ORIGINAL

CALCULATION COVER SHEET

Project	Calculation Number	Project Number
Effluent Treatment Facility Auditable Safety Analysis	S-CLC-H-00710	N/A
Title Effluent Treatment Facility Radiological and Chemical Hazards Identification	**Functional Classification** PS	**Sheet** 1 of 29
	Discipline Health and Safety	

☐ Preliminary ☐ Committed ☒ Confirmed

Computer Program No. (s) N/A	Version/Release No. N/A

Purpose and Objective

The purpose of this engineering calculation is to document the Radiological and Chemical hazards identified for the Effluent Treatment Facility.

Summary of Conclusion

The Radiological and Chemical hazards identified for the Effluent Treatment Facility are documented in a tabular form in Appendix A of this EC. Consequences resulting from these hazards consist of radiological or chemical consequences associated with the hazard. Controls are identified to prevent or mitigate these hazards in providing a margin of safety to the facility worker, the general public, and the environment.

Revision

Rev No.	Revision Description
0	Original Issue

Sign Off

Rev No.	Originator (Print) Sign / Date	Verification / Checking Method	Verifier / Checker (Print) Sign / Date	Manager (Print) Sign / Date
0	T. D. Lookabill JD Lookabill 5/19/99	Individual review of calculation	H. D. Trinh Helen Dick Trinh 5/19/99	A. W. Wiggins A.W. Wiggins JR 5/19/99

Classification

UNCLASSIFIED

ENGINEERING DOC. CONTROL - SRS

00459181

ADC and Reviewing Official: N/A

Date:

ORIGINAL

CALCULATION CHECKLIST

REVIEWER (S):

NAME (PRINT OR TYPE)	SIGNATURE	DATE
HELEN D. TRINH	Helen D. Trinh	5/19/99

CIRCLE ONE

1. Is the Subject and/or Purpose clearly stated? (YES) NO
2. Are the required Input Data and their references and source provided and are they consistent with the calculation purpose? (YES) NO
3. Are the Assumptions clearly identified, valid, and consistent with the calculation purpose? YES NO (N/A)
4. Are the Analytical Methods clearly identified? (YES) NO
5. Are all pages consecutively numbered and identified by the calculation number? (YES) NO
6. Is/are the version(s) of the computer program(s) used identified? YES NO (N/A)
7. Are input listings for all computer programs documented in this calculation? YES NO (N/A)
8. Are the Results and Conclusions clearly stated? (YES) NO
9. Are all OUTPUT documents (if not part of the calculation) clearly referenced in the results section? (YES) NO N/A

IF NO TO ANY OF THE ABOVE, SHEET NUMBER(S) WITH JUSTIFICATION:

REVIEWER'S NOTES (use additional pages as necessary)

Review method used: Alternate calculation _____ Attached? Y____ N____
APPROXIMATED ORIGINATORS STEPS ✓

TABLE OF CONTENTS

1. INTRODUCTION

The Auditable Safety Analysis (ASA) identifies the events leading to the potential release of hazardous radiological and chemical material. The purpose of this engineering calculation (EC) is to document the radiological and chemical hazards identified for the ETF, and the preventive and mitigative features that will ensure the protection of the employees, the general public, and the environment.

Engineering controls, administrative controls, and good work practices shall be implemented to protect the workers, the general public, and the environment. Personnel shall not be permitted to participate in job activities for which they are not properly trained. Only facility operations personnel shall be permitted to operate equipment. Visitors and other non-hazardous waste workers must meet different requirements to perform work. The preventive and mitigative features identified for the radiological and chemical hazards fall entirely within the scope of the ASA and WSRC Manuals 2Q, 3Q, 4Q, 5Q, 6Q, 8Q, 11Q, 20Q, 1S and 2S.

2. DISCUSSION

ETF shall comply with the guidelines and requirements of all applicable WSRC Manuals and the ASA. All workers and visitors to the ETF shall be expected to abide by the requirements of the Site Safety (8Q) and Radiological Control (5Q) Manuals in order to reduce the risks of radiological and chemical consequences during operations.

The release of the total maximum radionuclide inventory for each segment results in no exceedance of either on-site or off-site criteria. Likewise, release of total chemical inventory, through tank rupture, in no exceedance of on-site (Immediately Dangerous to Life or Health) or off-site (Emergency Action Level) criteria.

During facility operation, several programs ensure timely identification of chemical and radiological hazards. These programs include OSHA compliance reviews, routine safety audits and periodic safety inspections, incident investigations (formal reviews and assessments of any unsafe situation or incident), annual safety program review, monthly safety meetings, safety suggestion programs, Job Hazards Analysis (JHA), and the SRS Quality Assurance program.

3. SAFETY MANAGEMENT

This section of the ASA discusses the controls and procedures to protect the workers from the hazards that could reasonably be expected to originate from the operation of the ETF. This section examines and determines that there are adequate and sufficient controls and procedures to protect the workers, the public, and the environment.

3.1 HAZARDS ASSOCIATED WITH THE FACILITY'S OPERATIONS

3.1.1 POTENTIAL ACTIVITIES

The main operational activities at ETF are as follows:

NO.	TASKS	DESCRIPTIONS
1	Unloading, Mixing, Handling Chemicals	Task may include potential exposure to chemicals such as, but not limited to: caustic (up to 50 weight %), nitric acid (up to 45 weight %), oxalic acid, sodium hypochlorite, sodium nitrate, halon, spent resin, mercury, argon, etc.
2	Routine Operations	Task may include activities such as surveillance of treatment plant and basins; inspections; process sampling of basins and WCT; emptying sumps and diked areas; cartridge filter cleaning; flushing sample lines; housekeeping; startup, shut down, or operation of pumps, cooling towers, generators, HVAC equipment; unloading wastewater from tank trucks, portable containers, valve alignments, run-time equalization on pumps, tanks; waste handling; etc.
3	Non Frequent Operations	Task may include activities such as sanitizing mercury columns; backflushing carbon columns; WCT solid removal; etc.
4	Abnormal Operations	Task may include activities such as responding to leaks/spills, fires, etc.
5	Maintenance	Task may include activities such as unloading/loading resins, replacing process columns, carbon beds; pump seal replacement; preventive/corrective maintenance, etc.

(Tasks may not necessarily be in order.)

3.1.2 TASK HAZARD IDENTIFICATION

The following table identifies the potential hazards associated with operation of the ETF.

Hazard Type	Task(s)	Protection Provided
PHYSIOCHEMICAL		
[x] Flammable (diesel fuel, combustible storage areas, chemical storage cabinets)	2, 4	Extinguishers, wet standpipe system, SW22.5-EOP- 01, ticklers, WSRC Manual 2Q
[ ] Explosive	None	
[x] Corrosive	1, 2, 3, 4, 5	Chemical Protective Clothing (per WSRC 8Q, 61).
[x] Reactive	1	Chemical Protective Clothing (per WSRC 8Q, 61).
[ ] Oxygen Rich	None	
[x] Oxygen Deficient (confined spaces)	3, 4	Per WSRC 8Q, 33
Chemically Toxic		
[x] Inhalation	1	Respirators, per WSRC 8Q, 61 and WSRC 4Q, IH-502
[x] Ingestion	1	Chemical Protective Clothing (per WSRC 8Q, 61).
[x] Contact	All	Chemical Protective Clothing (per WSRC 8Q, 61),
[x] Absorption	All	Chemical Protective Clothing (per WSRC 8Q, 61)
[x] Carcinogen	3, 5	Chemical Protective Clothing (per WSRC 8Q, 61) and respirator, per WSRC 8Q, 61 and WSRC 4Q, IH-502
[ ] Mutagen	None	
[ ] Teratogen	None	
Ionizing Radiation		
[x] Internal Exposure	3, 4, 5	Protective clothing and respirator as deemed necessary by RCO; See WSRC 8Q, 61 and WSRC 4Q, IH-502, Training;
[x] External Exposure	3, 4, 5	Protective clothing; See WSRC 8Q, 61; Training;

4. CONCLUSION

Tables A-1 through A-6.9 in Appendix A of this EC lists all identified chemical and radiological hazards and corresponding preventive and mitigative controls for each section in the ETF in a tabular form. The administrative controls, programs, and procedures will be utilized to protect the workers, the public, and the environment from the anticipated chemical and radiological hazards that could reasonably be expected to originate from the operation of the ETF.

5. REFERENCE

1. Fire Protection Program, WSRC Procedure Manual 2Q, April 1999.

2. Environmental Compliance Manual, WSRC Procedure Manual 3Q, April 1999.

3. Industrial Hygiene, WSRC Procedure Manual 4Q, May 1999.

4. Radiological Control, WSRC Procedure Manual 5Q, September 1998.

5. SRS Emergency Plan, WSRC Procedure Manual 6Q, April 1999.

6. Employee Safety Manual, WSRC Procedure Manual 8Q, April 1999.

7. Facility Safety Document Manual, WSRC Procedure Manual 11Q, January 1999.

8. Health and Safety Manual for Hazardous Waste Operations, WSRC Procedure Manual 20Q, February 1999.

9. SRS Waste Acceptance Criteria Manual, WSRC Procedure Manual 1S, February 1999.

10. Conduct of Operations Manual, WSRC Procedure Manual 2S, October 1997.

11. Auditable Safety Analysis for the Effluent Treatment Facility, WSRC-TR-98-00379, January 1999.

APPENDIX A: HAZARD ASSESSMENT TABLES FOR RADIOLOGICAL AND CHEMICAL HAZARDS

Table A-1 F-Area Cooling Water Basin

Event No.	Event Category	Postulated Event Description	Causes	Preventive Features		Method of Detection	Mitigation Features	
				Design	Administrative		Design	Administrative
FCB-1	E-3	Release of radioactive material due to basin overflow	Diversion in excess of basin capacity; Inadvertent transfer; siphon malfunction	Cooling Water Basin overflows to Retention Basin	None.	Visual; High Level Alarm	None	Alarm Response Procedure (ARP)
FCB-2	E-3	Release of radioactive material due to basin leak	Flaw in liner.	Double Liner. Leak detection and pumping system between liners.	Response to leak detection.	Leak detection system. Visual. Water samples.	None.	ARP; Spill Response Procedure
FCB-3	E-4	Direct exposure from high solids buildup	Sampling error; Basin drained	None.	Inventory Control Program	Samples.	None.	None.

EVENT CATEGORIES

E-1 - Fire
E-2 - Explosion
E-3 - Loss of Containment /Confinement
E-4 - Direct Radiological/ Chemical Exposure
E-5 - Nuclear Criticality
E-6 - External Hazards
E-7 - Natural Phenomena

Table A-2. F-Area Retention Basin

Event No.	Event Category	Postulated Event Description	Causes	Preventive Features		Method of Detection	Mitigation Features	
				Design	Administrative		Design	Administrative
FRB-1	E-3	Release of radioactive material due to basin overflow	Diversion in excess of basin capacity.	Level indicator (Staff Gage)	AOP	Visual	None.	None
FRB-2	E-3	Release of radioactive material due to basin leak	Flaw in liner.	None.	None.	Groundwater sampling.	None.	Procedures to repair liner
FRB-3	E-3	Release of radioactive material into the Four Mile Creek	Flaw in interlocks on pumps; High radiation alarm malfunction	Design of interlocks on pumps	Sampling prior to transfer.	High Radiation Alarm	None.	Sampling during transfer.
FRB-4	E-4	Direct exposure from high solids buildup	Sampling error; Basin drained	None.	Inventory Control Program	Samples.	None.	None.

EVENT CATEGORIES

E-1 - Fire
E-2 - Explosion
E-3 - Loss of Containment /Confinement
E-4 - Direct Radiological/ Chemical Exposure
E-5 - Nuclear Criticality
E-6 - External Hazards
E-7 - Natural Phenomena

Table A-3 H-Area Cooling Water Basin

Event No.	Event Category	Postulated Event Description	Causes	Preventive Features		Method of Detection	Mitigation Features	
				Design	Administrative		Design	Administrative
HCB-1	E-3	Release of radioactive material due to basin overflow	Diversion in excess of basin capacity; Inadvertent transfer	Cooling Water Basin overflows to Retention Basin, Interlocks shutdown screw pumps;	AOP	Visual; High level alarm	None	ARP
HCB-2	E-3	Release of radioactive material due to basin leak	Flaw in liner.	Double Liner. Leak detection and pumping system between liners.	Response to leak detection.	Leak detection system. Visual. Water samples.	None.	ARP; Spill Response Procedure
HCB-3	E-4	Direct Exposure from high solids buildup	Sampling error; Basin drained	None.	Inventory Control Program	Samples.	None.	None.

EVENT CATEGORIES

E-1 - Fire
E-2 - Explosion
E-3 - Loss of Containment /Confinement
E-4 - Direct Radiological/ Chemical Exposure
E-5 - Nuclear Criticality
E-6 - External Hazards
E-7 - Natural Phenomena

Table A-4 H-Area Retention Basin

Event No.	Event Category	Postulated Event Description	Causes	Preventive Features		Method of Detection	Mitigation Features	
				Design	Administrative		Design	Administrative
HRB-1	E-3	Release of radioactive material due to basin overflow	Diversion in excess of basin capacity.	Level indicator (Staff Gage)	AOP	Visual	None.	None
HRB-2	E-3	Release of radioactive material due to basin leak	Flaw in liner	None.	None.	Groundwater sampling.	None.	Procedures to repair liner
HRB-3	E-3	Release of radioactive material into the Four Mile Creek	Flaw in interlocks on pumps; High radiation alarm malfunction	Design of interlocks on pumps	Sampling prior to transfer.	High Radiation Alarm	None.	Sampling during transfer.
HRB-4	E-4	Direct Exposure from high solids buildup	Sampling error; Basin drained	None.	Inventory Control Program	Samples.	None.	None.

EVENT CATEGORIES

E-1 - Fire
E-2 - Explosion
E-3 - Loss of Containment /Confinement
E-4 - Direct Radiological/ Chemical Exposure
E-5 - Nuclear Criticality
E-6 - External Hazards
E-7 - Natural Phenomena

Table A-5.1 F-Area Lift Station

Event No.	Event Category	Postulated Event Description	Causes	Preventive Features		Method of Detection	Mitigation Features	
				Design	Administrative		Design	Administrative
FLS-1	E-2	Release of radioactive material due to explosion in FLS	Generation of explosive concentrations of flammable gases as a result of incompatible chemicals	Exhaust blower at lift station	Waste Acceptance Criteria (WAC)	Visual; Sump alarms	Tank design; Dike; Sump	SOPs; EOPs for spill response; Alarm Response Procedures
FLS-2	E-3	Release of radioactive material due to overflow	Equipment malfunction; Operator error	Interlocks on pumps at the basin; Level Indicators/Alarms	Alarm Response Procedures	Overflow alarm	Overflows to sump.	Alarm Response Procedures
FLS-3	E-3	Release of radioactive material due to leak in Lift Station	Pipe leaks; Tank leaks; Pump failure	Pipe design; Tank design; Interlocks on pumps	Alarm Response Procedures	Visual, Sump Alarms	Overflows to sump.	Alarm Response Procedures; EOP
FLS-4	E-3	Release of radioactive material due to breakthru in exhaust blower HEPA	High differential pressure across filter; Operator error	Differential pressure gauge	Surveillance Procedures	RCO Survey	None.	None.

EVENT CATEGORIES

E-1 - Fire
E-2 - Explosion
E-3 - Loss of Containment /Confinement
E-4 - Direct Radiological/ Chemical Exposure
E-5 - Nuclear Criticality
E-6 - External Hazards
E-7 - Natural Phenomena

Table A-5.2 H-Area Lift Station

Event No.	Event Category	Postulated Event Description	Causes	Preventive Features		Method of Detection	Mitigation Features	
				Design	Administrative		Design	Administrative
HLS-1	E-2	Release of radioactive material due to explosion in HLS	Generation of explosive concentrations of flammable gases as a result of incompatible chemicals	Exhaust blower at lift station	Waste Acceptance Criteria (WAC)	Visual; Sump alarms	Tank design; Dike; Sump	SOPs; EOPs for spill response; Alarm Response Procedures
HLS-2	E-3	Release of radioactive material due to overflow	Equipment malfunction; Operator error	Interlocks on pumps at the basin; Level Alarms	Alarm Response Procedures	Overflow alarm	Overflows to sump.	Alarm Response Procedures
HLS-3	E-3	Release of radioactive material due to leak in Lift Station	Pipe leaks; Tank leaks; Pump failure	Pipe design; Tank design; Interlocks on pumps	Alarm Response Procedures	Visual, Sump Alarms	Overflows to sump.	Alarm Response Procedures; EOP
HLS-4	E-3	Release of radioactive material due to breakthru in exhaust blower HEPA	High differential pressure across filter; Operator error	Differential pressure gauge	Surveillance Procedures	RCO Survey	None.	None.

EVENT CATEGORIES

E-1 - Fire
E-2 - Explosion
E-3 - Loss of Containment /Confinement
E-4 - Direct Radiological/ Chemical Exposure
E-5 - Nuclear Criticality
E-6 - External Hazards
E-7 - Natural Phenomena

Table A-5.3 Force Main

Event No.	Event Category	Postulated Event Description	Causes	Preventive Features		Method of Detection	Mitigation Features	
				Design	Administrative		Design	Administrative
FM-1	E-3	Release of radioactive material due to leak in jacket	Impact; Corrosion; High pressure	Pipe design	None	Surveillance Procedures	Leak detection via conductivity probe	Alarm Response Procedures
FM-2	E-3	Release of radioactive material due to leak in sump	Impact; Corrosion; High pressure	Pipe design	None	Surveillance Procedures	Leak detection via conductivity probe	Alarm Response Procedures

EVENT CATEGORIES

E-1 - Fire
E-2 - Explosion
E-3 - Loss of Containment /Confinement
E-4 - Direct Radiological/ Chemical Exposure
E-5 - Nuclear Criticality
E-6 - External Hazards
E-7 - Natural Phenomena

Table A-5.4 Waste Water Collection Tanks

Event No.	Event Category	Postulated Event Description	Causes	Preventive Features		Method of Detection	Mitigation Features	
				Design	Administrative		Design	Administrative
WWC-1	E-2	Release of radioactive material due to explosion in WWCT	Generation of explosive concentrations of flammable gases as a result of incompatible chemicals	None.	Waste Acceptance Criteria (WAC)	Visual; Dike alarm; Sump alarm	Tank design; Dike; Sump	SOPs; EOPs for spill response; Alarm Response Procedures
WWC-2	E-2	Release of radioactive material due to pressurized tank	Incompatible chemicals	Tank/ pipe design; Vessel ventilation system; Loop seal	Periodic Non-Destructive Examination (NDE) on tanks; WAC	Visual; Dike alarm; Sump alarm	Dike; Sump	Alarm Response Procedures
WWC-3	E-3	Release of radioactive material due to leak/rupture of tank or pipe	Impact; Corrosion; High pressure	Tank/ pipe design	Periodic Non-Destructive Examination (NDE) on tanks	Dike alarm; Sump alarm; Visual	Dike; Sump	Alarm Response Procedures
WWC-4	E-3	Release of radioactive material due to tank overflow	Equipment malfunction; Operator error	Tank level alarms; Equipment design; Interlocks	Alarm Response Procedures; Abnormal Operating Procedures	Tank probes; Dike alarm; Sump alarm	Dike; Sump	SOPs; Alarm Response Procedures
WWC-5	E-3	Release of radioactive material due to tank vacuum	Equipment malfunction; Operator error	Vacuum Breaker	Pressure Protection Program	None.	Tank design	None.

EVENT CATEGORIES

E-1 - Fire
E-2 - Explosion
E-3 - Loss of Containment /Confinement
E-4 - Direct Radiological/ Chemical Exposure
E-5 - Nuclear Criticality
E-6 - External Hazards
E-7 - Natural Phenomena

Table A-5.5 Mercury Removal Columns

Event No.	Event Category	Postulated Event Description	Causes	Preventive Features		Method of Detection	Mitigation Features	
				Design	Administrative		Design	Administrative
MRC-1	E-2	Release of radioactive material due to explosion in HG Removal Columns	Generation of explosive concentrations of flammable gases as a result of incompatible chemicals	None.	Waste Acceptance Criteria (WAC)	Visual; Sump alarm	Tank design; Dike; Sump	SOPs; EOPs for spill response; AOP; Alarm Response Procedures
MRC-2	E-2	Release of radioactive material due to Hg Removal Vessel becomes overpressurized	Nitric Acid	Relief valve; Differential pressure alarm	Preventive Maintenance on relief valve; Cleaning Procedures, Pressure Protection Program	None; Sump alarm	Sump; Dike	Alarm Response Procedures
MRC-3	E-3	Release of radioactive material due to leak in the columns	Corrosion; Impact; High pressure	Tank design; Pipe design	NDE.	Sump alarm	Sump; Dike	Alarm Response Procedures
MRC-4	E-4	Direct exposure from radioactive materials and/or chemicals	Line leaks releasing hazardous material; Inadvertent transfer;	Pipe design	None	Visual; Samples	Sump; Dike .	Alarm Response Procedures .
MRC-5	E-4	High radiation exposure due to build up of radionuclides on Hg Removal Column	Sampling error; Calculation error causes column holdup; Resin is not exchanged.	Shield wall	Inventory Control Program	RCO area survey, Monthly holdup determination	None.	RCO Procedure

EVENT CATEGORIES

E-1 - Fire
E-2 - Explosion
E-3 - Loss of Containment /Confinement
E-4 - Direct Radiological/ Chemical Exposure
E-5 - Nuclear Criticality
E-6 - External Hazards
E-7 - Natural Phenomena

Table A-5.6 Carbon Adsorption Columns

Event No.	Event Category	Postulated Event Description	Causes	Preventive Features		Method of Detection	Mitigation Features	
				Design	Administrative		Design	Administrative
CAC-1	E-3	Release of radioactive material due to overflow in OR feed tank	Loss of flow thru the Carbon Adsorption Columns; Blocked lines; Equipment malfunction; Operator error	Tank level interlocks; Tank level alarms	Alarm Response Procedures	Tank level alarm; Sump alarm	Sump; Dike	Alarm Response Procedures
CAC-2	E-3	Release of radioactive material due to leak in the Carbon Adsorption Columns	Tank leak; Pipe leak	Tank design; Pipe design	None.	Sump alarm	Sump; Dike	Alarm Response Procedures
CAC-3	E-3	Release of radioactive material due to overpressurization of the CUNO filter housing	Filters plug; Operator error	Relief valve; Differential pressure alarm	Preventive Maintenance on Relief valve, Pressure Protection Program	Differential pressure alarm ; Sump alarm	Sump; Dike	Alarm Response Procedures
CAC-4	E-4	Direct exposure from radioactive material and/or chemicals	Line leaks releasing hazardous material; Inadvertent transfer; Sampling error; Calculation error causes column holdup	Pipe design	Inventory Control Program; SOPs to replace columns	Visual; Samples	None.	None.

EVENT CATEGORIES

E-1 - Fire
E-2 - Explosion
E-3 - Loss of Containment /Confinement
E-4 - Direct Radiological/ Chemical Exposure
E-5 - Nuclear Criticality
E-6 - External Hazards
E-7 - Natural Phenomena

Table A-5.7 Acid and Caustic Storage

Event No.	Event Category	Postulated Event Description	Causes	Preventive Features		Method of Detection	Mitigation Features	
				Design	Administrative		Design	Administrative
ACS-1	E-2	Release of acid and/or caustic due to explosion caused by pressurized tank	Incompatible Chemical Pumped Into Tank; Operator error	Different sized nozzles; Tank design	SOPs	Visual	Dike	Response to leak; EOP
ACS-2	E-3	Release of toxic fumes/chemicals from drainage line	Plugged drainage line causes incompatible chemical reaction due to accumulation of debris	None	Inspection each time a tank is unloaded.	Visual	None	None
ACS-3	E-3	Release of nitric acid due to leak/rupture in the Nitric Acid Tank	Impact; Corrosion; High pressure; Natural Phenomenon Hazard (NPH), Operator error	Tank design; Pipe design;	NDE; Pressure Protection Program	Dike alarm	Dike	Alarm Response Procedures
ACS-4	E-3	Release of caustic due to leak/rupture in the CausticTank	Impact; Corrosion; High pressure; NPH; Operator error	Tank design; Pipe design;	NDE; Pressure Protection Program	Dike alarm	Dike	Alarm Response Procedures
ACS-5	E-3	Concurrent Releases from Nitric Acid and Caustic tanks	Impact; Corrosion; High pressure; NPH; Operator error	Tank design	None.	Dike alarm	Dike	Alarm Response Procedures
ACS-6	E-3	Release due to leak/ rupture of Chemical Tanks.	Impact; Corrosion; High pressure; NPH; Operator error	Tank design; Pipe design;	NDE; Pressure Protection Program	Visual	Dike	None.
ACS-7	E-4	Direct exposure of chemicals	Line leaks releasing hazardous material; Inadvertent transfer	Pipe design	NDE of acid lines	Visual	None.	None.

EVENT CATEGORIES

E-1 - Fire
E-2 - Explosion
E-3 - Loss of Containment /Confinement
E-4 - Direct Radiological/ Chemical Exposure
E-5 - Nuclear Criticality
E-6 - External Hazards
E-7 - Natural Phenomena

Table A-6.1 pH Adjustment System

Event No.	Event Category	Postulated Event Description	Causes	Preventive Features		Method of Detection	Mitigation Features	
				Design	Administrative		Design	Administrative
PAS-1	E-2	Release of radioactive material and/or chemicals caused by pressurized tank	Incompatible chemicals introduced to pH Adjustment Tank; Operator error	None.	SOPs	Visual	Tank design	EOPs for spill response
PAS-2	E-3	Release of radioactive material and/or chemicals due to leak/ rupture on pH Adjustment tanks	Impact; Corrosion; High pressure; NPH	Tank design	Non-Destructive Examination Program	Sump alarm; Visual	Building sump.	Alarm Response Procedures.
PAS-3	E-3	Release of radioactive material and/or chemicals due to vacuum	Equipment malfunction; Operator error	Vacuum Breaker	Pressure Protection Program	Sump alarm; Visual	Tank design.	None.
PAS-4	E-4	Direct exposure from radioactive material and/or chemicals	Line leaks releasing hazardous material; Inadvertent transfer	Pipe design	None	Visual; Samples	None.	None.

EVENT CATEGORIES

E-1 - Fire
E-2 - Explosion
E-3 - Loss of Containment /Confinement
E-4 - Direct Radiological/ Chemical Exposure
E-5 - Nuclear Criticality
E-6 - External Hazards
E-7 - Natural Phenomena

Table A-6.2 Filtration System

Event No.	Event Category	Postulated Event Description	Causes	Preventive Features		Method of Detection	Mitigation Features	
				Design	Administrative		Design	Administrative
FS-1	E-2	Release of radioactive material caused by pressurized tank	Incompatible chemicals introduced to Filter Feed Tank	None.	SOPs	Visual	Tank design	EOPs for spill response
FS-2	E-3	Release of radioactive material due to leak/rupture on tanks or filter train	Impact; Corrosion; High pressure; NPH	Pipe design; Tank design; Relief valves	Non-Destructive Examination Program on the tank; Preventive maintenance on relief valves	Visual	Sumps	Periodic operator inspection
FS-3	E-3	Release of radioactive material due to overflow in the tanks	Equipment malfunction; Operator error	Tank level alarm; Interlocks	Alarm Response Procedures; SOPs	Visual; Level alarm; Sump alarm	Building sump	None
FS-4	E-3	Release of radioactive material due to vacuum on the tanks	Equipment malfunction; Operator error	Tank vacuum relief	Pressure Protection Program	None.	Tank design	None.
FS-5	E-4	Direct exposure of radioactive material and/or chemicals	Line leaks releasing hazardous material; Inadvertent transfer	Pipe design	SOPs	Visual; Samples	None.	None.

EVENT CATEGORIES

E-1 - Fire
E-2 - Explosion
E-3 - Loss of Containment /Confinement
E-4 - Direct Radiological/ Chemical Exposure
E-5 - Nuclear Criticality
E-6 - External Hazards
E-7 - Natural Phenomena

Table A-6.3 Reverse Osmosis System

Event No.	Event Category	Postulated Event Description	Causes	Preventive Features		Method of Detection	Mitigation Features	
				Design	Administrative		Design	Administrative
ROS-1	E-3	Release of radioactive material due to leak/ rupture in tanks or lines	High pressure; Impact; Corrosion, NPH	Pipe design; Tank design; Relief valves	Non-Destructive Examination Program on the tank; Preventive maintenance on relief valves;	Dike/ Sump alarm; Visual	Dike/ Sump	EOP
ROS-2	E-3	Release of radioactive material due to tank overflow	Equipment malfunctions; Operator error	Tank level alarm; Interlocks	Alarm Response Procedures; SOPs	Dike/ Sump alarm	Dike/ Sump	Alarm Response Procedures
ROS-3	E-3	Release of radioactive material due to breakage in trains' membrane	Overpressurization in the trains; Operator error	Pressure switch/interlocks on permeate line; Relief valves	SOPs; Preventive maintenance of relief valves	Train sampling	Train design	None.
ROS-4	E-3	Release of radioactive material due to vacuum	Equipment malfunction; Operator error	Tank vacuum relief	Pressure Protection Program	None.	Tank design	None.
ROS-5	E-4	Direct exposure from radioactive material	Line leaks releasing hazardous material; Inadvertent transfer	Pipe design	SOPs	Visual; Samples	None.	None.
ROS-6	E-4	High Radiation Exposure	Build up of radionuclides on the membrane	None.	SOPs .	RCO area survey	None.	None.

EVENT CATEGORIES

E-1 - Fire
E-2 - Explosion
E-3 - Loss of Containment /Confinement
E-4 - Direct Radiological/ Chemical Exposure
E-5 - Nuclear Criticality
E-6 - External Hazards
E-7 - Natural Phenomena

Table C-6.4 Evaporator System

Event No.	Event Category	Postulated Event Description	Causes	Preventive Features		Method of Detection	Mitigation Features	
				Design	Administrative		Design	Administrative
EVS-1	E-2	Release of radioactive material due to explosion caused by pressurized tank	Heat exchanger tubes plugged; Condenser plugs	Loop seal; High pressure alarm/interlock	SOPs	Flow indicators; Differential Level (Visual)	Tank design	EOPs for spill response
EVS-2	E-3	Leak in the steam condensate tank releases high radiological activity	Heat exchanger tube bundle failure	Heat exchanger design	SOPs	Radiation monitor; Conductivity probe	Interlock to send steam condensate to WWCT	Alarm Response Procedures
EVS-3	E-3	Release of radioactive material due to leak/ rupture in tanks or lines	High pressure; Impact; Corrosion	Pipe design; Tank design	Non-Destructive Examination Program on the tank; Pressure Protection Program	Sump/ Dike alarms; Visual	Sump / Dike	Alarm Response Procedures
EVS-4	E-3	Release of radioactive material due to overflow in feed tank	Equipment malfunctions; Operator error	Tank level alarm; Interlocks	Alarm Response Procedures, SOPs	Sump/ Dike alarms	Sump/ Dike	Alarm Response Procedures
EVS-5	E-3	Release of radioactive material due to vacuum	Equipment malfunction; Operator error	Tank vacuum relief	SOPs	None.	Tank design	None.
EVS-6	E-4	Direct exposure from radioactive material	Line leaks releasing hazardous material; Inadvertent transfer	Pipe design	SOPs	Visual; Samples	None.	None.

EVENT CATEGORIES

E-1 - Fire
E-2 - Explosion
E-3 - Loss of Containment /Confinement
E-4 - Direct Radiological/ Chemical Exposure
E-5 - Nuclear Criticality
E-6 - External Hazards
E-7 - Natural Phenomena

Table C-6.5 Ion Exchange System

Event No.	Event Category	Postulated Event Description	Causes	Preventive Features		Method of Detection	Mitigation Features	
				Design	Administrative		Design	Administrative
IES-1	E-3	Release of radioactive material and/or chemicals due to tank/ pipe leak	Impact; Corrosion; High pressure	Tank design; Pipe design	Non-Destructive Examination on tank	Visual; Sump/ Dike alarms	Sump/ Dike	Alarm Response Procedures; EOPs for spill response
IES-2	E-2	Release of radioactive material and/or chemicals due to overpressurization of tank	Equipment malfunctions; Operator error	Relief valves; Tank design	Non-Destructive Examination	Visual; Sump/ Dikealarms	Sump/ Dike	SOPs; Alarm Response Procedures
IES-3	E-3	Release of radioactive material and/or chemicals due to tank o'flow	Equipment malfunctions; Operator error	Tank level alarm / Interlocks	Alarm Response Procedures; SOPs	Sump/ Dike alarm	Sump/ Dike	Alarm Response Procedures
IES-4	E-3	Release of radioactive material and/or chemicals due to vacuum	Equipment malfunction; Operator error	Tank vacuum relief	Pressure Protection Program	None.	Tank design	None.
IES-5	E-4	Direct exposure from radioactive material and/or chemicals	Line leaks releasing hazardous material; Inadvertent transfer	Pipe design	SOPs	Visual; Samples	None.	None.
IES-6	E-4	High radiation exposure	Buildup of Cs on resin; Sampling error; Calc. error causes column holdup	None.	Inventory Control Program	RCO area survey; Samples	None.	Regenerate the resin when breakthru is indicated

EVENT CATEGORIES

E-1 - Fire
E-2 - Explosion
E-3 - Loss of Containment /Confinement
E-4 - Direct Radiological/ Chemical Exposure
E-5 - Nuclear Criticality
E-6 - External Hazards
E-7 - Natural Phenomena

Table A-6.6 Process Chemical Tanks (ANN/FEN Tanks, Acid/Caustic Day Tanks, Sodium Nitrate Mix Tank, Cleaning Mix Tank)

Event No.	Event Category	Postulated Event Description	Causes	Preventive Features		Method of Detection	Mitigation Features	
				Design	Administrative		Design	Administrative
PCT-1	E-2	Release of chemicals due to explosion	Inadvertent mixing of incompatible chemicals; Add nitric or caustic to wrong tank; Operator error	DCS software design; Pipe configuration	SOPs	Visual	Tank design; Building sump; Sump alarm	EOPs for spill response
PCT-2	E-3	Release of chemicals due to leak/rupture in tank/pipe	Corrosion; High pressure; Impact	Pipe design; Tank design	SOPs; NDE for all except Cleaning Mix Tank	Visual; Sump and/or Dike alarm	Sump and/or Dike	Response to leak (EOP); Alarm Response Procedures
PCT-3	E-3	Release of chemicals due to tank overflow	Equipment malfunctions; Operator error	Tank level alarms / Interlocks	Alarm Response Procedures; SOPs	Sump and/or Dike alarm	Sump and/or Dike	Alarm Response Procedures
PCT-4	E-4	Direct exposure from chemicals	Line leaks releasing hazardous material; Inadvertent transfer	Pipe design	SOPs	Visual	None.	None.

EVENT CATEGORIES

E-1 - Fire
E-2 - Explosion
E-3 - Loss of Containment /Confinement
E-4 - Direct Radiological/ Chemical Exposure
E-5 - Nuclear Criticality
E-6 - External Hazards
E-7 - Natural Phenomena

Table A-6.7 Control Building

Event No.	Event Category	Postulated Event Description	Causes	Preventive Features		Method of Detection	Mitigation Features	
				Design	Administrative		Design	Administrative
CB-1	E-3	Halon asphyxiation	Halon fire suppression system malfunctions; Fire alarm malfunctions (no advance notice of Halon release)	Halon fire suppression system designed to NFPA 12A to limit Halon discharge; Design of alarm system	Preventive maintenance (PM) and periodic testing on fire alarm system; PM on Halon system	Audible	60 second delay on Halon to allow evacuation of control room.	EOP

EVENT CATEGORIES

E-1 - Fire
E-2 - Explosion
E-3 - Loss of Containment /Confinement
E-4 - Direct Radiological/ Chemical Exposure
E-5 - Nuclear Criticality
E-6 - External Hazards
E-7 - Natural Phenomena

Table A-6.8 Treated Water System

Event No.	Event Category	Postulated Event Description	Causes	Preventive Features		Method of Detection	Mitigation Features	
				Design	Administrative		Design	Administrative
TWS-1	E-3	Release of radioactive material due to leak/rupture on tanks or pipes	Impact; Corrosion; High pressure	Pipe design; Tank design	None.	Visual	None	EOPs for spill response
TWS-2	E-3	Release of radioactive material due to overflow	Equipment malfunction; Operator error	Tank level alarm; Interlock	Alarm Response Procedures; SOPs	Visual	None	EOPs for spill response

EVENT CATEGORIES

E-1 - Fire
E-2 - Explosion
E-3 - Loss of Containment /Confinement
E-4 - Direct Radiological/ Chemical Exposure
E-5 - Nuclear Criticality
E-6 - External Hazards
E-7 - Natural Phenomena

Table A-6.9 Common Hazards (1 of 2)

Event No.	Event Category	Postulated Event Description	Causes	Preventive Features		Method of Detection	Mitigation Features	
				Design	Administrative		Design	Administrative
COM-1	E-3	Asphyxiation caused by confined spacing	Operator error; Equipment malfunction, e.g., breathing air system	None.	SOPs	None.	None.	Buddy System
COM-2	E-6	Heavy equipment or vehicles (i.e. trucks, forklift) strikes ETF releasing radioactive material and/or chemicals	Operator error	Building Structure	Speed limits; Limited access	None.	None.	Emergency Response
COM-3	E-6	Helicopter strikes ETF and starts fire releasing radioactive material and/or chemicals	Engine malfunction	None.	None.	Visual; Sound	None.	EOP
COM-4	E-6	Airplane strikes ETF and starts fire releasing radioactive material and/or chemicals	Engine malfunction	None.	None.	Visual; Sound	None.	EOP
COM-5	E-7	Earthquake damages building/ tanks releasing radioactive material and/or chemicals	Earthquake results in structural members puncturing tanks/ building	None.	None.	Visual; Sound	UBC Building design	AOP; EOP
COM-6	E-7	Earthquake damages building/ tanks releasing radioactive material and/or chemicals	Earthquake results in structural members puncturing tanks/ building	None.	None.	Visual; Sound	UBC Building design	AOP; EOP

Table A-6.9 Common Hazards (2 of 2)

Event No.	Event Category	Postulated Event Description	Causes	Preventive Features		Method of Detection	Mitigation Features	
				Design	Administrative		Design	Administrative
COM-7	E-7	Earthquake damages building/ tanks releasing radioactive material and/or chemicals	Earthquake results in structural members puncturing tanks/ building	None.	None.	Visual; Sound	UBC Building design	AOP; EOP
COM-8	E-7	Hurricane or tornado damages building/ tanks releasing radioactive material and/or chemicals	High wind results in structural members puncturing tanks/ building	None.	None.	Visual; Sound	UBC Building design	Emergency Response, i.e., immediate evacuation/ shelter
COM-9	E-7	Flooding releasing radioactive material and/or chemicals	Heavy rains	None.	None.	Visual	UBC Building design	Emergency Response, i.e., immediate evacuation/ shelter
COM-1	E-7	Snow, ice, or hail damages building/tank releasing radioactive material and/or chemicals	Snow, ice, or hail	None.	None.	Visual	UBC Building design	Emergency Response, i.e., immediate evacuation/ shelter

EVENT CATEGORIES

E-1 - Fire
E-2 - Explosion
E-3 - Loss of Containment /Confinement
E-4 - Direct Radiological/ Chemical Exposure
E-5 - Nuclear Criticality
E-6 - External Hazards
E-7 - Natural Phenomena