.00	1.00 i/	0.00
Potassium	µg/l	6,013	1,043	0	0.00	1.00 i/	0.00
Selenium	µg/l	5.0 U	1	7.20E-01	0.62	1.00	0.62
Silicon	µg/l	43,267	7,504	0	0.00	1.00 i/	0.00
Silver	µg/l	10.0 U	2	4.68E+01	81.16	1.00	81.16
Sodium	µg/l	22,883	3,969	0	0.00	1.00 i/	0.00
Strontium	µg/l	100 U	17	0	0.00	1.00	0.00
Sulfate	µg/l	5,000 U	867	0	0.00	1.00 i/	0.00
Sulfide	µg/l	677 b/	117	2.80E+00 k/	328.75	1.00 i/	328.75
Titanium	µg/l	100 U	17	0	0.00	1.00	0.00
Vanadium	µg/l	50.0 U	9	0	0.00	1.00	0.00
Zinc	µg/l	553	96	5.09E-02 h/	4.88	44.51	0.11

TABLE 6.4 (continued)
EFFECTIVENESS ANALYSIS – ALTERNATIVE 3
BEST AVAILABLE TECHNOLOGY ANALYSIS
DECONTAMINATION LAUNDRY FACILITY
WESTINGHOUSE HANFORD COMPANY, RICHLAND, WASHINGTON

Analyte	Units		Expected Influent		Total Pounds in Treatment Plant Influent Per Year	Toxic Weighting Factor a/		Total Toxic Pounds in Treatment Plant Influent Per Year		Decon-tamination Factor		Toxic Pounds Remaining in Treatment Plant Effluent Per Year
Organic Species												
Acetone	µg/l		227	B	39	0		0.00		9.42		0.00
Benzoic acid	µg/l		307		53	0		0.00	>	1.80		0.00
Benzyl alcohol	µg/l		32		6	0		0.00	>	1.00		0.00
bis(2-Ethylhexyl)phthalate	µg/l		400	B	69	0		0.00		2.48		0.00
Butylbenzylphthalate	µg/l		37		6	0		0.00		1.00		0.00
Chloroform	µg/l		10		2	2.95E+01		51.16	>	2.20	<	23.30
Di-n-Octyl phthalate	µg/l		36	J	6	0		0.00		1.33		0.00
Phenol	µg/l		343		60	3.79E-03		0.23	>	10.19	<	0.02
Total Organic Carbon	µg/l		55,000		9,539	0		0.00		2.93		0.00
Total Carbon	µg/l		116,500	b/	20,204	0		0.00		–		–
Total Organic Halides (TOX	µg/l		623	b/	108	0		0.00		–		–
Radionuclides												
Gross Alpha	pCi/l		111.5		3.16E-04	6.87E+03	l/	2.17		ERR	k/	0.00
Gross Beta	pCi/l		50,997		6.27E-05	2.63E+08	n/	16,490.10		52.53		313.91
Americium-241	pCi/l		17.97		9.61E-07	4.54E+05		0.44	>	222.22		0.00
Curium-244	pCi/l		ND		0.00E+00	6.67E+06		0.00		1.00	i/	0.01
Gamma Scan:												
Potassium-40	pCi/l		1,270		3.10E+01	0	o/	0.00		1.00	i/	0.01
Manganese-54	pCi/l		ND		0.00E+00	4.47E+07		0.00		1.42		0.00
Cobalt-58	pCi/l	<	241.7		1.33E-09	1.77E+08		0.24		2.90		0.08
Cobalt-60	pCi/l	<	171.8		2.64E-08	1.27E+07		0.34		9717.44		0.00
Cesium-134	pCi/l	<	99.4		1.33E-08	8.09E+07		1.08		1.00		1.08
Cesium-137	pCi/l		53,305		1.06E-04	2.44E+06		258.64		174.58		1.48
Europium-154	pCi/l	<	343.6		4.10E-07	4.07E+06		1.67	>	55.30	<	0.03
Europium-155	pCi/l		ND		0.00E+00	3.57E+06		0.00		1.00		0.00
Radium-226	pCi/l		ND		0.00E+00	1.84E+07		0.00		1.00		0.00
Radium-228	pCi/l		ND		0.00E+00	4.37E+09		0.00		1.00		0.00
Thorium-228	pCi/l		ND		0.00E+00	6.57E+07		0.00		1.00		0.00
Thorium-232	pCi/l		ND		0.00E+00	3.05E-02		0.00		1.00		0.00
Strontium-90	pCi/l		1,522		1.87E-06	2.63E+08		491.81		58.03		8.48
Total Radium	pCi/l	<	0.278		0.00E+00	p/ 0	p/	0.00	p/ >	8.16		0.00
Uranium-234	pCi/l		2.646		2.14E-01	3.99E-02		0.01	>	50.51		0.00
Uranium-235	pCi/l		0.2049		1.66E-02	4.00E-02		0.00	>	6.84		0.00
Uranium-238	pCi/l		1.652		8.60E-01	4.66E-03		0.00	>	44.44		0.00
Plutonium-238	pCi/l		7.95		7.92E-08	1.95E+06		0.15	>	181.82		0.00
Plutonium-239,240	pCi/l		82.5		2.33E-04	6.87E+03	l/	1.60	>	384.62	<	0.004
Lead-210	pCi/l		ND		0.00E+00	4.68E+08		0.00		1.00	i/	0.00
Hydrogen-3	pCi/l		ND		0.00E+00	1.80E+06		0.00		1.00	i/	0.00
Ruthenium-106	pCi/l		ND		0.00E+00	1.88E+08		0.00		1.00	i/	0.00
Total Uranium	pCi/l		ND		0.00E+00	p/ 0	p/	0.00	p/	1.00		0.00
								50,424.93				5,189.72

Notes

a/ The toxic weighting factor is a measure of the relative toxicity of a given constituent using the water quality criteria for copper as a baseline value.

b/ Where the expected influent values are not available the worst-case design basis values are used.

TABLE 6.4 (continued)
EFFECTIVENESS ANALYSIS – ALTERNATIVE 3
BEST AVAILABLE TECHNOLOGY ANALYSIS
DECONTAMINATION LAUNDRY FACILITY
WESTINGHOUSE HANFORD COMPANY, RICHLAND, WASHINGTON

Notes (continued)

c/ Dash (–) indicates that the parameter cannot be calculated.
d/ Greater than for the decontamination factor indicates that the compound was present below the detection limit for the treatability study test effluent, and therefore the detection limit was used in the calculation.
e/ Calculated as total ammonia.
f/ Calculated as total arsenic.
g/ The decontamination factor for arsenic is based on engineering experience.
h/ These values are hardness dependent (100 mg/l used).
i/ Removal of these species may occur is they are precipitated from solution or are otherwise adsorbed. However, removal has not been considered, and the decontamination factor is assumed to be 1.00.
j/ Calculated as hexavalent chromium.
k/ Calculated as hydrogen sulfide.
l/ Calculated as Plutonium–239.
m/ ERR indicates that all of the parameter has been removed and therefore the decontamination is infinite.
n/ Calculated as Strontium–90.
o/ No radionuclide limit established in 10 CFR 20.
p/ The individual constituents of these general categories have been evaluated based on total pounds per year and the toxic weighting factor, and therefore these general categories have not been evaluated.

TABLE 6.5
EFFECTIVENESS ANALYSIS – ALTERNATIVE 4
BEST AVAILABLE TECHNOLOGY ANALYSIS
DECONTAMINATION LAUNDRY FACILITY
WESTINGHOUSE HANFORD COMPANY, RICHLAND, WASHINGTON

Analyte	Units	Expected Influent	Total Pounds in Treatment Plant Influent Per Year	Toxic Weighting Factor a/	Total Toxic Pounds in Treatment Plant Influent Per Year	Decon-tamination Factor	Toxic Pounds Remaining in Treatment Plant Effluent Per Year
Miscellaneous Data							
pH	SU	8.7 b/	– c/	0	–	–	0.00
Temperature	C	47 b/	–	0	–	–	0.00
Conductivity	µmhos	829 b/	–	0	–	–	0.00
Alkalinity	µg/l	348,700 b/	60,474	2.80E-04	16.93	1.00	16.93
Total Dissolved Solids	µg/l	440,000	76,308	2.24E-05	1.71	21.22	0.08
Total Suspended Solids	µg/l	193,400 b/	33,541	0	0.00	> 12.00 d/	0.00
Oil and Grease	µg/l	159,333 b/	27,633	0	0.00	48.08	0.00
Inorganic Species							
Aluminum	µg/l	200 U	35	0	0.00	> 7.55	0.00
Ammonia (as N)	µg/l	22,193	3,849	2.67E-03 e/	10.28	5.54	1.85
Arsenic	µg/l	70 U	12	2.55E+03 f/	30,956.90	10.00 g/	3,095.69
Barium	µg/l	200 U	35	5.60E-03	0.19	1.00	0.19
Boron	µg/l	100 U	17	0	0.00	1.00	0.00
Cadmium	µg/l	5.0 U	1	5.65E+00 h/	4.90	> 5.67	< 0.86
Calcium	µg/l	21,167	3,671	0	0.00	4.43	0.00
Chloride	µg/l	62,667	10,868	0	0.00	23.98	0.00
Chromium	µg/l	10.0 U	2	6.21E-01 i/	1.08	> 3.53	< 0.31
Copper	µg/l	28.5	5	4.67E-01 h/	2.31	6.04	0.38
Cyanide	µg/l	6,682 b/	1,159	1.10E+00	1,275	1.00 j/	1,275
Fluoride	µg/l	107	18	0	0.00	> 1.20	0.00
Hydrazine	µg/l	100 U	17	0	0.00	1.00	0.00
Iron	µg/l	3,670	636	2.43E-02	15.47	> 147.61	< 0.10
Lead	µg/l	1,223	212	1.86E+00 h/	394.62	5095.94	0.08
Lithium	µg/l	100 U	17	0	0.00	1.00	0.00
Magnesium	µg/l	6,013	1,043	0	0.00	1.05	0.00
Manganese	µg/l	50.7	9	1.12E-01	0.98	> 16.32	< 0.06
Mercury	µg/l	0.30	0.05	5.06E+02	26.62	> 4.13	< 6.45
Nickel	µg/l	40.0 U	7	4.53E-01 h/	3.14	1.00	3.14
Nitrate (as N)	µg/l	210	36	5.60E-04	0.02	1.90	0.01
Phosphate (as P)	µg/l	213,667	37,056	0	0.00	18.58	0.00
Potassium	µg/l	6,013	1,043	0	0.00	1.00	0.00
Selenium	µg/l	5.0 U	1	7.20E-01	0.62	1.00	0.62
Silicon	µg/l	43,267	7,504	0	0.00	19.55	0.00
Silver	µg/l	10.0 U	2	4.68E+01	81.16	1.00	81.16
Sodium	µg/l	22,883	3,969	0	0.00	3.78	0.00
Strontium	µg/l	100 U	17	0	0.00	1.00	0.00
Sulfate	µg/l	5,000 U	867	0	0.00	4.43	0.00
Sulfide	µg/l	677 b/	117	2.80E+00 k/	328.75	1.00 j/	328.75
Titanium	µg/l	100 U	17	0	0.00	1.00	0.00
Vanadium	µg/l	50.0 U	9	0	0.00	21.01	0.00
Zinc	µg/l	553	96	5.09E-02 h/	4.88	44.51	0.11

TABLE 6.5 (continued)
EFFECTIVENESS ANALYSIS – ALTERNATIVE 4
BEST AVAILABLE TECHNOLOGY ANALYSIS
DECONTAMINATION LAUNDRY FACILITY
WESTINGHOUSE HANFORD COMPANY, RICHLAND, WASHINGTON

Analyte	Units	Expected Influent	Total Pounds in Treatment Plant Influent Per Year	Toxic Weighting Factor a/	Total Toxic Pounds in Treatment Plant Influent Per Year	Decon-tamination Factor	Toxic Pounds Remaining in Treatment Plant Effluent Per Year
Organic Species							
Acetone	µg/l	227 B	39	0	0.00	9.42	0.00
Benzoic acid	µg/l	307	53	0	0.00	> 1.80	0.00
Benzyl alcohol	µg/l	32	6	0	0.00	> 1.00	0.00
bis(2-Ethylhexyl)phthalate	µg/l	400 B	69	0	0.00	2.48	0.00
Butylbenzylphthalate	µg/l	37	6	0	0.00	1.00	0.00
Chloroform	µg/l	10	2	2.95E+01	51.16	> 2.20	< 23.30
Di-n-Octyl phthalate	µg/l	36 J	6	0	0.00	1.33	0.00
Phenol	µg/l	343	60	3.79E-03	0.23	> 10.19	< 0.02
Total Organic Carbon	µg/l	55,000	9,539	0	0.00	2.93	0.00
Total Carbon	µg/l	116,500 b/	20,204	0	0.00	–	–
Total Organic Halides (TOX	µg/l	623 b/	108	0	0.00	–	–
Radionuclides							
Gross Alpha	pCi/l	111.5	3.16E-04	6.87E+03 l/	2.17	ERR m/	0.00
Gross Beta	pCi/l	50,997	6.27E-05	2.63E+08 n/	16,490.10	781.72	21.09
Americium-241	pCi/l	17.97	9.61E-07	4.54E+05	0.44	> 27100.27	0.00
Curium-244	pCi/l	ND	0.00E+00	6.67E+06	0.00	1.00 j/	0.00
Gamma Scan:					0.00		
Potassium-40	pCi/l	1,270	3.10E+01	0 o/	0.00	1.00 j/	0.00
Manganese-54	pCi/l	ND	0.00E+00	4.47E+07	0.00	ERR	0.00
Cobalt-58	pCi/l	< 241.7	1.33E-09	1.77E+08	0.24	2.90	0.08
Cobalt-60	pCi/l	< 171.8	2.64E-08	1.27E+07	0.34	9717.44	0.00
Cesium-134	pCi/l	< 99.4	1.33E-08	8.09E+07	1.08	1.00	1.08
Cesium-137	pCi/l	53,305	1.06E-04	2.44E+06	258.64	1745.50	0.15
Europium-154	pCi/l	< 343.6	4.10E-07	4.07E+06	1.67	> 55.30	< 0.03
Europium-155	pCi/l	ND	0.00E+00	3.57E+06	0.00	1.00	0.00
Radium-226	pCi/l	ND	0.00E+00	1.84E+07	0.00	1.00	0.00
Radium-228	pCi/l	ND	0.00E+00	4.37E+09	0.00	1.00	0.00
Thorium-228	pCi/l	ND	0.00E+00	6.57E+07	0.00	1.00	0.00
Thorium-232	pCi/l	ND	0.00E+00	3.05E-02	0.00	1.00	0.00
Strontium-90	pCi/l	1,522	1.87E-06	2.63E+08	491.81	36134.73	0.01
Total Radium	pCi/l	< 0.278	0.00E+00 p/	0 p/	0.00 p/	> ERR	0.00
Uranium-234	pCi/l	2.646	2.14E-01	3.99E-02	0.01	> 952.93	0.00
Uranium-235	pCi/l	0.2049	1.66E-02	4.00E-02	0.00	> 12.89	0.00
Uranium-238	pCi/l	1.652	8.60E-01	4.66E-03	0.00	> 542.01	0.00
Plutonium-238	pCi/l	7.95	7.92E-08	1.95E+06	0.15	> 2222.72	0.00
Plutonium-239,240	pCi/l	82.5	2.33E-04	6.87E+03 l/	1.60	> 226244.34	0.00
Lead-210	pCi/l	ND	0.00E+00	4.68E+08	0.00	1.00 j/	0.00
Hydrogen-3	pCi/l	ND	0.00E+00	1.80E+06	0.00	1.00 j/	0.00
Ruthenium-106	pCi/l	ND	0.00E+00	1.88E+08	0.00	1.00 j/	0.00
Total Uranium	pCi/l	ND	0.00E+00 p/	0 p/	0.00 p/	1.00	0.00
					50,424.93		4,840.37

Notes

a/ The toxic weighting factor is a measure of the relative toxicity of a given constituent using the water quality criteria for copper as a baseline value.

b/ Where the expected influent values are not available the worst-case design basis values are used.

TABLE 6.5 (continued)
EFFECTIVENESS ANALYSIS – ALTERNATIVE 4
BEST AVAILABLE TECHNOLOGY ANALYSIS
DECONTAMINATION LAUNDRY FACILITY
WESTINGHOUSE HANFORD COMPANY, RICHLAND, WASHINGTON

Notes (continued)

c/ Dash (–) indicates that the parameter cannot be calculated.

d Greater than for the decontamination factor indicates that the compound was present below the detection limit for the treatability study test effluent, and therefore the detection limit was used in the calculation.

e/ Calculated as total ammonia.

f/ Calculated as total arsenic.

g/ The decontamination factor for arsenic is based on engineering experience.

h/ These values are hardness dependent (100 mg/l used).

i/ Calculated as hexavalent chromium.

j/ Removal of these species may occur if they are precipitated from solution or are otherwise adsorbed. However, removal has not been considered, and the decontamination factor is assumed to be 1.00.

k/ Calculated as hydrogen sulfide.

l/ Calculated as Plutonium-239.

m/ ERR indicates that all of the parameter has been removed and therefore the decontamination is infinite.

n/ Calculated as Strontium-90.

o/ No radionuclide limit established in 10 CFR 20.

p/ The individual constituents of these general categories have been evaluated based on total pounds per year and the toxic weighting factor, and therefore these general categories have not been evaluated.

TABLE 6.6
COST ACHIEVABILITY SUMMARY
BEST AVAILABLE TECHNOLOGY ANALYSIS
DECONTAMINATION LAUNDRY FACILITY
WESTINGHOUSE HANFORD COMPANY, RICHLAND, WASHINGTON

Alternative	Alternative EUAC a/	Toxic Pounds Removed b/
1	1,523,000	14,036
2	2,079,000	45,031
3	2,249,000	45,235
4	3,343,000	45,585

Notes
a/ EUAC for alternatives from Table 5.10
b/ Toxic pounds removed from total toxic pounds in treatment plant influent (50,425) and total toxic pounds remaining data in Tables 6.2 through 6.5.

7.0 SELECTED ALTERNATIVE

The previous sections of this document have reviewed the identification of potential alternatives, the evaluation of alternatives, and the final selection of BAT/AKART for the DLF. In addition, a basic description of the processes incorporated in the each of the alternatives was provided. The following sections review additional details concerning the selected alternative only.

7.1 DESIGN PARAMETERS

Section 5.0 reviewed the basic process design parameters for each of the unit operations included in the recommended alternative. The following paragraphs summarize the important design parameters which will be addressed during definitive design of the recommended alternative.

The first step in the facility is wastewater collection and heat recovery. Also included in these operations is gross solids (lint) removal. Separate collection systems will be provided for the regulated and nonregulated sides of the facility. The collection system will be designed to collect wastewater as it is discharged from the washing machine and transfer it to the solids removal and heat recovery systems. Collection tanks/sumps will be sized to accommodate the maximum volume of water which can be produced if all washing machines discharge simultaneously. This system will also take into account the surges of wastewater which are produced as the machines go through various cycles.

The gross solids removal step will be accomplished through the use of static shaker screens. These screens will be designed hydraulically for the expected flow. In addition, the screens will be replaceable. This will allow easy replacement of the screen should it become damaged. It will also allow for the use of different mesh size screens should operating experience dictate that a change is required. Accumulated lint and solids will be automatically discharged to a dewatering device prior to packaging for disposal.

Separate heat recovery systems will be provided for the regulated and nonregulated sides of the laundry. The regulated system will recover heat by using screened wastewater to preheat regulated laundry feedwater, while the nonregulated system will recover heat through the direct use of steam condensate produced throughout the DLF as part of the nonregulated feedwater. Both systems will be designed to provide sufficient feedwater for all of the washing machines in the facility.

All screened wastewater will be directed to an equalization tank. This tank will be designed to provide sufficient capacity to eliminate surges in flow to the rest of the treatment facility. This tank will also provide limited storage in the event of a minor malfunction in the treatment system.

Wastewater will be pumped from the equalization tank to the chemical pretreatment reaction system. The reaction system will include the necessary tanks to allow the for the precipitation of metals and radionuclides by adjustment of pH to approximately 12. Reaction tanks will be designed to allow for the completion of the reaction, and will be baffled to promote complete mixing and prevent short circuiting. It is anticipated that a solution of lime will be used to accomplish the precipitation reaction.

The possible use of multiple step reactions will also be further investigated during definitive design to see if such a system could potentially reduce sludge volumes.

Chemical storage systems will be provided for lime and other chemicals. Depending upon usage, these systems will be designed for three to five days of storage. Bulk storage systems will be considered for chemicals with high usage rates. Chemicals which are not used in large volumes will most likely be procured in drums or bags, and will be stored in the facility. Appropriate segregation of reactive chemicals will be provided, and all chemicals will be stored in contained areas.

Pretreated water will be pumped to the membrane microfiltration system. This system will include appropriate feed pumps, permeate tanks, cleaning tanks, and the membrane modules themselves. The system will be provided in two parallel trains each with capacity to treat half of the design flow. This arrangement will allow for continuous processing when one of the trains is down for maintenance. The materials of construction for the membranes will be carefully selected to allow for use in high pH applications. In addition, the potential for oil and grease will be considered in selecting the membrane materials. Based on the results of the treatability study and experience on other projects, it is anticipated that a tubular membrane configuration will be used. This configuration is generally preferred in chemical treatment applications where relatively high solids containing streams are produced. The membrane system will also be provided with an integral cleaning system to allow for periodic cleaning of the membranes.

Filtered water from the membrane system will be treated through the zeolite ion exchange system for the removal of radioactive cesium and strontium. The system will use two columns operated in series. Series operation allows for more complete

utilization of media capacity as any leakage of the contaminant of concern from the first column is retained by the second column. Series operation also ensures that there is sufficient media capacity to handle sudden changes in feed concentrations.

The zeolite columns and activated carbon columns will be hydraulically designed to prevent channeling and short circuiting in the bed, as well as to minimize pressure drop across the column. Differential pressure measurement will also be provided to indicate the presence of any fines which may cause increased pressure drops. Provisions will be made to backwash the column should fines be produced. Spent media from the columns will be transferred as a water slurry to a dewatering tank. This tank will be screened to allow for the removal of free water from the media. The dewatered media will then be loaded into appropriate disposal containers. New media will be transferred into the empty column by a jet eductor system.

Treated water from the column systems will be directed to a recycle tank. A discharge pump will be used to discharge the treated water to the TEDF. A portion of the treated water will be recycled back to through the heat recovery system, and will be used as part of the feedwater to the regulated laundry.

A variety of monitoring and control systems will be provided with the wastewater treatment system. All pumped tanks will be provided with level control systems with remote readout. In addition, these tanks will be equipped with float switches to shut down affected systems should the automatic level system fail. High and low level conditions will also activate visual and audible alarms. A pH control system will be provided to control all chemical addition to the reaction system. The system pH will be continuously displayed, and appropriate alarms provided. In addition, on-line turbidity monitors and alarms will be provided to indicate failure of a membrane.

Finally, differential pressure monitors and alarms will be provided for the column systems to provide indication of excessive pressure drop in the media beds.

The main control panel will monitor and control all wastewater treatment operations both in the wastewater treatment room as well as any remote equipment. The main control panel will provide indication of all important process parameters such as level, flow, temperature, pressure, and others as determined during definitive design.

7.2 ABILITY TO MEET COMPARATIVE LEVELS

Section 5.1.2 of this document presented an estimate of the ability of the selected alternative to meet Comparative Levels. As shown, not all of the Comparative Levels can be met. However, these limits were only intended to provide the basis for the comparative evaluation of alternatives. Final discharge standards for the DLF will be established after the permit process for the DLF is complete.

In general, the selected alternative will produce a very high quality effluent. The expected quality of the effluent has been predicted based on actual treatability study data. The unit operations incorporated into the design of the facility are all capable of responding to sudden changes in wastewater characteristics, and a consistent quality effluent is anticipated.

Because of the expected consistent quality of the DLF discharge, retention of wastewater prior to discharge to the TEDF is not required. The removal of inorganic contaminants and radionuclides is largely accomplished by the chemical precipitation system. This system will be controlled by an automatic pH control system, and upsets will activate alarms. Once the contaminants are transformed to a solid form,

they are removed by the membrane microfiltration system. This system is an absolute particle barrier, and as such, is not affected by system upsets. In addition, in-line turbidity sensors will detect any failures of the membrane system.

The remainder of the contaminants of concern will be removed by the zeolite ion exchange and granular activated carbon systems. To prevent any possible release of significant concentrations of contaminants, two columns in series will be operated. This type of operation will allow for changes in feed concentrations with continued contaminant removal. Any problems with either of these systems will be noted through periodic sampling. Once operating experience is gained, it is likely that indicator parameters which may easily measured in the field will be identified which will allow even more warning of potential problem conditions with these systems.

The process which generated the wastewater itself will also allow for an indication of potential problems. Because laundry is washed on a batch basis, laundry operators will be able to notify the wastewater treatment system operators of any unusual events. In addition, the generation of wastewater can be stopped simply by shutting down washing operations.

7.3 PERSONNEL TRAINING REQUIREMENTS

An important consideration in the implementation of the DLF effluent treatment facility is the training of personnel to operate the facility. Personnel requirements for the facility include operators to operate and monitor the treatment process itself, radiation protection personnel, maintenance personnel, and general building/facility support personnel. Because the DLF will be a major facility at the Hanford Site, all of these personnel with the exception of the operators will be available as permanently

assigned staff. Therefore, the following sections focus on training requirements for the operators only.

The basic unit operations in the facility will include wastewater collection and heat recovery, chemical pretreatment and membrane microfiltration, zeolite ion exchange, granular activated carbon, and secondary waste handling. In addition, the overall process control system will require monitoring. The basic facility functions with respect to operations of heating, ventilation, and air conditioning systems will be operated by other personnel assigned to the DLF, and not the treatment plant personnel.

The collection and heat recovery systems will be designed as automated systems. However, the heat recovery system will require a fairly sophisticated process control system operated by a programmable logic controller. In addition, these systems will require specific monitoring to ensure continued efficient operations. Specific skills which will be required include an understanding of mechanical and electrical systems. Therefore, detailed Operations and Maintenance Manuals will be prepared for these systems. In addition, the supplier of these systems will be required to provide on-site start-up and training services.

The chemical pretreatment and membrane microfiltration system is the heart of the treatment system, as well as probably the most complex part of the system. Similar to the wastewater collection and heat recovery system, a programmable logic controller will be used for overall automatic control. This minimizes direct operator time required to control the system. However, periodic monitoring of control parameters will be required to ensure that the facility is operating in an efficient manner. This will require an operator with specific skills and training as a wastewater

treatment plant operator. This individual must have an understanding of process chemistry such that he/she can identify potential process upsets before they occur, and implement appropriate corrective action. The operator must also have basic mechanical and electrical skills as well. Detailed Operations and Maintenance Manuals will be prepared for these systems, and the supplier will be required to provide on-site start-up and training services.

Both the zeolite ion exchange and activated carbon system require minimal monitoring and attention. Both are very passive processes which have require no automated controls other than monitoring for high differential pressure conditions. No special skills other than general mechanical skills are required for these systems.

Secondary waste systems include spent media dewatering and sludge dewatering and drying. Both of these systems will be operated on a batch basis. This minimizes the amount of continuous operator attention, although full-time operators are required during periods of actual waste processing operations. The spent media dewatering operation is controlled manually, and requires no special skills. The sludge dewatering and drying process will be initiated manually, but will be operated automatically after a cycle is started. General mechanical and electrical skills will be required to operate these systems.

As previously discussed, the overall operations of wastewater treatment unit processes will be performed through the use of programmable logic controllers. Additional hardware including field-mounted sensors and control subsystems (i.e. pH controllers, level controllers) will also be used. These automated systems will require three categories of trained personnel. The first has been discussed, and is the treatment system operators themselves. These operators must be trained and

experienced in the use and interpretation of monitoring, control, alarm, and data logging functions available through the programmable controllers. The second category of personnel includes instrument technicians trained to calibrate, diagnose, and repair field mounted equipment as well as computer hardware. Certain sensors which monitor critical parameters associated with safety (i.e. radiation levels) and treated water quality (i.e. pH, turbidity) will require frequent calibration. These calibration activities, together with scheduled and unscheduled maintenance, may prove to be relatively labor intensive. Finally, the third category of personnel includes engineers trained to routinely verify the integrity of control logic software and to modify the software to reflect process equipment configuration changes and increased operating experience. The vendors who supply the hardware and software will be responsible for initial training in all three categories. Following initial training, WHC will establish ongoing training programs to maintain and update expertise in each of the three categories.

7.4 RELATIONSHIP TO EXISTING TREATMENT FACILITIES

Section 2(n) of WAC Chapter 173-240-130 requests that this document discuss any relationships between the proposed treatment facility and existing treatment facilities. No treatment facilities other than those described in this document will be used for treatment of DLF wastewater.

7.5 TREATMENT SYSTEM UNCERTAINTIES

There are no significant technological or design uncertainties associated with the selected alternative. There are several operational uncertainties such as the actual usage rate of zeolites and granular activated carbon. However, these uncertainties will

not prevent the design and construction of the facility. The most significant unknown is the final requirements with respect to the treated water quality. However, it has been demonstrated that the selected alternative will produce a high quality effluent, and that the potential exceedances of Comparative Levels are not believed to be significant.

7.6 COMMITTED FUTURE PLANS

Section 2(u) of WAC Chapter 173-240-130 requests that a discussion be provided with respect to any committed future plans relevant to the proposed treatment facility. One future project, the 200 Area Treated Effluent Disposal Facility (TEDF), will have a bearing on the operation of the proposed DLF treatment facility.

The purpose of the 200 Area TEDF is to provide for the disposal of 18 liquid effluent generated in the 200 Area. BAT/AKART will be applied to each of these effluent prior to finalizing the TEDF design. The current TEDF concept includes a retention system where each of the 18 effluent will be collected and sampled, and a stand-by treatment system. If contaminant concentrations are below release limits established in the facility permit(s), the combined effluent will be discharged to the disposal site. Engineering studies are currently underway to determine the specific disposal method which will be used. Effluent that are not acceptable for disposal will be routed to the stand-by treatment facility.

7.7 SEPA/NEPA COMPLIANCE

The State Environmental Protection Act (SEPA) and National Environmental Protection Act (NEPA) require that an environmental impact statement (EIS) be prepared for any

major action which has the potential of significantly affecting the environment. Documentation addressing both NEPA and SEPA requirements have been prepared for the DLF, and indicate that there will be no significant environmental impacts from the facility.

8.0 PROJECT IMPLEMENTATION

Sections 2 (w) of WAC 173-240-130 requires a schedule for completion of design and construction of the proposed facility. Section 2 (s) of the same Chapter, requires that a statement also be included as to who will own, operate, and maintain the treatment system after construction. These two requirements are addressed below.

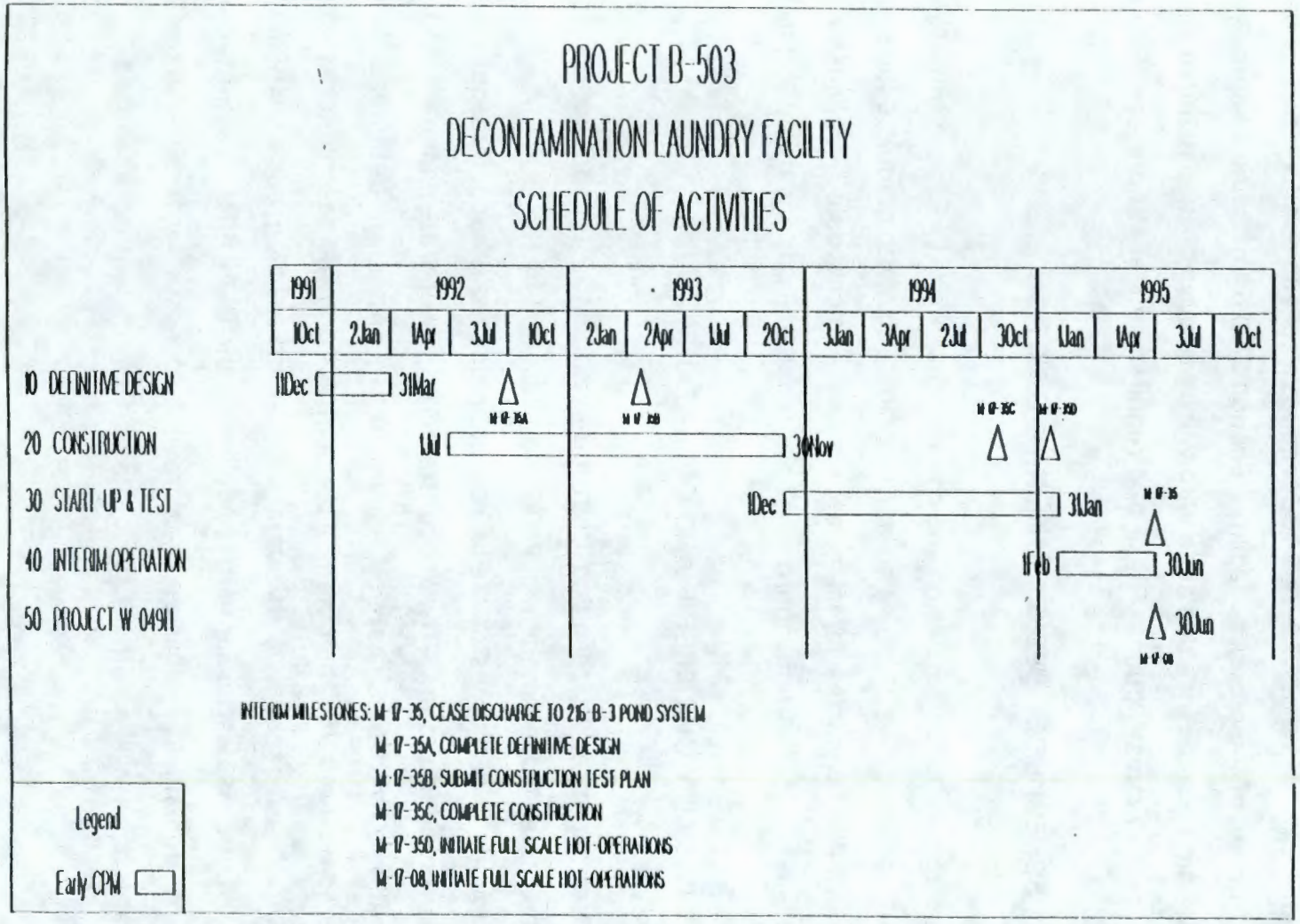
8.1 SCHEDULE OF DESIGN AND CONSTRUCTION

The current schedule for design and construction of the DLF is presented in Figure 8.1. This schedule shows all major tasks which are required to complete the project. There are no major obstacles foreseen at this time which could significantly impact this schedule other than final approval of the recommendations made in this document.

8.2 FACILITY OWNERSHIP AND OPERATION

The treatment facility resulting from the execution of this project (B-503) will be a United States Government installation administered by the DOE. In administering the facility, the DOE intends to assign operating and maintenance responsibilities to one or more subcontractors. The subcontractor(s) will operate and maintain the facility in accordance with technical and administrative criteria as determined and routinely updated by the DOE. The potential subcontractor(s) will be limited to those who have demonstrated experience in operating and maintaining equipment and processes having complexities similar to those utilized in the DLF. Such subcontracted operation and maintenance is typical, and has proven successful for facilities under DOE control at Hanford as well as other United States Government installations.

FIGURE 8.1
PROJECT SCHEDULE



During an initial period of operation (possibly several months), the DOE will retain a group of vendor employees to assist the subcontractor(s) in various activities including training, detecting and correcting operational abnormalities or deficiencies, and updating design operating and maintenance procedures. The assistance group will be comprised, as necessary, of employees or representatives of companies associated with all phases of the project including technology development, design, engineering, equipment fabrication, and construction.

9.0 PROFESSIONAL ENGINEERING ASSESSMENT

Section 2(q) of Chapter 173-240-130 WAC requires that this report incorporate a summary statement assessing the ability of the proposed BAT/AKART to result in discharged water which will meet applicable permit effluent criteria. The results of the treatability studies indicate that not all of the Comparative Levels could be met. However, many of the observed exceedances were based on incomplete data or limits which are beyond analytical or technical feasibility. The engineers who participated in the selection of BAT/AKART as described in this report are confident that the completed system will result in effluent contaminant concentrations that will be lower or equal to reasonable effluent discharge criteria which may be applied.

All activities on this project were directly supervised by a licensed Professional Engineer. In preparing this report, he has examined and assessed the BAT/AKART procedure which the DOE has developed and applied consistently and uniformly to all technical evaluations of this nature. The BAT/AKART procedure was determined to be a valid codification of comprehensive, precise, and impartial methods for applying Best Professional Judgement and engineering discipline to the selection of source control measures and technologies.

A thorough review of the many documents that, collectively, present the results of the BAT/AKART evaluation for the DLF, indicate that the procedure was applied carefully and resulted in a system that is likely to meet the requirements which can be presently anticipated.

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APPENDIX A
BEST AVAILABLE TECHNOLOGY PROCEDURE

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BEST AVAILABLE TECHNOLOGY PROCEDURE

Many of the Hanford wastewater streams are unique in terms of the combination of contaminant species and associated concentrations. Hence, the approach to selection of BAT/AKART for treatment of those streams must include consideration and evaluation of a large number of related components.

For certain industries, federal and state agencies have provided guidance for selection of BAT/AKART for treating certain contaminant species or categories. However, that guidance cannot be directly applied to Hanford streams because there are federal or state guidances for discharges from facilities such as Hanford. Considering these facts, the selection of BAT/AKART for treating a given Hanford stream evolves into a process of identifying and adapting systems used, or planned for use, in treating similar streams or specific contaminants. This process requires identification and evaluation of treatment methods or technologies which are either being applied successfully, or have been approved for application, in treating streams which exhibit contaminant characteristics similar to those of the Hanford stream.

The resulting BAT/AKART selection process relies heavily on the existence of treatment systems which can be adapted for use at Hanford. However, the adaptation process is complicated by the fact that Hanford streams typically display unique contaminant characteristics. For example, various industries have used a wide range of technologies to successfully treat organic contaminants. However, the dissolved solids and radionuclides commonly found in Hanford streams in combination with organic contaminants preclude simple application or adaptation of those technologies. Furthermore, operability or removal efficiency of certain technologies which are effective in treating a given contaminant category is often impaired by the presence of additional contaminant categories in the stream. For example, when using activated

carbon the presence of high levels of total organic carbon can complicate the removal of other organic contaminants of concern present at trace concentrations due to the competition for adsorption sites.

Therefore, treatment of a typical Hanford wastewater stream requires development of a system consisting of a carefully considered combination of technologies to be applied to the stream in sequence.

For streams where no applicable effluent limits exist, an important, additional constraint in BAT/AKART selection is the case-by-case application by regulators of a technique known as Best Professional Judgement (BPJ) to establish effluent limitations. According to the EPA, BPJ is "the highest quality technical opinion developed by a permit writer after consideration of all reasonably available and pertinent data or information." Existing regulatory criteria identify key BPJ considerations including engineering feasibilities, environmental objectives, and economic realities. The Clean Water Act and recent EPA training manuals provide regulators with additional guidance for striking a balance among competing considerations, for ensuring consistency in application among similar cases, and for avoiding arbitrary decisions.

After considering the complexities described above, the DOE organized the BAT/AKART selection process into a series of five steps which can be applied, in sequence, to determine BAT/AKART for a given wastewater stream. The resulting procedure was illustrated schematically in Figure 1.1. The first step involves acquisition and correlation of stream-specific data. Any one of the four succeeding steps can result in determination of BAT/AKART. Thus, steps two through four are applied in sequence, but only up to a point at which a determination of BAT/AKART is reached. The following sections provide summaries for the five individual steps.

A.1 WASTEWATER CHARACTERIZATION

The first step in the BAT/AKART procedure is to characterize the wastewater stream. Characterization consists of identifying and quantifying the radioactive and nonradioactive contaminants in the stream as well as quantifying the flow characteristics of the stream. Comparison of the maximum concentration of each contaminant with applicable or relevant effluent limits provides an indication of the extent of treatment required, if any, for specific contaminants. In cases where treatment is indicated, the categories and concentrations of those contaminants guide the subsequent search for a treatment process or a series of treatment processes which can provide the necessary reductions in concentration.

A series of treatment Comparative Levels have been developed for liquid effluents discharged to the TEDF. These values are intended to serve as an initial baseline to assess the effectiveness of treatment alternatives in reducing the concentrations of contaminants of concern. The Comparative Levels for a number of species are provided in Functional Design Criteria for the 200 Area Treated Effluent Disposal System, Project W-049H (WHC 1991a), and a copy may be found in Attachment 1. For radionuclide species which do not have Comparative Levels, 4% of the Derived Concentration Guide (DCG) values for ingested water may be used in accordance with DOE Order 5400.5 (DOE 1990). The specific Comparative Levels applicable to the DLF are further discussed in Section 3.1.

Zero discharge of effluents through source controls may be determined to be BAT/AKART for some Hanford wastestreams. In these cases, the Comparative Levels will be assumed to be the concentrations present in raw water which feeds the facility producing the wastestream.

A.2 EFFLUENT GUIDELINES METHOD

BAT/AKART may be determined in step two based on identification and evaluation of relevant or applicable effluent guidelines. For treatment of certain streams, federal or state effluent guidelines may establish BAT/AKART. Those guidelines could include limits for specific chemical compounds or for radiation exposure. In cases for which guidelines exist, evaluation of process technologies used to satisfy them in similar applications can provide direction for the purpose of determining BAT/AKART for the Hanford treatment application.

A.3 TECHNOLOGY TRANSFER METHOD

Step three can determine BAT/AKART by identifying technology which can be duplicated or adapted (i.e. transferred) from systems which are either operating or have been approved for design and construction in other, similar applications. It entails surveying potentially comparable wastewater streams and associated BAT/AKART treatment systems and then assessing the degree of similarity with the Hanford stream under consideration. If one or more applications are identified as being sufficiently comparable to the Hanford requirement in terms of influent characteristics and desired effluent quality, then it may be possible to apply similar treatment technologies and effluent limitations to the Hanford stream as BAT/AKART.

A.4 TREATABILITY STUDIES METHOD

Failure to determine BAT/AKART by application of steps two or three, as described above, leads to step four. Step four involves performing a series of treatability studies, the results of which may suggest several treatment options which could be applied as BAT/AKART for the Hanford stream. This method involves identifying one

or more systems which have been proven effective in treating wastewater streams similar to the Hanford stream. This differs from step three in that it considers a wider array of applications in which influent characteristics and desired effluent quality are similar to those of the Hanford stream, but not sufficiently comparable to support direct technology transfer.

A.5 GENERIC TREATMENT SYSTEMS METHOD

Step five is the generic treatment systems method. It is a procedure for determining BAT/AKART in cases where there is little or no relevant data available regarding treatment of similar wastewater streams. The procedure begins with identification and evaluation of generic control methods. If necessary, it continues with identification and evaluation of technologies for treatment of specific stream contaminants. Acceptable technologies, individually or in combination with others, are used to formulate a group of candidate alternatives. The overall procedure is shown schematically in Figure A.1.

The generic treatment systems which are developed should represent a range of progressive treatment as follows:

- Source controls;
- Source controls, pretreatment, and suspended solids removal;
- Source controls, pretreatment, suspended solids removal, and one step of dissolved solids removal; and
- Source controls, pretreatment, suspended solids removal, and two steps of dissolved solids removal.

The general range of alternatives are presented schematically in Figure A.2

FIGURE A.1
GENERIC TREATMENT SYSTEMS METHOD SUMMARY

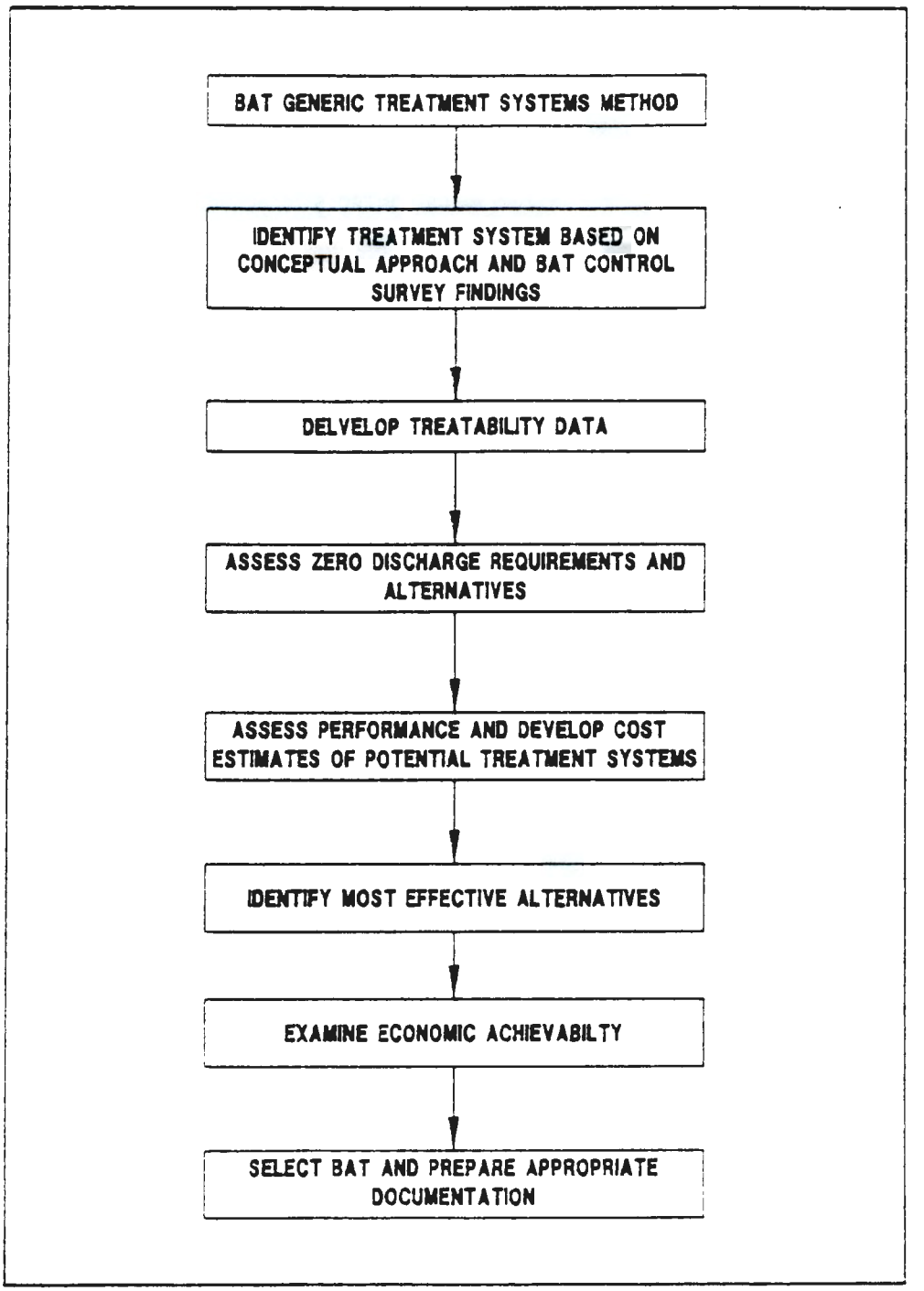
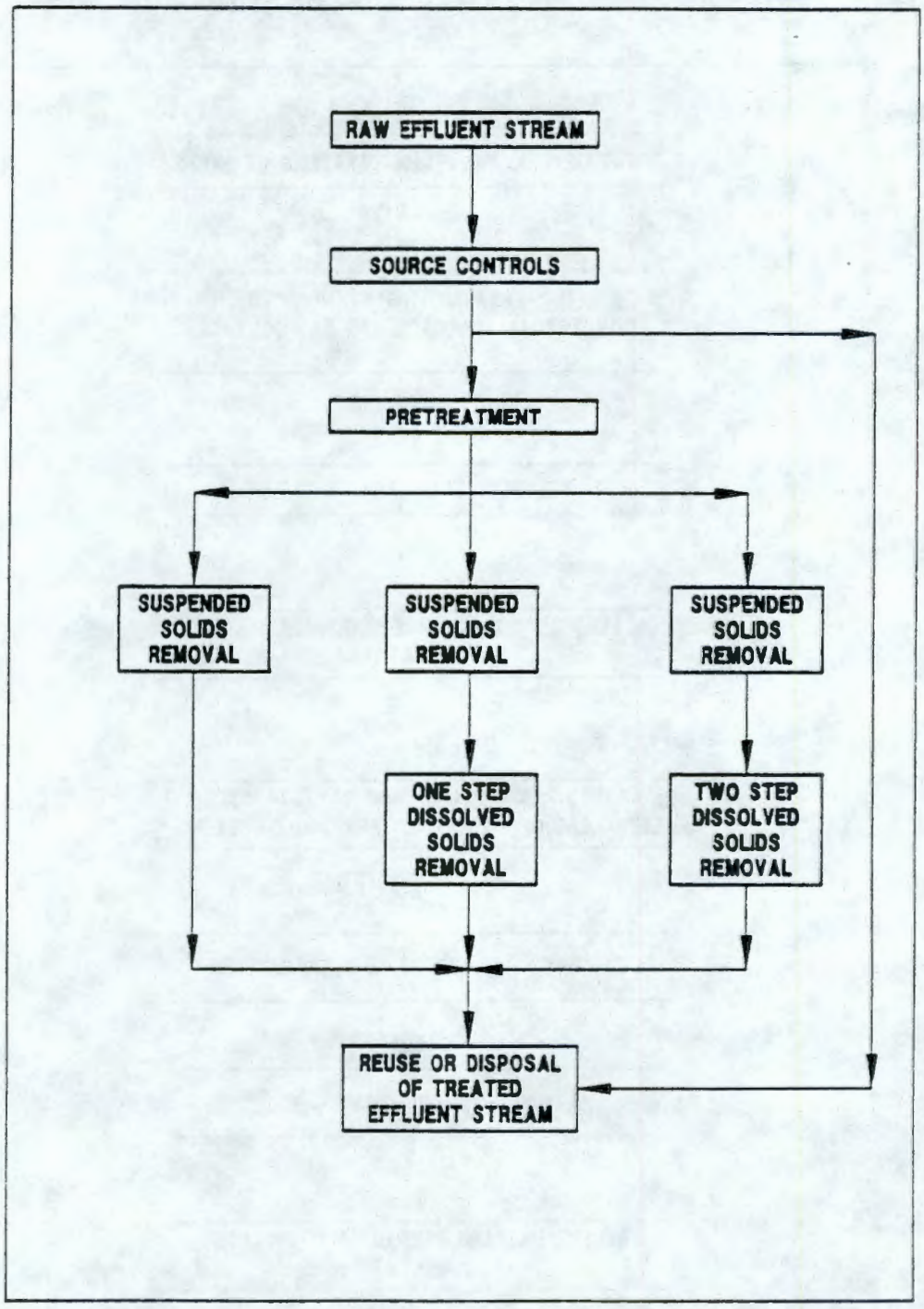


FIGURE A.2
GENERIC TREATMENT SYSTEMS METHOD ALTERNATIVES



A.6 ECONOMIC ACHIEVABILITY

Commercial and industrial facilities are not required to implement controls unless they are economically achievable. However, established tests of economic achievability cannot be applied directly to the Hanford Site because they draw on economic indicators (i.e., revenues) that do not exist for the Hanford Site. However, a modified economic analysis has been developed in the BAT Guidance Manual (WHC 1988b) using the Cost Effectiveness Method. Information necessary to complete this analysis includes toxic weighting factors, decontamination factors, and cost data. The development of this information and the economic achievability analysis are discussed in the following sections.

A.6.1 Toxic Weighting Factors

The toxic weighting factor (TWF) is a measure of the relative toxicity of a given constituent using the water quality criteria for copper as a baseline value. The TWF's for organic and inorganic constituents are calculated from the EPA water quality criteria (WQC) using the following equation as specified in the Bat Guidance Manual (WHC 1988b):

$$TWF = 5.6/WQC_x + 5.6/WQC_y$$

where WQC_x and WQC_y are human health WQC (10^{-6} carcinogen risk level) and the freshwater species chronic exposure WQC, respectively (in ppb).

WQC criteria for nonradiological constituents are found in EPA (1986). WQC criteria for radiological constituents are 1/100 of the values found in Table II, Column 2, Appendix A of WAC 402-24-220, and are the same as in Appendix B of 10 CFR 20.

Values must be converted to concentrations by multiplying each constituent by the appropriate specific activity (Bureau of Radiological Health 1970).

The higher the value of the TWF, the higher the relative toxicity of that constituent. If no WQC exists for a particular constituent, then that constituent is considered nontoxic and its TWF given a value of zero. The total toxic pounds is then determined by multiplying the pounds of the constituent produced per year by the TWF (using appropriate conversions).

A.6.2 Decontamination Factor

The decontamination factor (DF) is a measure of the removal efficiency of each constituent by a particular treatment process. Decontamination factors for each species are developed from surveys of similar facilities, from literature values, or from laboratory and/or pilot plant studies on the actual or similar wastewater to that under consideration.

The toxic pounds for each constituent remaining after treatment using BAT/AKART is obtained by dividing the total toxic pounds present without treatment by the appropriate DF for that constituent, as in the following equation:

$$\text{Toxic pounds remaining} = \frac{\text{total toxic pounds}}{\text{DF}}$$

Where: DF = decontamination factor = C_{in}/C_{out}

C_{in} = constituent concentration without treatment, mg/L

C_{out} = constituent concentration with treatment, mg/L

mg/l = milligrams per liter

The difference between the original total toxic pounds and the toxic pounds remaining is the toxic pounds removed by BAT/AKART.

A.6.3 Cost Effectiveness Method

The cost effectiveness method compares the incremental removal of toxic pollutants to the incremental cost of controls. To allow comparisons of various pollutants, the toxic weighting factors are used. The total initial toxic pounds are calculated as discussed in Section A.6.1. The decontamination factor is then applied to determine the total toxic pounds remaining after application of BAT/AKART, as discussed in Section A.6.2. The difference between the values is the total toxic pounds removed by BAT/AKART.

A.7 SECONDARY WASTE TREATMENT AND DISPOSAL

The objective in treating wastewater is to remove particular species which may have an adverse affect on human health or the environment if discharged. However, with the exception of some organic treatment processes, these contaminants are not destroyed. Rather, they are generally removed from the wastewater and concentrated in a secondary wastestream.

At Hanford, secondary wastes can be nonregulated, low level waste (LLW), radioactive mixed waste (RMW), or transuranic waste (TRU). Depending upon the designation of the waste, different criteria could apply with respect to the final form of the waste to allow disposal to take place. This designation often dictates the types of processes which are acceptable for secondary waste treatment.

The cost to treat and package secondary wastes is often a significant portion of the overall cost to treat a given wastestream. Therefore, it is important that secondary waste treatment be carefully considered in the overall evaluation and selection of BAT/AKART.

ATTACHMENT 1

Comparative Levels

Appendix A
Comparative levels
(with radionuclides)
March 1, 1991

* Determined from the most restrictive of the constituent values from the table "Liquid Effluent Current Comparative Limits, October 16, 1990" (WA State Dept. of Ecology) as supplemented by adding constituents and comparative levels needed for the RCRA delisting petition.

CONSTITUENT	COMPARATIVE LEVELS (ppb)
1,1,1,2- tetrachloroethane	5.0
1,1,1-trichloroethane	7.0
1,1,2,2-tetrachloroethane	0.5
1,1,2-Trichloro-1,2,2-trifluoroethane	57.0
1,1,2-trichloroethane	0.6
1,1-dichloroethane	1.0
1,1-dichloroethylene	7.0
1,2,3,4-tetrachlorobenzene	50.0
1,2,3,5- tetrachlorobenzene	50.0
1,2,3-trichlorobenzene	50.0
1,2,3-trichloropropane	5.0
1,2,4,5-tetrachlorobenzene	10.0
1,2,4-trichlorobenzene	9.0
1,2-dibromo-3-chloropropane	5.0
1,2-dibromoethane	0.001
1,2-dichlorobenzene	50.0
1,2-dichloroethane	0.5
1,2-dichloropropane	0.6
1,2-dimethylhydrazine	60.0
1,2-diphenylhydrazine	0.04
1,3,5-trichlorobenzene	50.0
1,3-Butadiene	0.3

CONSTITUENT	COMPARATIVE LEVELS (ppb)
1,3-dichlorobenzene	36.0
1,3-dichloropropene	0.2
1,3-dinitrobenzene (meta)	10.0
1,4-dichlorobenzene	4.0
1,4-dichloro-2-butene	5.0
1,4 dinitrobenzene	320.0
1,4-dioxane	7.0
1,4-napthaquinone	10.0
1-butanol	5000.0
1-napthylamine	10.0
2,3,4,6-tetrachlorophenol	10.0
2,3,7,8-tetrachlorodibenzo-p-dioxin	0.0000006
2,4,5-T	2.0
2,4,5-TP (Silvex)	50.0
2,4,5-trichlorophenol	16.0
2,4 6-trichlorophenol	4.0
2,4-D	100.0
2,4-dichlorophenol	44.0
2,4-dimethylphenol	5.0
2,4-dinitrophenol	50.0
2,4-dichlorophenoxy-acetic acid	1000.0
2,4-dinitrotoluene	0.1
2,4-diaminetoluene	0.002
2,4,6-trinitrotoluene	1.0
2,6-dichlorophenol	10.0
2,6-dimethylphenol	2.0
2,6-dinitrotoluene	0.1
2,6-toluenediamine	6000.0

CONSTITUENT	COMPARATIVE LEVELS (ppb)
2-chloroethyl vinyl ether	57.0
2-sec-Butyl-4,6-dinitrophenol	66.0
2-acetylaminofluorene	59.0
2-hexanone	50.0
2-methoxy-5-nitroaniline	2.0
2-methylaniline	0.2
2-methylaniline hydrochloride	0.5
2-methylnaphthalene	10.0
2-acetylaminofluorene	10.0
2-chloronaphthalene	10.0
2-chlorophenol	44.0
2-naphthylamine	10.0
2-picoline	5.0
3,3'-dichlorobenzidine	0.2
3,3'-dimethoxybenzidine	6.0
3,3'-dimethylbenzidine	0.007
3-chloropropene (see Allyl chloride)	
3-methylcholanthrene	5.5
3,4-dimethylphenol	4.0
4,4'-methylene-*bis*-(2-chloroanaline)	500.0
4,4'-methylene-*bis*- (N,N'-dimethyl)analine	2.0
4,6-dinitro-o-cresol and salts	50.0
4-nitro-1-oxo-quinoline	10.0
4-aminobiphenyl	10.0
4-bromophenyl phenyl ether	10.0
4-chloro-2-methyl aniline	0.1
4-chloro-2-methyl aniline hydrochloride	0.2
4-nitrophenol	120.0

CONSTITUENT	COMPARATIVE LEVELS (ppb)
5-nitro-o-toluidine	10.0
7,12-dimethylbenz(a) anthracene	10.0
Acenaphthalene	10.0
Acenapthene	59.0
Acetone	50.0
Acetonitrile	100.0
Acetophenone	10.0
Acrolein	21.0
Acrylamide	0.02
Acrylic acid	3000.0
Acrylonitrile	0.07
Adipates [Di(ethylhexyl)adipate]	500.0
Alachlor	2.0
Aldrin	0.005
Allyl alcohol	200.0
Allyl chloride	10.0
Aluminum	50.0
Aluminum, filtered	50.0
Ammonia	1300.0
α,α-dimethylphenethylamine	10.0
Analine	10.0
Anthracene	10.0
Antimony	3.0
Antimony, filtered	1600.0
Antimony-125	300 pCi/l
Aramite	3.0
Arochlor 1016	0.1
Arochlor 1221	0.1

CONSTITUENT	COMPARATIVE LEVELS (ppb)
Arochlor 1232	0.1
Arochlor 1242	0.1
Arochlor 1248	0.1
Arochlor 1254	0.1
Arochlor 1260	0.1
Arsenic	50.0
Arsenic, total metals	0.05
Arsenic, filtered	48.0
Arsenic acid	790.0
Arsenic oxide	790.0
Azobenzene	0.7
Barium	1000.0
Barium, total metals	1000.0
Barium, filtered	1000.0
Benz(a)anthracene	10.0
Benzal Chloride	280.0
Benzyl Chloride	100.0
Benzene	1.0
Benzidine	0.002
Benzotrichloride	0.007
Benzo(a)anthracene	10.0
Benzo(g,h,i)perylene	5.5
Benzo(k)fluoranthene	10.0
Benzo(a)pyrene	zero (10.0)
Benzo(b/k)fluoranthene	29.0
Benzo(b)fluoranthene	10.0
Benzo(k)fluoranthene	10.0
Benzyl alcohol	20.0

CONSTITUENT	COMPARATIVE LEVELS (ppb)
Benzyl chloride	0.5
Beryllium	zero (2.0)
Beryllium, filtered	5.3
Bis(2-chloro-isopropyl)ether	10.0
Bis(2-chloroethoxy) methane	10.0
Bis(chloroethyl)ether	0.07
Bis(2-chloroethyl) ether	7.0
Bis(chloroisopropyl)ether	1000.0
Bis(chloromethyl)ether	0.0002
Bis(2-ethylhexyl) phthalate	6.0
Bromodichloromethane	0.3
Bromoform	2.0
Bromomethane	50.0
Butyl benzyl phthalate	17.0
Cadmium	10.0
Cadmium, total metals	10.0
Cadmium, filtered	1.1
Carbazole	5.0
Carbon disulfide	5.0
Carbon tetrachloride	0.3
Carbon-14	2000 pCi/l
Cesium-137	200 pCi/l
Chloral	70.0
Chlordane	0.06
Chloride	250000.0
Chlorobenzene	2.0
Chlorobenzene (by ABN)	2.0
Chlorobenzilate	30.0

CONSTITUENT	COMPARATIVE LEVELS (ppb)
Chlorodibromomethane	0.5
Chloroethane	5.0
Chloroform	6.0
Chloromethane	190.0
Chloromethyl methyl ether	0.004
Chlorthalonil	30.0
Chromium	50.0
Chromium, total metals	50.0
Chromium (VI)	11.0
Chromium, filtered	11.0
Chrysene	10.0
cis-1,2-dichloroethylene	70.0
cis-1,3-dichloropropene	36.0
Cobalt-60	100 pCi/l
Coliform bacteria, total	1/100 ml
Color	15 color units
Copper	1000.0
Copper, total metals	1000.0
Copper, filtered	12.0
Corrosivity	noncorrosive
Cresols	10.0
Cresols, m and p isomers	770.0
Cyanides, amenable	100.0
Cyanide	5.2
Cyanogen	1000.0
Cyanogen bromide	3000.0
Cyclohexanone	125.0
DDD	0.1

CONSTITUENT	COMPARATIVE LEVELS (ppb)
DDE	0.05
DDT	0.01
DDT+ DDE+ DDD	0.3
δ-BHC	0.1
Dalapon	200.0
Di-n-butyl phthalate	57.0
Di-n-octal phthalate	17.0
Di-n-propylnitrosamine	10.0
Diallate	1.0
Dibenz(a,h)acridine	10.0
Dibenz(a,h)anthracene	10.0
Dibenzofuran	10.0
Dibromomethane	110.0
Dibromochloromethane	1.0
Dichlorodifluoromethane	5.0
Dichlorovos	0.3
Dieldrin	0.005
Diethyl phthalate	200.0
Dimethyl phthalate	47.0
Dimethyl terephthalate	4000.0
Diquat	20.0
Dimethoate	10.0
Dinitrobenzene	10.0
Dinoseb	1.0
Dioxane	150.0
Dioxin	0.01
Diphenylamine	10.0
Diphenylnitrosamine	400.0

CONSTITUENT	COMPARATIVE LEVELS (ppb)
Direct black 38	0.009
Direct blue 6	0.009
Direct brown 95	0.009
Disulfoton	2.0
Endosulfan I	0.06
Endosulfan II	29.0
Endosulfan sulfate	29.0
Endothall	100.0
Endrin	0.01
Endrin aldehyde	25.0
Epichlorohydrin	8.0
Ethyl acetate	50.0
Ethyl acrylate	2.0
Ethyl benzene	2.0
Ethyl ether	50.0
Ethyl methacrylate	5.0
Ethyl methanesulfonate	10.0
Ethylene dibromide	0.001
Ethylene thiourea	2.0
Ethylene oxide	0.1
Famphur	17.0
Fluoranthene	10.0
Fluorene	7.0
Fluoride	2000.0
Flourotrichloromethane	20.0
Foaming agents	500.0
Folpet	20.0
Formic acid	70000.0

CONSTITUENT	COMPARATIVE LEVELS (ppb)
Furazolidone	0.02
Furium	0.002
Furmecyclox	3.0
Glyphosate	700.0
Gross alpha	15 pCi/l
Gross beta particle activity, gross beta activity	50 pCi/l
Gross beta particle activity, tritium	20,000 pCi/l
Gross beta particle activity, strontium 90	8 pCi/l
Heptachlor	0.01
Heptachlor epoxide	0.009
Hexabromobenzene	70.0
Hexachlorobenzene	0.05
Hexachlorobutadiene	5.0
Hexachlorocyclohexane (alpha)	0.001
Hexachlorocyclohexane (technical)	0.05
Hexachlorocyclopentadiene	5.2
Hexachlorodibenzofurans	1.0
Hexachlorodibenzo-p-dioxin, mix	0.00001
Hexachlorodibenzo-furans, All	0.063
Hexachloroethane	7.0
Hexachlorophene	10.0
Hexachloropropene	10.0
Hydrazine/Hydrazine Sulphate	0.03
Hydrocyanic acid	700.0
Hydrogen sulfide	2.0
i-butyl alcohol	5000.0
Indeno(1,2,3-c,d)pyrene	5.5
Iodine-129	1 pCi/l

CONSTITUENT	COMPARATIVE LEVELS (ppb)
Iodine-132	3 pCi/l
Iodomethane	5.0
Iron	300.0
Iron, total metals	300.0
Iron, filtered	300.0
Isobutanol	1000.0
Isodrin	10.0
Isophorone	10.0
Isosafrole	10.0
Kepone	1.1
Lead	37.0
Lead, total metals	50.0
Lead, filtered	3.2
Lindane	0.06
Lindane, α-BHC	0.14
Lindane, ß-BHC	0.14
Lindane, δ-BHC	23.0
Lindane, γ-BHC	0.08
m-phenylenediamine	200.0
Maleic anhydride	4000.0
Maleic hydrazide	20000.0
Manganese	50.0
Manganese, total metals	50.0
Manganese, filtered	50.0
Mercury	2.0
Mercury, total metals	2.0
Mercury, filtered	0.01
Methacrylonitrile	5.0

CONSTITUENT	COMPARATIVE LEVELS (ppb)
Methanol	250.0
Methapyrilene	10.0
Methomyl	90.0
Methoxychlor	0.3
Methyl bromide	10.0
Methyl chloride	1.0
Methyl chlorocarbonate	40000.0
Methyl chrysene	3000.0
Methyl ethyl ketone	10.0
Methyl isobutyl ketone	5.0
Methyl methacrylate	2.0
Methyl methanesulfonate	10.0
Methyl parathion	0.5
Methylene chloride	5.0
Mirex	0.05
Nitric oxide	4000.0
Nitrogen dioxide	40000.0
N-nitrosodiphenylamine	10.0
N-nitroso-di-n-butylamine	0.006
N-nitrosodiethanolamine	0.01
N-nitrosodiethylamine	0.0005
N-nitrosodimethylamine	0.002
N-nitroso-di-n-propylamine	0.01
N-nitroso-n-methylethylamine	0.004
N-nitrosomorpholine	10.0
N-nitrosopiperidine	10.0
N-nitrosopyrrolidine	0.04
Napathalene	7.0

CONSTITUENT	COMPARATIVE LEVELS (ppb)
Nickel	100.0
Nickel, filtered	160.0
Nickel-63	50 pCi/l
Nitrate (as nitrogen)	10000.0
Nitrite	3300.0
Nitrobenzene	10.0
Nitrofurazone	0.06
Nitrosopyrrolidine	10.0
Odor	3 threshold odor units
O,O,O-triethyl phosphorothioate	10.0
O-toluidine hydrochloride	10.0
o-cresol	200.0
Oxamyl	200.0
p-chloroaniline	100.0
p-chloro-m-cresol	200.0
PAH	0.01
PBBs	0.01
PCBs	0.01
Parathion	0.2
Pcdd's	0.01
Pcdf's	0.01
Pentachlorobenzene	10.0
Pentachlorodibenzo furans	1.0
Pentachloro-dibenzo-p- dioxins, all	0.063
Pentachloro-dibenzo-p-furans, all	0.035
Pentachloroethane	7.0

CONSTITUENT	COMPARATIVE LEVELS (ppb)
Pentachloronitrobenzene	10.0
Pentachlorophenol	13.0
pH	6.5 - 8.5
Phenacetin	10.0
Phenanthrene	7.0
Phenol	39.0
Phenylenediamine	10.0
Phenylmercury acetate	3000.0
Phorate	2.0
Phthalates [Di(ethylhexyl)phthalate]	zero
Phthalic anhydride (as phthalic acid)	540.0
Phthalic acid esters	3.0
Picloram	500.0
Plutonium-238	1.6 pCi/l
Plutonium-239,240	1.2 pCi/l
Pronamide	10.0
Propionitrile (Ethyl cyanide)	5.0
Propylene oxide	0.01
Pynene	4000.0
Pyrene	10.0
Pyridine	14.0
para-α,α,α-Tetrachlorotoluene	0.004
Quinoline	0.003
Radium-226 & 228	5 pCi/l
Radium-226	3 pCi/l
Radium	5 pCi/l
Ruthenium-103	200.0
Ruthenium-106	30 pCi/l

CONSTITUENT	COMPARATIVE LEVELS (ppb)
Safrol	10.0
Selenium, total metals	10.0
Selenium, filtered	10.0
Selenium	10.0
Selenious acid	100.0
Silver	50.0
Silver, total metals	50.0
Silver, filtered	1.0
Simazine	1.0
solids, Total dissolved	500,000.0
Strontium-89	20 pCi/l
Styrene	1.0
Sulfate	250,000.0
Sulfide	14,000.0
Sym-trinitrobenzene	10.0
Technetium-99	900 pCi/l
Tetrachlorodibenzofurans	1.0
Tetrachloro-dibenzo-p-dioxins, all	0.063
Tetrachloro-dibenzo-furans, all	0.063
Tetrachloroethene	6.0
Tetrachlorophenols (total)	18.0
Tetrachloroethylene	0.8
Tetraethyldithiopyrophosphate	20.0
Tetraethylpyrophosphate	10.0
Thallium	0.5
Thiourea	0.02
Tin, filtered	8000.0
Toluene	2.0

CONSTITUENT	COMPARATIVE LEVELS (ppb)
Toxaphene	0.08
trans-1,2-dichloroethane	33.0
trans-1,2-dichloroethylene	1.0
trans-1,3-dichloropropene	36.0
Trichloroethylene	3.0
Trichloroethane	200.0
Trichlorofluoromethane	50.0
Trichloromonofluoromethane	5.0
Trihalomethanes (includes chloroform, bromoform, bromodichloromethane, and dibromochloromethane)	100.0
Trimethyl phosphate	2.0
tris-(2,3 dibromopropyl) phosphate	25.0
Uranium	40 pCi/l
Uranium, chemical	59.0
Vanadium	42.0
Vanadium, filtered	40.0
Vanadium Pentoxide	70.0
Vinyl acetate	5.0
Vinyl chloride	0.02
Xylene	11.0
Zinc	5000.0
Zinc, total metals	5000.0
Zinc, filtered	110.0
m,p-cresols	770.0
m-dichlorobenzene	36.0
m-nitroaniline	50.0
m-xylene	5.0
n-butyl alcohol	5000.0

CONSTITUENT	COMPARATIVE LEVELS (ppb)
o,p'-DDD	23.0
o,p'-DDE	31.0
o,p'-DDT	3.9
o-chloronitrobenzene	3.0
o-cresol	110.0
o-dichlorobenzene	8.0
o-nitroaniline	50.0
o-nitrophenol	28.0
o-phenylenediamine	0.005
o-toluidine	0.2
o-xylene	5.0
p,p'-DDD	23.0
p,p'-DDE	31.0
p,p'-DDT	3.9
p-chloro-m-cresol	5.0
p-chloroaniline	20.0
p-chloronitrobenzene	5.0
p-dichlorobenzene	8.0
p-dimethylaminoazobenzene	10.0
p-nitroaniline	28.0
p-nitrophenol	150.0
p-xylene	5.0

APPENDIX B

SUMMARY OF TREATABILITY STUDY

APPENDIX B
SUMMARY OF TREATABILITY STUDY

A bench-scale treatability study was performed to support the evaluation of treatment processes potentially applicable to the DLF. The following sections summarize the results of the treatability study, and make recommendations on processes to accomplish the following.

- Pretreatment;
- Suspended solids removal;
- Primary dissolved solids removal;
- Secondary dissolved solids removal;
- Total dissolved solids reduction; and
- Organic removal.

The treatability study was conducted at the Personnel Equipment Decontamination Facility (PEDF), which will be replaced by the DLF. Wastewater samples were collected from the PEDF to simulate a worst case condition (labeled 20-01 to 20-06 or RTG-1 to RTG-6), regulated wastewater (labeled 20-09 or RTG-9), nonregulated wastewater (labeled 20-10 or RTG-10), and a mixture of regulated/nonregulated wastewater (labeled 20-08 or RTG-8).

Because the treatment process had not been determined at the time treatability testing was performed, a sequential evaluation of treatment processes was not possible. Therefore, each process was evaluated using a previously untreated sample of raw wastewater. Suspended solids were removed by filtration for processes where they may harm the equipment such as ion exchange testing. The drum of wastewater used

in such tests was originally labeled as Drum RTG-6 and after filtration the filtered wastewater was transferred to a clean drum and labeled as Drum RTG-7.

B.1 PRETREATMENT PROCESSES

Pretreatment was not evaluated in the treatability study because the pretreatment processes are well defined and do not require further testing. The pretreatment for the DLF raw effluent stream will consist of:

- Flow equalization to provide a consistent water quality feed to the treatment system;
- Heat recovery system to cool the water and to recover the heat value for use in the DLF; and
- Lint removal using a vibrating screen.

B.2 SUSPENDED SOLIDS REMOVAL PROCESSES

Suspended solids removal testing was performed on wastewater samples to evaluate several process requirements. Since most of the radioactivity in a laundry sample may exist in particulate form, suspended solids removal testing was the main indicator used to evaluate the removal of radioactivity from the waste stream. In addition to removal of particulate radioactivity, suspended solids removal is required to protect other treatment processes such as ion exchange and reverse osmosis from fouling. A number of processes for suspended solids removal were identified and evaluated during the treatability study. A review of each of the processes and the results of the treatability study follows.

B.2.1 Sedimentation

Sedimentation is typically used as a pretreatment when relatively high concentrations (greater than 500 mg/l) of suspended solids are present. The high concentrations are reduced by gravity settling in order to minimize the solids load on subsequent processes. Since the initial wastewater samples did not contain a minimum of 500 mg/l of suspended solids as determined in the preliminary screening, these tests were not run. In addition, the relatively low suspended solids levels which were present indicate that sedimentation would not be required in a full-scale facility.

B.2.2 Conventional Filtration

Conventional filtration using various types of porous media is one of the most common processes used in industry for the removal of moderate levels of suspended solids. Types of conventional filters include strainers, bag filters, cartridge filters, and backwashable media filters.

Filtration performance in the treatability study was evaluated by filtering the wastewater through filter media with pore sizes ranging from 0.45 micron to 105 micron. The filtration time for a given volume of wastewater was measured and samples of the filtrate were submitted for radiological analysis to determine the effectiveness of the removal of radiological particulate expected to be present in the DLF wastewater. The results of the treatability study indicated virtually no removal of gross alpha and gross beta activity with filters having pore sizes of greater than 10 micron. At 10 micron, approximately 40% of the suspended solids were removed, but

only about 30% of the gross alpha and 40% of the gross beta were removed. The 0.45 micron filter removed approximately 80% of the suspended solids and also the gross alpha and gross beta activity.

B.2.3 Precoat Filtration

Precoat filtration is essentially identical to conventional filtration except that a precoat of a material such as diatomaceous earth is placed on the filtration media. Precoat filtration is typically used in lieu of a conventional static filtration process if filtration rates are very slow, when a higher quality filtrate is desired, or when oil and grease concentrations greater than approximately 20 mg/l are present. A 1/4-inch layer of diatomaceous earth was used for the precoat filtration test with a backing filter. The pore sizes tested for the backing filter were 20 and 52 micron.

The results for the precoat filtration indicated that there was virtually no solids removal by the precoat filters and the filtration rate was very slow. This indicated that a precoat was not effective in reducing the filtration time as the precoat became clogged with a thin film that nearly stopped the filtration. Gentle scraping of the film allowed filtration to resume at nearly the initial rate, however, if the scraping of the precoat to remove the film was discontinued, filtration nearly stopped.

B.2.4 Dissolved Air Flotation

Dissolved air flotation (DAF) is used to remove oil and grease at concentrations greater than approximately 50 mg/l, and finely divided suspended solids which do not easily settle by gravity. The basic process uses finely dispersed air bubbles to float the oil and grease, suspended solids, and other material to the surface for removal and

subsequent treatment. Coagulant chemicals such as aluminum sulfate ($(Al_2SO_4)_3$) and ferric chloride ($FeCl_3$) can be used to promote particle removal in the float.

Oil and grease removal is not expected to be required in the DLF due to the use of administrative controls to minimize oils and greases in the wastewater. Therefore, DAF is potentially applicable only for removing suspended solids. However, suspended solids removal using coagulant chemicals was performed as part of the chemical precipitation studies. The major difference between the two processes in this application is that DAF removes particles by flotation, while conventional precipitation uses sedimentation. Both processes will require polishing filtration to remove fine particles which carry over. Therefore, DAF with underflow filtration and conventional precipitation with overflow filtration are the same basic process. Consequently, the two sets of tests were determined to be redundant in terms of the chemistry being tested. The results of the conventional precipitation tests can be used to estimate DAF performance, and standard design methods used to estimate equipment sizing. The results of the conventional precipitation tests indicated that membrane filtration was the optimum alternative for solids. Separation and DAF will not be considered further.

B.2.5 Multi-Media Filtration

Multi-media filtration uses a graded bed of media such as sand or gravel to remove suspended solids. Specific testing for multi-media filtration were not performed. The results of the conventional filtration studies provide the necessary information required to complete the evaluation of this process.

The conventional filtration test results showed that a 0.45 micron filter was more

effective for removal of gross alpha and gross beta activity than a one micron filter. This indicates that much of the activity is associated with particles less than one micron in size. Multi-media filters are generally effective for removal of particles that are one to three micron in size or larger, but are generally not effective for removal of particles of less than one micron in size. Multi-media filters will therefore not be considered further.

B.2.6 Membrane Filtration

In wastewater treatment applications, membrane filtration is a continuous process used for the removal of suspended solids and oil and grease to low levels. Types of membrane filtration processes include microfiltration (MF), ultrafiltration (UF) and reverse osmosis (RO). Reverse osmosis is actually a dissolved solids removal process and is discussed later.

Both microfiltration and ultrafiltration use membranes deposited on a support material to act as an absolute barrier to particle passage. Microfiltration is usually defined in terms of particle size removal, and typically has a pore size of approximately 0.1 to 0.2 microns. Ultrafiltration is usually defined in terms of molecular weight cut-off (MWCO), and typically is used to separate molecules of approximately 1,000 to 100,000 molecular weight (approximate molecular diameter of 10 to 100 angstroms).

Bench-scale polysulfone microfiltration and ultrafiltration membrane systems were used in the treatability testing. The microfiltration cartridge was a hollow fiber membrane with a nominal pore size of 0.2 microns, and a surface area of 450 square centimeters. The ultrafiltration cartridge was also a hollow fiber membrane with a MWCO of 10,000, and a surface area of 450 square centimeters.

The test objectives were to evaluate membrane performance with respect to flux rates and permeate quality. Samples of the final permeate and concentrate were also submitted for radionuclide analysis after completion of both the ultrafiltration and microfiltration runs.

The results of the treatability study indicated that the flux rate for the microfilter was approximately 0.035 ml/min/cm^2, and that the flux rate for the ultrafilter was 0.020 ml/min/cm^2. Virtually all of the gross alpha activity was removed by both membrane processes, and approximately 98% of the gross beta was removed by ultrafiltration and 84 to 85% of the gross beta was removed by microfiltration.

B.2.7 Optimum Alternative - Suspended Solid Removal

Table B1 shows a summary of the efficiency of the best performing suspended solids removal processes tested. The table shows that ultrafiltration and microfiltration were the most effective processes to remove gross alpha and gross beta activity from the influent with ultrafiltration being the optimum at 100% removal of gross alpha and 98.3% removal of gross beta activity. Microfiltration was also very effective with 100% removal of the gross alpha and 84.3% removal of the gross beta activity, and it is apparent that either ultrafiltration or microfiltration could be used for suspended solids removal. The capital cost, maintenance cost and operating experience were evaluated for the two technologies, and it was determined that microfiltration was the preferred alternative.

TABLE B1
FILTRATION TECHNOLOGIES – REMOVAL EFFICIENCY a/
BEST AVAILABLE TECHNOLOGY ANALYSIS
DECONTAMINATION LAUNDRY FACILITY
WESTINGHOUSE HANFORD COMPANY, RICHLAND, WASHINGTON

Analysis Parameter	Conventional Filtration 0.45μm % Removal	Membrane Filtration Ultrafiltration % Removal	Membrane Filtration Microfiltration % Removal
Radionuclides			
Gross Alpha	83.33	100	100
Gross Beta	80.06	98.32	84.26
Gamma Scan:			
Potassium–40	NDI b/	NDI	NDI
Manganese–54	100 c/	NDI	NDI
Cobalt–58	NDI	NDI	NDI
Cobalt–60	95.86	>99.06	98.32
Cesium–134	NDI	NDI	NDI
Cesium–137	51.71	48.82	42.15
Europium–154	>81.56	>89.91	>86.82
Europium–155	>17	NDI	NDI
Radium–226	NDI	NDI	NDI
Thorium–228	NDI	NDI	NDI
Thorium–232	NDI	NDI	NDI
Oil and Grease	91.48	>98.24	97.92
Total Sus. Solids	94.06	89.88	91.67

Notes
a/ The removal efficiencies were calculated from data generated during treatability studies at the PEDF in June and July, 1991.
b/ A value of 100 % removal indicates that there was no contaminant detected in effluent. A value greater than indicates the compound was below detection limit.
c/ NDI indicates that the contaminate was not detected in the feed or in the effluent.

B.3 PRIMARY DISSOLVED SOLIDS REMOVAL

The primary dissolved solids removal technology tested in the treatability study was chemical precipitation. The specific processes tested for metals and radionuclide precipitation included the following:

- Hydroxide precipitation using either sodium hydroxide or lime for pH adjustment;
- Sulfide precipitation using sodium sulfide and either sodium hydroxide or lime for pH adjustment;
- Insoluble iron sulfide treatment; and
- Coprecipitation of metal hydroxides using iron or aluminum as the coprecipitant.

Results obtained for these precipitation processes are presented in the following paragraphs.

B.3.1 Hydroxide Precipitation

Precipitation of metals as hydroxide compounds is a well established method of wastewater treatment. Both hydrated lime ($Ca(OH)_2$) and sodium hydroxide (NaOH) were evaluated as the alkali in this process.

The evaluation of hydroxide precipitation was performed utilizing batch jar tests. Wastewater was flash mixed with the alkali and allowed to settle either with or without coagulation polymers. A total of eight chemical precipitation tests were run. Both $Ca(OH)_2$) and NaOH were tested at pH 9, 10, 11 and 12. The initial test solution

was greater than pH 8, so testing at this value was not required.

The objective of these tests was the determination of precipitation effectiveness in reducing metal and radionuclide concentrations. In addition, specific design information was generated including chemical consumption, solids settling rates, solids generation rates, and the effect of polymers on solids settling rates.

The most effective condition for metal and radionuclide removal by hydroxide precipitation was calcium hydroxide at a pH of 12. Sodium hydroxide was the most effective at a pH of 10, although it was not as effective as the calcium hydroxide at pH 12. The results obtained under these conditions are found in Table B2 in Section B.3.5.

B.3.2 Sulfide Precipitation

Sulfide is often used in conjunction with calcium hydroxide and sodium hydroxide to improve the removal efficiencies of metals and radionuclides by precipitation. Sulfide precipitation tests were conducted over a pH range of 8 to 12 using hydrochloric acid, calcium hydroxide or sodium hydroxide for pH adjustment. The most effective conditions for metal and radionuclide removal using sulfide addition were at pH 12 using calcium hydroxide and at pH 11 using sodium hydroxide. The results obtained at these conditions are found in Table B2 in Section B.3.5.

B.3.3 Insoluble Sulfide Process

Insoluble ferrous sulfide (FeS) has been used for treatment of wastewater containing a number of heavy metals. The use of insoluble FeS in wastewater treatment is

patented and its use requires payment of a licensing fee to the patent holder. This process is referred to as the Sulfex Process or the Insoluble Sulfide Process (ISP).

In the ISP process, the wastewater is mixed with slightly soluble (although the process is referred to as the ISP, it should be noted that FeS is slightly soluble) FeS which will dissociate to satisfy its solubility product. This yields a dissolved sulfide concentration of approximately 0.02 μg/l. The dissolved sulfide ions will precipitate a metal sulfide for any metal with a sulfide solubility less than that of FeS.

This test was performed on filtered water samples from all eight metal hydroxide precipitation tests, and is designed as a polishing process. Approximately two gallons of filtrate from each metal hydroxide precipitation test (samples from the pH 9, 10, 11, and 12 tests using both sodium hydroxide and calcium hydroxide) were mixed with freshly prepared FeS. The samples were intermittently mixed over a two hour period and filtered. Filtrate samples from each test were submitted for analysis. The objective of the test was to determine whether ISP improves the removal efficiencies for metals and radionuclides when used in conjunction with conventional hydroxide precipitation.

As compared to the filtrates from the hydroxide precipitation, there was no noticeable increase in the removal of dissolved species with the addition of FeS. At the lower pH values with calcium hydroxide used for adjustment, there was some increase in removal efficiency, however, the final quality was still not as good as the hydroxide precipitation at pH 12 and adjustment with calcium hydroxide. The optimum removal efficiency using the Insoluble Sulfide Process was obtained at a pH of 12 using calcium hydroxide and a pH of 9 using sodium hydroxide. The removal efficiencies obtained at these conditions are found in Table B2 in Section B.3.5.

B.3.4 Coprecipitation of Contaminants with Metal Hydroxides

Coprecipitation of metal hydroxides with iron or aluminum is often more effective than conventional hydroxide precipitation for the removal of contaminants due to adsorption of heavy metals and radionuclides on the iron/aluminum matrix. The adsorption prevents the formation of soluble hydroxyl complexes, which often occurs at elevated pH, decreasing removal efficiency.

The experimental procedure used was identical to the procedure used for the metal hydroxide precipitation tests, except that iron and aluminum were added to the test solutions prior to pH adjustment, with aluminum tested at a pH of 8 and 9 only. Aluminum was not tested at higher pH levels since aluminum is amphoteric and therefore, is soluble at high pH levels. Approximately 45 mg/l of iron (as Fe^{3+}) or aluminum (as Al^{3+}) were added. Filtrate samples from each test were submitted for analysis.

The results of the tests indicated that the optimum conditions for coprecipitation of contaminants are with iron and calcium hydroxide at pH 12. Coprecipitation with iron using sodium hydroxide at a pH of 12 indicated effective contaminant removal, but also indicated that a large fraction of the iron remained soluble. When ferric iron remains soluble at a pH of 12, the presence of complexing agents is almost certain. It should be noted that the ferric iron precipitated almost quantitatively when calcium hydroxide was used to adjust the pH. The only reasonable explanation for this phenomenon is that the calcium hydroxide is adsorbing the complexing agent (probably an organic from the laundry cleaners) and preventing formation of iron complexes.

Coprecipitation of contaminants with aluminum salts was generally ineffective with

the best results obtained at pH 9 with either calcium hydroxide or sodium hydroxide. The removal efficiencies for the iron and aluminum coprecipitation tests noted are found in Table B2 in Section B.3.5.

B.3.5 Optimum Alternative - Primary Dissolved Solids Removal

Table B2 presents a summary of removal efficiencies for the technologies tested for primary dissolved solids removal. A number of technologies evaluated were very effective reducing the concentration of the metals and radionuclides, and include:

- Hydroxide precipitation at pH 12 using calcium hydroxide;
- Sulfide precipitation at pH 12 using calcium hydroxide;
- Insoluble sulfide polishing of the effluent from hydroxide precipitation at pH 12 using calcium hydroxide; and
- Coprecipitation of contaminants with iron using calcium hydroxide at pH 12.

Hydroxide precipitation at pH 12 using calcium hydroxide appears to be as effective as any of the other technologies evaluated and has been chosen as the optimum alternative on the following basis:

- Effective removal of contaminants;
- Lowest operating cost of the effective alternatives;
- Produces less sludge than the coprecipitation alternatives;
- Has no safety problems (unlike sulfide which can produce a toxic gas under acid conditions); and

TABLE B2
PRECIPITATION TESTING REMOVAL EFFICIENCIES a/
BEST AVAILABLE TECHNOLOGY ANALYSIS
DECONTAMINATION LAUNDRY FACILITY
WESTINGHOUSE HANFORD COMPANY, RICHLAND, WASHINGTON

	Hydroxide Precipitation		Sulfide Precipitation		Insoluble Sulfide		Coprecipitation			
	Ca(OH)2 pH 12	NaOH pH 10	Ca(OH)2 pH 12	NaOH pH 11	Ca(OH)2 pH 12	NaOH pH 9	Fe/Ca(OH)2 pH 12	Fe/NaOH pH 12	Al/Ca(OH)2 pH 9	Al/NaOH pH 9
Parameter	% Removal	% Removal	% Removal	% Removal	% Removal	% Removal	% Removal	% Removal	% Removal	% Removal
Metals										
Silver	NDI b/	NDI	NDI	NDI	NDI	NDI	NDI	ND	NDI	NDI
Aluminum	>86.75 c/	>89.90	>79.12	57.71	>86.76	>89.90	>81.48	32.22	−752.78	−1131.48
Arsenic	NDI	NDI	NDI	NDI	NDI	NDI	NDI	NDI	NDI	NDI
Boron	NDI	NDI	NDI	NDI	NDI	NDI	NDI	NDI	NDI	NDI
Barium	NDI	NDI	NDI	NDI	NDI	NDI	NDI	NDI	NDI	NDI
Cadmium	>77.78	>79.50	>78.07	41.23	>77.78	>79.51	>77.78	69.33	72.44	65.78
Chromium	>71.67	80.23	>42.85	40.00	>71.67	>85.78	>52.83	34.91	34.91	38.21
Copper	83.44	87.23	>91.75	67.99	91.61	91.45	77.65	46.25	77.98	69.38
Iron	>98.21	80.15	>97.71	4.59	87.58	43.04	95.98	−253.68	17.06	−43.99
Mercury	>39.40	25.64	>35.48	3.23	>39.40	>48.72	>23.08	−100.00	−3.85	−53.85
Lithium	−3.09	9.71	7.48	−4.90	−25.93	−37.80	3.72	4.10	1.03	2.05
Manganese	>85.58	79.28	>84.11	65.57	>85.58	83.69	>83.82	15.97	69.80	48.33
Nickel	NDI	>24.24	NDI	NDI	NDI	>24.24	NDI	NDI	NDI	NDI
Lead	97.35	82.38	>99.22	84.72	93.93	90.17	>99.26	94.58	96.31	94.73
Selenium	NDI	NDI	NDI	NDI	NDI	NDI	NDI	NDI	NDI	NDI
Strontium	NDI	NDI	NDI	NDI	NDI	NDI	NDI	NDI	NDI	NDI
Titanium	NDI	>16.68	NDI	NDI	NDI	>16.68	NDI	NDI	NDI	NDI
Vanadium	NDI	NDI	NDI	NDI	NDI	NDI	NDI	NDI	NDI	NDI
Zinc	97.75	83.90	96.90	71.14	97.53	79.19	98.08	69.25	69.62	61.88
Inorganics										
Fluoride	>16.67	−41.67	>16.67	−58.33	>16.67	−33.33	>37.50	12.50	>37.50	>37.50
Hydrazine	NDI	NDI	NDI	NDI	NDI	NDI	NDI	NDI	NDI	NDI
Ammonia (as N)	7.95	44.16	8.14	39.53	25.00	25.97	5.62	15.73	21.35	24.72
Tot. Sus. Solids	>98.43	78.01	92.26	50.00	97.81	85.86	21.70	1.89	−10.38	33.02

TABLE B2 (continued)
PRECIPITATION – REMOVAL EFFICIENCY a/
BEST AVAILABLE TECHNOLOGY ANALYSIS
DECONTAMINATION LAUNDRY FACILITY
WESTINGHOUSE HANFORD COMPANY, RICHLAND, WASHINGTON

	Hydroxide Precipitation		Sulfide Precipitation		Insoluble Sulfide		Coprecipitation			
Analysis Parameter	Ca(OH)2 pH 12 % Removal	NaOH pH 10 % Removal	Ca(OH)2 pH 12 % Removal	NaOH pH 11 % Removal	Ca(OH)2 pH 12 % Removal	NaOH pH 9 % Removal	Fe/Ca(OH)2 pH 12 % Removal	Fe/NaOH pH 12 % Removal	Al/Ca(OH)2 pH 9 % Removal	Al/NaOH pH 9 % Removal
Radionuclides										
Gross Alpha	94.14	92.50	99.64	95.34	100	97.5	100	91.55	100	97.54
Gross Beta	87.90	82.73	88.87	90.16	89.47	82.59	88.55	90.96	90.73	93.94
Gamma Scan:										
Potassium–40	NDI	NDI	NDI	NDI	NDI	NDI	NDI	NDI	NDI	NDI
Manganese–54	100	100	NDI	NDI	100	100	100	100	100	100
Cobalt–58	NDI	NDI	NDI	NDI	NDI	NDI	NDI	NDI	NDI	NDI
Cobalt–60	99.39	98.79	98.26	>98.07	>98.92	98.24	99.18	96.56	97.80	96.08
Cesium–134	NDI	NDI	NDI	NDI	NDI	NDI	NDI	NDI	NDI	NDI
Cesium–137	–452.48	43.22	47.60	51.51	64.07	48.00	60.96	44.24	46.19	47.01
Radium–226	NDI	NDI	NDI	NDI	NDI	NDI	NDI	NDI	NDI	NDI
Europium–154	>86.28	>99.17	>83.46	85.04	>83.86	>91.03	>83.31	>79.64	82.84	>74.05
Strontium–90	94.80	92.97	90.30	75.05	97.31	91.81	95.67	73.24	82.60	79.83
Total Radium	>87.75	81.13	>85.36	>85.36	>87.78	>81.13	>69.47	>84.73	>69.47	>84.73
Uranium–234	>98.02	87.25	97.79	81.17	>96.05	92.35	95.70	69.91	82.80	76.35
Uranium–235	>85.39	>79.42	83.36	81.70	>85.39	>79.42	>83.40	>50.21	>83.40	>66.80
Uranium–238	>97.75	85.22	98.91	87.90	>95.91	92.86	95.53	70.92	88.81	79.87
Plutonium–238	>99.45	83.47	99.68	88.26	>98.90	95.87	>98.97	84.59	90.76	87.16
Plutonium–239,240	>99.74	97.78	99.70	87.54	>99.94	95.90	99.62	81.08	91.17	85.50
Americium–241	>99.55	97.22	>99.76	86.33	>99.78	96.52	99.65	81.11	84.18	64.59

Notes
a/ The removal efficiencies were calculated from data generated during treatability studies at the PEDF in June and July, 1991.
b/ NDI indicates that the compound was not detected in the influent or the effluent from the test.
c/ Greater than indicates that the compound was detected in the influent to the test but was below detection limit in the effluent, therefore the detection limit was used to calculate the removal. ND indicates that it was not possible to calculate a removal and 100 % removal indicates there was no detection of the compound.

- Equipment to implement this alternative is readily available and well understood.

B.4 SECONDARY DISSOLVED SOLIDS REMOVAL

The only technology tested for secondary dissolved solids removal was selective ion exchange. This technology was tested because it was recognized that selective ion exchange could be required for the selective removal of radioactive cesium and strontium from the DLF effluent. The treatability study tested the effectiveness of two naturally occurring zeolite materials (chabazite and clinoptilolite), and the results of the tests are presented in the following paragraphs.

B.4.1 Selective Ion Exchange - Adsorption Isotherms

The naturally occurring zeolite materials chabazite and clinoptilolite were tested for removal of radioactive cesium and strontium. The tests included both adsorption isotherms and column test procedures. Adsorption (or Freundlich) isotherms are determined by contacting varying quantities of the adsorbent with the wastewater. An isotherm which relates adsorptive capacity versus the equilibrium concentration of the adsorbate in the liquid phase in mg/l is then prepared. This isotherm can be used to estimate the equilibrium loading of the contaminant on the material being studied, and is a useful tool in the design and sizing of ion exchange columns. Isotherms are used to estimate the equilibrium loading because it is not practical to determine loading using column tests due to the large volume of test solution that would be required.

Adsorption isotherms were prepared using one liter samples of Drum RTG-6 at pH 8.6

with varying dosages of adsorbent. The specific zeolite dosages tested included 25, 50, 100, 125 and 225 mg per liter of wastewater. The filtered water from each of the isotherm test bottles was submitted for analysis.

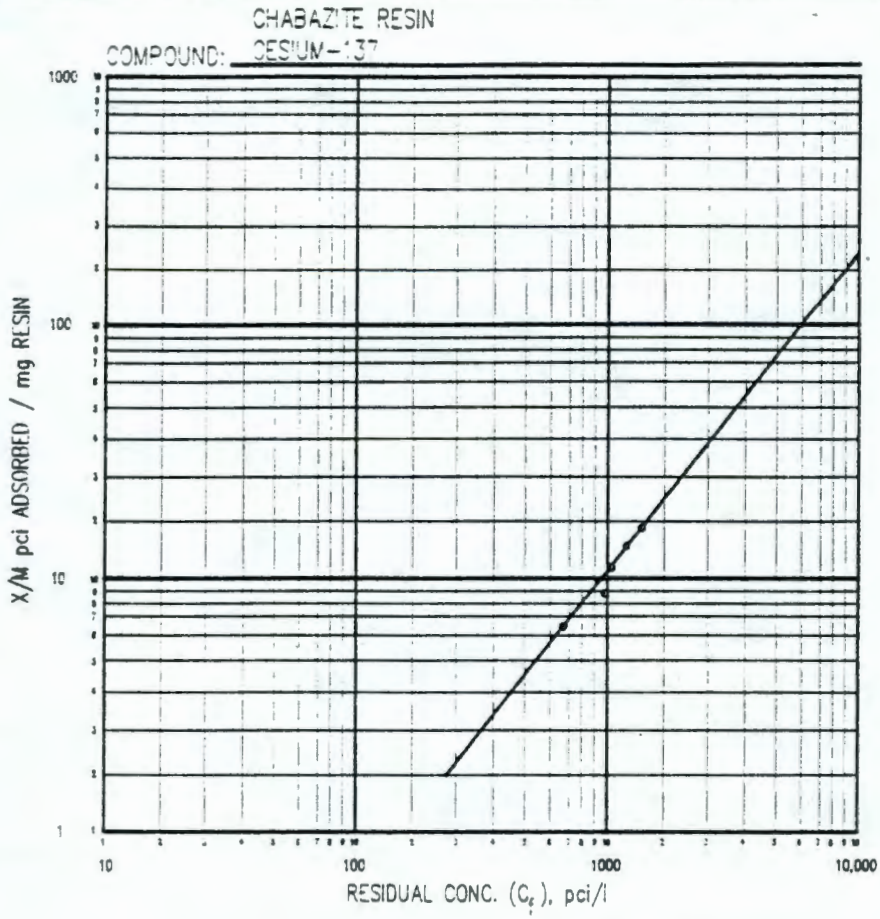
The objectives of preparing adsorption isotherms included predicting overall adsorptive capacity and predicting relative adsorptive intensity. The overall adsorptive capacity is determined from the X/M intercept (the mass of contaminant loaded per unit mass of carbon) at a given concentration of the compound in the untreated solution and the relative adsorptive intensity is determined from the slope of the isotherm line.

The data obtained from the isotherm tests indicated the following:

- The Cs-137 concentration was reduced from 2,097 pCi/l to 660 pCi/l using chabazite over the dosage range tested. The chabazite data was used to prepare an isotherm as shown in Figure B1. The isotherm shows an equilibrium loading of 10,000 pCi/l Cs-137/gram of chabazite, with a residual concentration of 1,000 pCi/l. This loading is significantly less than the Cs-137 loading reported in the literature. The most likely reasons for the decreased loading include:

  - The total dissolved solids (TDS) of the feed (Drum RTG-6) was approximately 1,280 mg/l. The cationic fraction of the TDS may be occupying the exchange sites and diminishing the loading for Cs-137.

FIGURE B1
ADSORPTION ISOTHERM - CHABAZITE RESIN DATA



	pH = 8.6			pH =		
RESIN DOSE mg/l	C_f	$C_0-C_f=X$	X/M	C_f	$C_0-C_f=X$	X/M
0	2097	–	–			
25	1615	–	19.28			
50	1312	–	15.7			
100	1023	–	10.74			
125	982	–	8.921			
225	660	–	6.38			

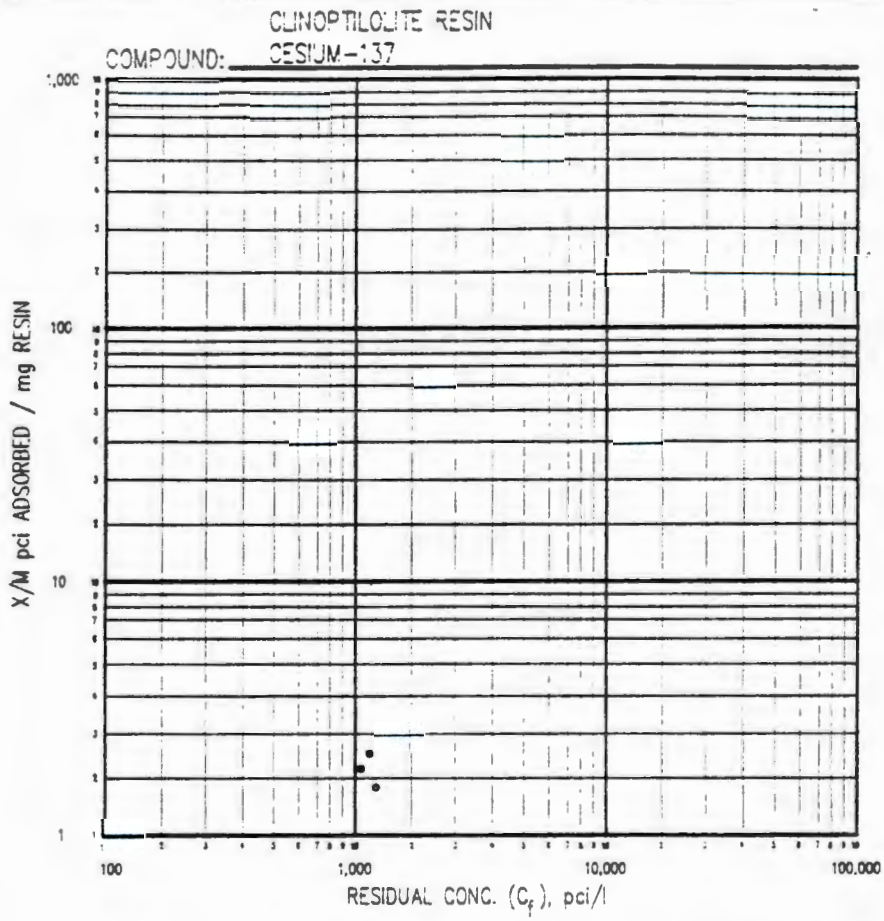
- The total organic carbon (TOC) content of the DLF effluent (Drum RTG-6) was 125 mg/l. The high TOC may be adsorbing on the zeolites and preventing Cs-137 loading.

- The Sr-90 concentration was reduced from 376 pCi/l in the feed to 284 pCi/l using chabazite over the dosage range evaluated. The data obtained were not suitable to prepare an isotherm. The poor adsorption of Sr-90 is most likely due to the reasons noted for Cs-137.

- The Cs-137 concentration was reduced from 1,553 pCi/l to 1,040 pCi/l using clinoptilolite over the dosage range tested. The data are found in Figure B2 and as can be seen from the data, a meaningful isotherm could not be prepared. An evaluation of the raw data indicates that clinoptilolite is not as effective as chabazite for Cs-137 removal.

- The Sr-90 concentration remained relatively constant using clinoptilolite over the dosage range tested (286 pCi/l at zero dosage versus 277 pCi/l at 225 mg/l dosage). Obviously, the data were not suitable to prepare an isotherm. An evaluation of the raw data indicates that clinoptilolite is not as effective as chabazite for Sr-90 removal.

FIGURE B2
ADSORPTION ISOTHERM - CLINOPTILOLITE RESIN DATA



	pH = 8.6			pH =		
RESIN DOSE mg/	C_f	$C_0-C_f=X$	X/M	C_f	$C_0-C_f=X$	X/M
0	1553	–	–			
25	1600	–	–1.88			
50	1719	–	–0.32			
100	1372	–	1.81			
125	1234	–	2.55			
225	1040	–	2.29			

B.4.2 Selective Ion Exchange - Column Tests

One inch columns containing approximately 250 ml of 16 x 40 mesh chabazite or clinoptilolite were used for the column tests. Feed samples for the column tests came from RTG-Drums 8, 9 and 10. Drums 8, 9 and 10 were collected specifically to test processes which would require large volumes of sample (such as the selective ion exchange column tests). The effect of pH on contaminant removal was not evaluated, however, the initial pH of the wastewater was approximately 8.6. These samples represented the different effluent streams from the PEDF as follows:

Drum RTG-8 -	This drum consisted of 25% regulated wash, 25% regulated rinse, 25% nonregulated wash, 25% nonregulated rinse;
Drum RTG-9 -	50% regulated wash, 50% regulated rinse; and
Drum RTG-10 -	50% nonregulated wash, 50% nonregulated rinse.

The columns were fed from a constant head tank at a rate of nominally 4 gpm/ft^2 (approximately 85 ml/min). A total of 4 columns were used, and a total of 21 gallons was processed. This would be equivalent to approximately 79 bed volumes per column. The effluent from the column test was sampled for radionuclides and the removal efficiencies are shown in Table B3.

As can be seen from the data, up to 99% of the Cs-137 was removed while the Sr-90 removal efficiency varied from 47 to 88%. The removal efficiency appears to be similar for the three types of PEDF effluent tested with the poorest efficiency found on the sample from the nonregulated PEDF wastewater. Based on the results of the

TABLE B3
SELECTIVE ION EXCHANGE COLUMN TEST REMOVAL EFFICIENCIES a/
BEST AVAILABLE TECHNOLOGY ANALYSIS
DECONTAMINATION LAUNDRY FACILITY
WESTINGHOUSE HANFORD COMPANY, RICHLAND, WASHINGTON

Analysis Parameter	RTG-8 Chabazite Resin % Removal	RTG-8 Clinoptilolite Resin % Removal	RTG-9 Chabazite Resin % Removal	RTG-9 Clinoptilolite Resin % Removal	RTG-10 Chabazite Resin % Removal	RTG-10 Clinoptilolite Resin % Removal
Gamma Scan:						
Potassium-40	NDI b/	NDI	100 c/	100	NDI	NDI
Manganese-54	7.81	29.80	ERR d/	ERR	NDI	NDI
Cobalt-57	NDI	NDI	NDI	NDI	NDI	NDI
Cobalt-58	100	100	100	31.01	NDI	NDI
Cobalt-60	NDI	NDI	NDI	ERR	NDI	NDI
Cesium-134	NDI	NDI	NDI	NDI	NDI	NDI
Cesium-137	98.58	98.44	99.18	99.26	88.00	92.32
Europium-154	NDI	NDI	NDI	NDI	NDI	NDI
Europium-155	NDI	NDI	NDI	NDI	NDI	NDI
Radium-226	NDI	NDI	NDI	NDI	NDI	NDI
Tantalum-182	NDI	ERR	ERR	ERR	NDI	NDI
Thorium-228	NDI	NDI	NDI	NDI	NDI	NDI
Thorium-232	NDI	NDI	NDI	NDI	NDI	NDI
Strontium-90	66.95	75.67	46.79	88.05	45.06	36.80

Notes:
a/ The removal efficiencies were calculated from data generated during treatability studies at the PEDF in June and July, 1991.
b/ NDI indicates that the contaminant was not detected in either the test feed or the test influent.
c/ 100 % removal indicates that the contaminant was detected in the test feed but not in the test effluent.
d/ ERR indicates that the contaminant was detected in the test effluent but not in the test influent. This is probably due to high-energy gamma emitter interference. The lower-energy contaminants were able to be detected in the effluent because the high-energy gamma emitters were removed during the test.

column tests, the clinoptilolite was significantly more effective than chabazite for the removal of Sr-90 and about the same as chabazite for the removal of Cs-137.

B.4.3 Optimum Alternative - Selective Ion Exchange

The column test data indicated that chabazite had approximately the same loading capacity for Cs-137 as clinoptilolite, while the column test data showed that clinoptilolite was more efficient for the removal of Sr-90. The isotherm data for Sr-90 removal were inconclusive and no significant data were obtained for either zeolite. The isotherm data for Cs-137 indicated that chabazite may have a higher loading capacity than clinoptilolite.

The column test data appears to be more reliable that the isotherm data, and the column test data indicate that clinoptilolite is the preferred zeolite. The capacity of the clinoptilolite is unknown at this time since the isotherm data were inconclusive. However, the chabazite isotherm data indicate an equilibrium capacity of 10,000 pCi Cs-137/gram at a residual concentration of 1,000 pCi Cs-137/l. Assuming that 3,000 pCi/l of Cs-137 will be adsorbed, the saturation capacity of the chabazite can be calculated to be approximately 2,400 bed volumes. The saturation capacity of clinoptilolite should be similar to that measured for chabazite. The calculated value of 2,400 bed volumes is for Cs-137 only, and in a full-scale operation the saturation capacity will be dependent upon many variables including:

- Total cation content of the DLF effluent;
- TOC content of the DLF effluent; and
- Concentration of other cationic radionuclides such as Sr-90.

In summary the most reliable data from the treatability study indicates that clinoptilolite is the preferred zeolite for the full-scale operation to remove radioactive cesium and strontium.

B.5 TOTAL DISSOLVED SOLIDS REDUCTION

Two types of dissolved solids removal may be required in the DLF treatment system. The first type is selective dissolved solids removal as discussed in the previous section. The second type is gross dissolved solids removal, and involves the removal of all dissolved species from the wastewater. Processes investigated in the treatability study for gross dissolved solids removal include conventional ion exchange and reverse osmosis.

B.5.1 Conventional Ion Exchange

Conventional ion exchange uses strong acid or strong base ion exchange resins to remove cationic and anionic species from solution. The process is non-selective in that both cationic and anionic contaminants, as well as other species of little concern such as calcium, sodium, chloride, and sulfate, are removed.

Both cationic and anionic contaminants may be present in the DLF wastewater. In addition, overall reduction in TDS may be required. Therefore, mixed bed ion exchange (a mixture of strong acid and strong base resin) was tested. One inch columns were used in the ion exchange treatability study with a bed volume of 250 ml of Dow Chemical MR-3 mixed bed resin. The feed to the ion exchange columns was filtered through a three micron filter to remove suspended solids. The PEDF effluent was fed to the columns at a volumetric flow rate of 3 gpm/ft^2 of column area. The electrical

conductivity of the effluent was measured to determine the gross removal efficiency of the ion exchange process. Samples of the effluent were taken at approximately 10, 25, 75 and 100% of saturation, and analyzed for metals and radionuclides. The number of bed volumes that correspond to percent saturation were as follows:

- 10% - 8 bed volumes;
- 25% - 20 bed volumes;
- 75% - 52 bed volumes; and
- 100% - 72 bed volumes.

An evaluation of the data indicated that significant major ion (sodium, chloride, silicon, phosphate) breakthrough occurred at 75% saturation, while some of the metals (iron, copper, aluminum) showed increased concentrations even at 10% of saturation. Table B4 shows the removal efficiency for metals, inorganics, and radionuclides at 10% and 25% of saturation. A review of the data indicates that conventional ion exchange can effectively remove most inorganics, metals and radionuclides until the resin is approximately 25% saturated, and severe breakthrough occurs between 25% and 75% of saturation.

The data on metals show that iron is not effectively removed even at 10% saturation. This indicates the presence of an uncharged soluble iron complex which will not ion exchange with the resin. The presence of an iron complex was also observed in the hydroxide precipitation tests when iron did not completely precipitate even at a pH of 12.

The results of the ion exchange test indicate that it may be necessary to regenerate or dispose of the resin after as few as 20 bed volumes. Normal regeneration of ion exchange resin will generate 5 to 10 bed volumes of brine which indicates that brine generation could be as much as 25 to 50% of the influent flow.

TABLE B4
CONVENTIONAL ION EXCHANGE – REMOVAL EFFICIENCY
BEST AVAILABLE TECHNOLOGY ANALYSIS
DECONTAMINATION LAUNDRY FACILITY
WESTINGHOUSE HANFORD COMPANY, RICHLAND, WASHINGTON

Analysis Parameter	10% Saturation % Removal	25% Saturation % Removal
Metals		
Silver	NDI a/	NDI
Aluminum	80.43	80.52
Arsenic	NDI	NDI
Boron	NDI	NDI
Barium	NDI	NDI
Calcium	>81.82 b/	>81.82
Cadmium	>80.39	>80.39
Chromium	>68.75	>68.75
Copper	78.35	77.93
Iron	43.97	37.28
Mercury	>31.03	>31.03
Potassium	>38.04	>38.04
Lithium	>98.88	>98.88
Magnesium	>29.68	>29.68
Manganese	>84.82	>84.82
Sodium	>88.18	>88.18
Nickel	NDI	NDI
Lead	87.58	92.74
Selenium	NDI	NDI
Silicon	97.45	87.20
Strontium	NDI	NDI
Titanium	NDI	NDI
Vanadium	NDI	NDI
Zinc	91.93	88.53
Inorganics		
Chloride	>97.51	>97.51
Fluoride	>28.57	>28.57
Hydrazine	NDI	NDI
Ammonia (as N)	>98.85	98.16
Nitrate (as N)	NDI	NDI
Phosphate (as P)	75.88	25.88
Sulfate	>9.1	ERR c/
Tot. Dis. Solids	92.66	86.17

TABLE B4 (continued)
CONVENTIONAL ION EXCHANGE – REMOVAL EFFICIENCY
BEST AVAILABLE TECHNOLOGY ANALYSIS
DECONTAMINATION LAUNDRY FACILITY
WESTINGHOUSE HANFORD COMPANY, RICHLAND, WASHINGTON

Analysis Parameter	10% Saturation % Removal	25% Saturation % Removal
Radionuclides		
Gross Alpha	98.94	93.29
Gross Beta	98.65	99.33
Gamma Scan:		
Potassium–40	NDI	NDI
Manganese–54	100	100
Cobalt–58	NDI	NDI
Cobalt–60	>99.07	>98.69
Cesium–134	NDI	NDI
Cesium–137	>97.25	>96.88
Radium–226	NDI	NDI
Europium–154	NDI	NDI
Europium–155	NDI	NDI
Thorium–228	NDI	NDI
Strontium–90	97.80	98.43
Total Radium	>85.10	>85.10
Uranium–234	86.71	83.39
Uranium–235	82.35	>80.38
Uranium–238	87.57	80.10
Plutonium–238	94.75	>94.75
Plutonium–239,240	94.72	97.68
Americium–241	94.09	90.67

Notes
a/ NDI indicates that the compound was not deteced in the influent or effluent to the treatability study.
b/ The greater than sign indicates that the compound was below detection limit which was used to calculate the percent removal. A value of 100% removal indicates that the compound was not detected.
c/ ERR indicates that the value reported in the effluent was greater than the value reported in the influent.

B.5.2 Reverse Osmosis

Reverse osmosis (RO) is a process which utilizes osmotic pressure and a permeable membrane to remove gross dissolved solids from solution. Several different membrane materials are available including cellulose acetate, thin film composite (TFC), and polyamide. A common membrane in use for industrial wastewater applications is the TFC.

A small pilot (20 liters/hr) reverse osmosis test unit with a TFC membrane was used to perform an extended reverse osmosis test. The unit also contained a five micron prefilter to protect the membrane. The testing utilized the three drums of wastewater (Drums-8, RTG-9, RTG-10) described previously in Section B.4.2 collected for the extended tests. No pH adjustment was made on the wastewater and the initial pH was approximately 9.

Twenty four gallons were processed through the RO unit on three consecutive days. A minimum of four continuous hours of processing each day was performed at a flow of approximately 400 ml per minute. A nominal split of 75% permeate and 25% reject (brine) was obtained during the test program. Samples of the permeate and reject were submitted to the laboratory for analysis of metals, inorganics and radionuclides.

Table B5 shows the removal efficiency obtained on each of the three drums tested. The overall ion rejection, as determined from the TDS data, indicates a 90 to 95% rejection. This rejection is consistent with literature data which indicate up to 95% overall ion rejection.

TABLE B5
REVERSE OSMOSIS REMOVAL EFFICIENCIES a/
BEST AVAILABLE TECHNOLOGY ANALYSIS
DECONTAMINATION LAUNDRY FACILITY
WESTINGHOUSE HANFORD COMPANY, RICHLAND, WASHINGTON

Analysis Parameter	RTG-8 % Removal	RTG-9 % Removal	RTG-10 % Removal
Metals			
Silver	NDI b/	NDI	NDI
Aluminum	NDI	NDI	NDI
Arsenic	NDI	NDI	NDI
Boron	NDI	NDI	ERR c/
Barium	NDI	NDI	NDI
Calcium	>77.43 d/	>80.84	>55.75
Cadmium	>20.64	NDI	NDI
Chromium	NDI	NDI	NDI
Copper	NDI	NDI	>29.38
Iron	62.15	62.54	95.60
Mercury	>60	NDI	>60.78
Potassium	NDI	>23.31	NDI
Lithium	NDI	NDI	NDI
Magnesium	>4.95	>23.31	NDI
Manganese	>57.51	>73.78	>60.11
Sodium	>73.54	37.46	26.07
Nickel	NDI	NDI	NDI
Lead	>99.26	>99.83	NDI
Selenium	NDI	NDI	NDI
Silicon	94.88	97.29	98.47
Strontium	NDI	NDI	NDI
Titanium	NDI	NDI	NDI
Vanadium	NDI	NDI	NDI
Zinc	>95.24	>97.05	>93.41
Inorganics			
Chloride	>95.83	>88.64	>95.00
Fluoride	NDI	>9.09	NDI
Hydrazine	NDI	NDI	NDI
Ammonia (as N)	80.41	90.03	36.84
Nitrate (as N)	>47.37	>54.55	>47.37
Total Organic Carbon	NA e/	NA	NA
Phosphate (as P)	94.62	99.79	99.98
Sulfate	NDI	NDI	NDI
Total Dissolved Solids	95.29	92.16	90.33

TABLE B5 (continued)
REVERSE OSMOSIS REMOVAL EFFICIENCIES a/
BEST AVAILABLE TECHNOLOGY ANALYSIS
DECONTAMINATION LAUNDRY FACILITY
WESTINGHOUSE HANFORD COMPANY, RICHLAND, WASHINGTON

Analysis Parameter	RTG-8 % Removal	RTG-9 % Removal	RTG-10 % Removal
Radionuclides			
Gross Alpha	100.00	100.00	100.00
Gross Beta	93.28	94.76	94.08
Gamma Scan:			
Potassium-40	NDI	100.00	NDI
Manganese-54	100.00	NDI	NDI
Cobalt-58	ND	>99.65	NDI
Cobalt-60	NDI	NDI	NDI
Cesium-134	NDI	NDI	NDI
Cesium-137	90.00	94.46	90.23
Europium-154	NDI	NDI	NDI
Strontium-90	99.84	99.96	98.14
Total Radium	>56.62	>71.37	NDI
Uranium-234	>94.70	>97.35	>73.77
Uranium-235	>46.92	>66.07	ND
Uranium-238	>91.80	>95.71	>66.02
Plutonium-238	>98.21	>99.04	>96.65
Plutonium-239,240	>99.83	>99.91	>99.60
Americium-241	>99.18	>99.61	>98.83

Notes
a/ The removal efficiencies were calculated from data generated during treatability studies at the PEDF in June and July, 1991.
b/ NDI indicates that the contaminant was not detected in either the test feed or the test influent.
c/ ERR indicates that the contaminant was detected in the test effluent but not in the test influent.
d/ Greater than indicates that the contaminant was detected in the test feed but was below detection limit in the test effluent.
e/ NA indicates that this constituent was not analyzed for.

The removal efficiency of individual species shows very good rejection on most metals, inorganics and radionuclides with the following exceptions.

- Iron was not efficiently removed on Drums RTG-8 and RTG-9. These are drums of the nonregulated/regulated PEDF effluent (Drum-8), and a 50-50 mix of PEDF effluent and first rinse water (Drum RTG-9). On Drum RTG-10, the iron was effectively removed (over 95%). Drum RTG-10 is the PEDF effluent from the nonregulated system. Previous tests (hydroxide precipitation, ion exchange) have indicated that iron may be present in the PEDF effluent as a complexed species, and iron removal efficiency has been erratic. The reverse osmosis data show the same erratic behavior of iron on PEDF effluent from the regulated laundry. The effluent removal of iron from the nonregulated PEDF effluent indicates that different cleaning compounds that do not complex iron are used for nonregulated laundry, and that the iron can be removed by conventional treatment technologies.

- Sodium rejection was less that anticipated on Drums RTG-9 and RTG-10. The poor sodium rejection has little impact on the overall performance since total ion rejection was still 90-95% even with poor sodium rejection. Sodium has little environmental impact and even with the relatively poor rejection it may be possible to achieve the Comparative Level.

- Ammonia rejection on Drum RTG-10 appears poor (approximately 37%), but the feed concentration was only 0.4 mg/l and at very low concentrations, the analytical error becomes very significant.

B.5.3 Optimum Alternative - Dissolved Solids Removal

Reverse osmosis was determined to be the optimum alternative for dissolved solid removal based on the following:

- Contaminant removal using reverse osmosis was generally superior to contaminant removal using conventional ion exchange. Total ion reduction of 90 to 95% was achieved with reverse osmosis and individual ion and radionuclide rejection was generally greater than 90%.

- Secondary waste generation from conventional ion exchange could be as much as 25 to 50% of the flow. Secondary waste generation from reverse osmosis was 25% of the influent for a single stage. A conventional multi-stage reverse osmosis unit should generate a maximum of 10% reject secondary waste.

B.6 ORGANIC REMOVAL

There are two processes which are potentially applicable in removing the organic compounds present in laundry wastewater. These processes are granular activated carbon (GAC) and ultraviolet (UV) oxidation. The GAC process was tested in the treatability study using two testing techniques including adsorption isotherms and column tests. The adsorption isotherm procedure is a method for determination of the adsorptive capacity of activated carbons. Column tests are conducted to determine the optimum level to which contaminants can be reduced and to provide a dynamic test to determine carbon adsorption capacity. The dynamic test to determine carbon adsorption capacity may require large volumes of test solution and was not performed

in this treatability study.

UV/oxidation uses ultraviolet light to activate the organic molecule to be oxidized and also activates the oxidant (usually hydrogen peroxide). The combination of the UV activation and oxidation potential of the oxidant provides an effective method for breaking down organics in waste streams. The equipment to test UV/oxidation is specialized and treatability studies are normally conducted by the vendors. No UV/oxidation vendors are licensed to receive radioactive materials and, therefore, no treatability study was performed on UV/oxidation.

B.6.1 Activated Carbon Isotherms

Adsorption isotherms were prepared for GAC by contacting one liter samples of Drum RTG-7 with GAC. The carbon tested was Calgon Filtrasorb 400 at carbon dosages of 25, 50, 75, 125, and 200 mg per liter of wastewater. This is the test protocol prescribed in Carbon Adsorption Isotherms for Toxic Organics (EPA-600/8-80-023). After two hours of contact time followed by filtration to remove carbon particles, filtrate samples were collected for analysis for the organic compounds of concern.

The data are inconclusive and it is not possible to construct isotherms for specific compounds. There were very few organic compounds present in the influent water tested and those present were at extremely low concentrations near the detection limit so that the resulting analyses were sporadic. The TOC in the samples used for the isotherms was approximately 125 mg/l. The TOC in the samples would also be expected to load and fill all of the available sites on the carbon and prevent or reduce loading of the constituents requiring removal. The loading of TOC on the carbon was verified during the column testing.

B.6.2 Activated Carbon Column Tests

Activated carbon column tests were conducted in one inch diameter glass columns containing approximately 250 grams of GAC (12x40 mesh). Two GAC columns were run in series, and the columns were operated at a flowrate of approximately 40 ml/min. This flow corresponds to a velocity of 2 gpm/ft^2, and empty bed contact time for the two columns in series was approximately thirteen minutes.

Three sets of columns were used for this test, and the feed to each set of columns came from an individual drum. The feed for the activated carbon column test came from the following samples:

- Drum RTG-8 - This drum consisted of 25% regulated wash, 25% regulated rinse, 25% nonregulated wash, 25% nonregulated rinse;
- Drum RTG-9 - 50% regulated wash, 50% regulated rinse; and
- Drum RTG-10 - 50% nonregulated wash, 50% nonregulated rinse.

Approximately 2.5 gallons of sample was passed through each set of columns. Samples of the effluent were submitted for analysis, and only a small number of volatile and semi-volatile organic compounds were detected. Table B6 lists the compounds that were detected and presents the removal efficiency after treatment with GAC in the column test. A review of the data indicates the following:

TABLE B6

TABLE B6
ACTIVATED CARBON – REMOVAL EFFICIENCY a/
BEST AVAILABLE TECHNOLOGY ANALYSI
DECONTAMINATION LAUNDRY FACILITY
WESTINGHOUSE HANFORD COMPANY, RICHLAND, WASHINGTON

Analysis Parameter		% Removal
Sample ID		
Volatile Organics		
Acetone		89.39
Benzoic acid	>	44.44 b/
Benzyl alcohol		NDI c/
bis(2–Ethylhexyl)phthalate		59.64
Butylbenzylphthalate		NDI
Chloroform	>	54.45
Di–n–Octyl phthalate		24.56
Phenol	>	90.19
Total Organic Carbon		65.86

Notes
a/ The removal efficiencies were calculated from data generated during treatability studies at the PEDF in June and July, 1991
b/ A greater than value indicates that the compound was present in the effluent below the detection limit which was used to calculate the removal.
c/ NDI indicates that the compound was not detected in the influent or the effluent.

- Approximately 90% of the acetone was removed by GAC column treatment. This was not expected because based on the literature as acetone is not effectively adsorbed by GAC. The data that acetone adsorbed indicate a large excess of carbon.

- The data in Table B6 indicate that bis (2-Ethylhexyl) phthalate and Di-n-Octyl phthalate were not effectively removed. The analytical data on these compounds indicate that these compounds were found in the blanks. This is expected since phthalates are found in almost all plastics and, by necessity, some components of the treatment system were plastic.

- The data show that approximately 66% of the TOC was adsorbed by the carbon. This data indicate that the compounds that make up the TOC (organic constituents of cleaning agents, organics from the laundry) are adsorbed to some extent by the GAC. With no Comparative Level, TOC removal is often not evaluated in treatability studies. However, if TOC loads on the carbon, it will have a significant impact on carbon consumption and therefore may have a significant impact on the design of the carbon adsorption system.

B.6.2 UV/Oxidation

UV/oxidation is a relatively new process used for the destruction of organic contaminants in wastewater. The main advantage to UV/oxidation is the degradation of organic compounds to carbon dioxide, water, and chlorides (if halogenated com-

pounds are present). Therefore, a secondary waste (i.e. spent carbon) is not produced.

There is no simple bench-top field equipment available to test UV/oxidation. Vendors have small units available, but generally prefer to perform tests in their laboratory, and since no known vendors can accept radioactive materials, this option was not available.

Because of the problems discussed above, specific treatability testing of UV/oxidation did not take place. However, the detailed organic analyses that was performed as part of this treatability study allows an engineering evaluation of the UV/oxidation process.

The detailed organic analysis indicated that volatile and semi-volatile organic compounds are present at concentrations that seldom exceed 100 ug/l. The organic analysis also indicated that TOC can be present at high concentrations (greater than 300 mg/l) and that TOC concentration can vary significantly (from less than 20 mg/l to over 300 mg/l). It may not be possible to remove the regulated compounds to the appropriate Comparative Levels unless the TOC is removed also, even though TOC has no Comparative Level.

UV/oxidation has been used to treat wastewater similar to the PEDF effluent and, in some cases, UV/oxidation has been successful at oxidizing contaminants of concern without oxidizing all of the TOC. This can be successfully carried out only when the contaminants of concern are easier to oxidize than the TOC. Since the composition of the TOC is unknown at this time, it is not possible to predict whether UV/oxidation could remove the priority pollutants without oxidizing all of the TOC. A laboratory treatability study would be required to provide these data. If it is necessary to oxidize

all of the TOC in order to remove the priority pollutants, the capital and operating cost of the UV/oxidation system would be expected to be substantial, but no estimation can be made with existing data.

It should be noted that although information is available to indicate that it may be possible to oxidize contaminants of concern in the presence of high TOC, the DLF wastewater is extremely complex and comparing streams on paper can lead to incorrect conclusions. This was demonstrated during several of the treatability tests which indicated that there are several innocuous compounds present that interfere with the removal of contaminants of concern. Therefore, it is not prudent to consider this process for use at the DLF in the absence of treatability data.

B.6.3 Optimum Alternative - Organic Removal

The results of the treatability study indicate that GAC can remove a portion of the contaminants of concern. GAC will adsorb approximately 66% of the TOC present in the DLF effluent, and with the highly variable TOC content of the DLF effluent, it will be necessary to use a conservative approach for the design of the carbon adsorption system. A conservative design approach should result in additional removal of contaminants of concern.

UV/oxidation has been successful at treating some of the contaminants of concern in the presence of TOC without oxidizing all of the TOC. In order to determine the applicability of UV/oxidation to treat the DLF, a treatability study will be required. As described earlier, it was not possible to perform a treatability study on UV/oxidation, and therefore the actual performance of the process for this application is unknown. However, it is predicted that the capital and operating costs of the UV/oxidation

process will be high. At this time, it does not appear feasible to utilize an expensive unproven process, although UV/oxidation will be further evaluated if more information becomes available.

Based on the results of the treatability study, GAC appears to be the optimum alternative for organic contaminant removal, and, as stated earlier a conservative approach will be used for design purposes. If further information becomes available regarding the UV/oxidation process the economics of replacement will be evaluated at that time.